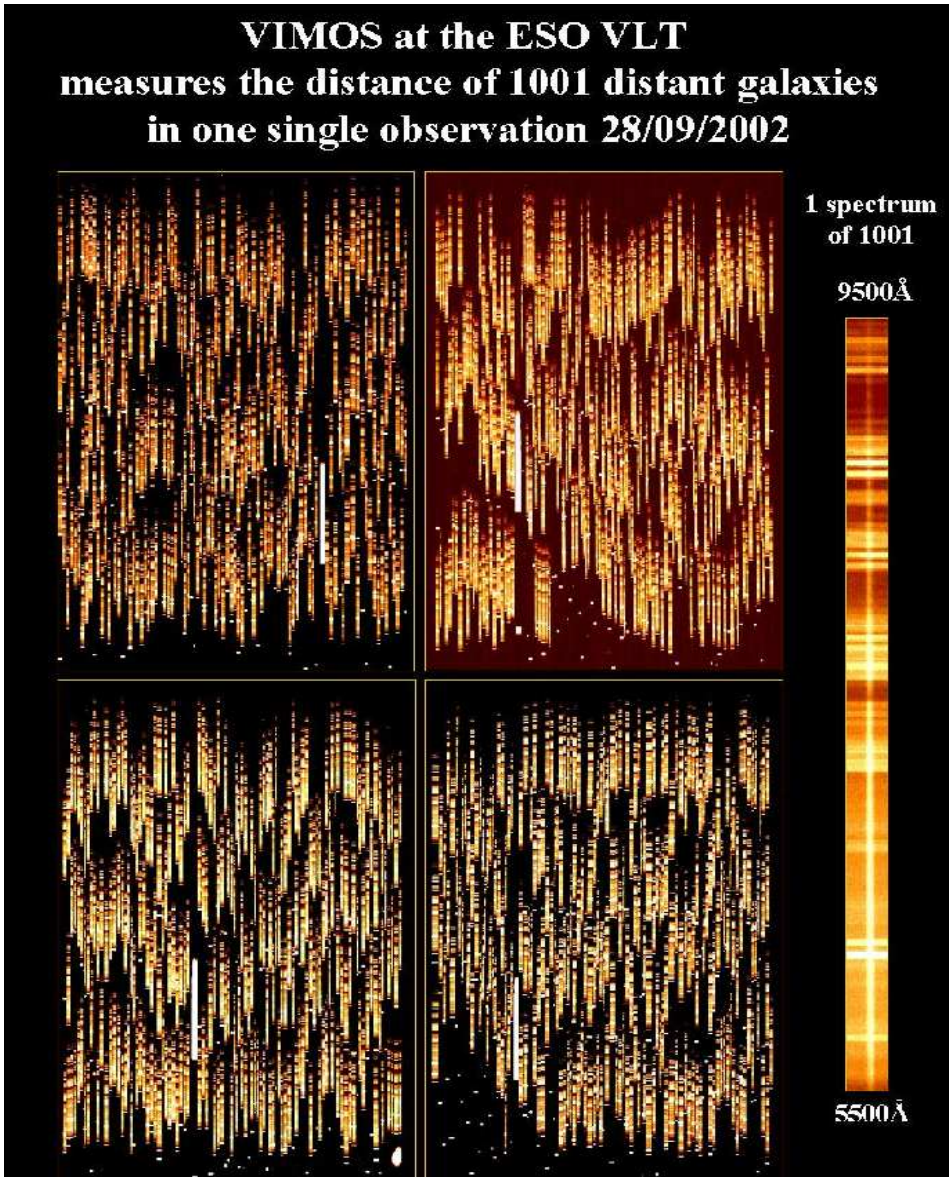
VIMOS at the ESO VLT
measures the distance of 1001 distant galaxies
in one single observation 28/09/2002
1 spectrum
of 1001
9500Å
5500Å

Osservatorio Astronomico
di Bologna

Annual Report 2002

Osservatorio Astronomico di Bologna
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Cover: 1001 spectra obtained with the VIMOS spectrograph on the ESO-VLT, on the night of 28-Sept-2002. The LRRED grism was used to observe galaxies with magnitudes $I_{AB} \leq 24$, in one of the VIRMOS-VLT Deep Survey (VVDS) areas. Credit: The VIRMOS Consortium and ESO

Presentation

The *Osservatorio Astronomico di Bologna*, one of the twelve Italian Observatories, is one of the research structures of the National Institute for Astrophysics (INAF), operating under the supervision of the Ministry for Instruction, University and Research (MIUR). The Ministry provides most of the financial resources which make our activity possible.

This Report provides an overview of our scientific research, covering a wide range of topics in astronomy such as :

- stellar population and galactic evolution studies and their cosmological implications;
- study of the structure, evolution and distribution of galaxies, clusters and AGN and their contribution to the cosmological backgrounds;
- numerical studies in the field of gas hydrodynamics and turbulence simulations;
- management and upgrading of the two telescopes in Loiano (152 and 60 cm) and development of astronomical instruments in the framework of national and international programs.

Most of these studies are based on an intensive use of the most advanced instruments available today at all wavelengths. These are carried out in collaboration with many international and national institutes and, locally, with the *Università di Bologna, Dipartimento di Astronomia* and with the *Consiglio Nazionale delle Ricerche (CNR)*. Moreover, a large fraction of the staff is involved in international long-term projects (e.g. VIMOS, FLAMES, ISO-ELAIS, K20 redshift survey).

A very schematic summary of the Observatory budget in 2002 is presented (in Italian) in Appendix A, for administrative purposes.

This report has been prepared by **Alberto Cappi**, **Antonio De Blasi**, **Annibale D'Ercole**, **Luciana Federici**, **Monica Marra**, **Roberto Merighi**, **Livia Origlia**, **Gianluigi Parmeggiani**, **Giovanna Stirpe**, **Monica Tosi** and **Valentina Zitelli**.

Flavio Fusi Pecci

(Director)

Osservatorio Astronomico di Bologna: 2002

- *Director:* Flavio Fusi Pecci
- *Deputy Director:* Monica Tosi
- *Board:* Flavio Fusi Pecci (chair), Sandro Bardelli, Michele Bellazzini, Bruno Marano, Renzo Sancisi, Franco Tinti, Valentina Zitelli.

Staff

- *Scientific Staff:* Bardelli, Sandro; Bedogni, Roberto; Bellazzini, Michele; Bonifazi, Angelo; Bragaglia, Angela; Cacciari, Carla; Cappi, Alberto; Ciliegi, Paolo; Ciotti, Luca (until September 30, 2002); Clementini, Gisella; Comastri, Andrea; D'Amico, Nicolò (until May 31, 2002); Delpino, Federico; D'Ercole, Annibale; De Ruiter, Hans; Federici, Luciana; Ferraro, Francesco R.(until September 30, 2002); Fusi Pecci, Flavio; Greggio, Laura (until August 31, 2002); Londrillo, Pasquale; Merighi, Roberto; Mignoli, Marco; Origlia, Livia; Parmeggiani, Gianluigi; Pozzetti, Lucia; Sancisi, Renzo; Stanghellini, Letizia; Stirpe, Giovanna; Tosi, Monica; Zamorani, Gianni; Zitelli, Valentina; Zucca, Elena
- *Computer Centre:* Di Luca, Roberto; Gatti, Michele; Lolli, Marco; Madama, Guido; Montegriffo, Paolo; Policastro, Rocco
- *Laboratory:* Bregoli, Giovanni; Ciattaglia, Costantino; Innocenti, Giancarlo;
- *Technical Services:* Tinti, Franco; Ravaglia, Maurizio
- *Loiano Staff:* Bernabei, Stefano; Bruni, Ivan; De Blasi, Antonio; Gualandi, Roberto; Mezzini, Rino; Muzi, Ivo; Salomoni, Paolo;
- *Administration:* Greganti, Andrea; Abicca, Renata (since February 18, 2002); Caiulo, Alessandro (since September 16, 2002); Diodato, Olga; Guizzardi, Clara (until February 28, 2002); Leonardi, Laura (until February 28, 2002); Mazzone, Filomena (until August, 31 28, 2002); Orlandi, Marco; Pavan, Claudia (since June 3, 2002); Piccioni, Annalia; Polastri Tiziana: Venturini, Adele

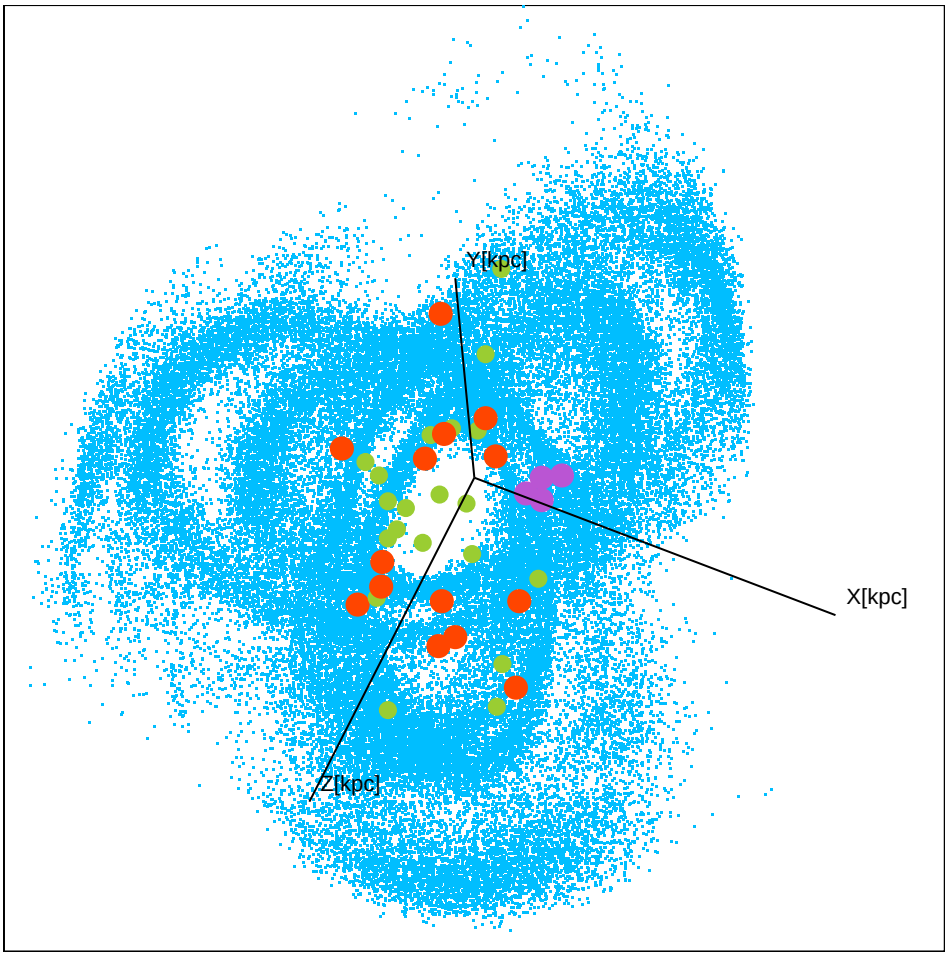
- *Library:* Marra, Monica Alboresi, Katia (ext. contract)
- *Reception:* Caputo, Silvana; Iuso, Annalisa;

PhD, fellows and contracts:

- *PhD students with OAB supervisors:* Angeretti Luca; Baldacci Lara; Brusa, Marcella; Monaco, Lorenzo; Nipoti, Carlo; Pancino, Elena; Ranalli, Piero; Sabbi Elena
- *Post-doc:* Fraternali Filippo; Lanzoni, Barbara; Possenti, Andrea; Pozzi Francesca;
- *Fellows and contracts:* Angeretti Luca; Calabrese Emanuela; Galleti, Silvia; Giacintucci Simona; Maio Marcella; Marcolini Andrea; Rossetti, Emanuel; Sollima Antonio; Valenti Elena

Contents

1 Stars and Stellar Populations



The figure presents a 3-D view of the Sgr Stream as modeled by the N-body simulation by Ibata & Lewis 1998. The large violet dots are the globular clusters that still reside in the main body of Sgr, the large red dots are the Galactic Halo globulars that lie in regions of the phase-space also reached by the Sgr stream, green points are the remaining Galactic globulars with $R_{GC} > 10$ kpc. (Bellazzini, Ferraro & Ibata (2003)

People involved at OAB:

- *Scientific staff:* M. Bellazzini, A. Bonifazi, A. Bragaglia, C. Cacciari, G. Clementini, N. D'Amico, L. Federici, F.R. Ferraro, F. Fusi Pecci, L. Greggio, L. Origlia, L. Stanghellini, M. Tosi;
- *Technical staff:* M. Lolli, P. Montegriffo;
- *Fellows:* L. Baldacci, S. Galleti, M. Maio, L. Monaco, A. Possenti, E.Valenti.

The evolution of stars and stellar systems is a very active research field of the OAB since its foundation. The interests range from evolution of galaxies to galactic and extragalactic globular clusters systems, from binaries to variable stars, from pulsars to LMXBs, covering the whole range of astronomical wavelengths.

The present description of the activity in the year 2002 has been organized in a few main sections to provide a very general overview: 1. The Galaxy, 2. Globular clusters, 3. Nearby Galaxies, 4. Pulsating Variable stars, 5. Eclipsing binaries, 6. Planetary Nebulae, 7. Pulsars.

1.1 The Galaxy

1.1.1 Chemical evolution models

People involved at OAB: Tosi.

Models of Galactic chemical evolution are nowadays able to reproduce the vast majority of the observed characteristics of our Galaxy. There are, however, a number of open questions on the evolution of the Galaxy, which still require further studies (e.g. Tosi 2002). Some of these issues are being examined in detail at the Bologna Observatory. In 2002, we have proceeded in the effort of accurately analysing the feedback between stellar nucleosynthesis and chemical evolution, the evolution of the abundance gradients and the impact of Galactic chemical evolution models on cosmology. To this aim new models for D, ^{3}He, ^{4}He, ^{12}C, ^{13}C, ^{14}N, ^{16}O, ^{17}O, ^{18}O, ^{20}Ne, ^{22}Ne have been computed and compared with the available data, adopting all the most recent and reliable stellar yields.

A collaboration exists with the International Space Science Institute in Berne (Switzerland) to study all the aspects of stellar and

galactic evolution affecting the abundances of the light elements. All the Galactic chemical evolution models able to reproduce the largest set of observational constraints have shown that the primordial abundance of D and ^3He must have been fairly low. This implies that the baryon/photon ratio was fairly high during the Big Bang, a result emphasized by the MAXIMA and BOOMERANG, and most recently WMAP, experiments on the cosmic microwave background. Our group, in collaboration with Galli and Palla (Arcetri Obs.), has been particularly active in this field and has been the first in reaching these results. Spectra of Planetary Nebulae acquired with HST-STIS have allowed us (Palla et al. 2002) to put new stricter constraints on the still puzzling evolution of ^3He, by confirming the interrelation between ^3He and $^{12}C/^{13}C$ production and depletion in low mass stars.

1.1.2 Open clusters as tracers of the evolution of the abundance gradients.

People involved at OAB: Bonifazi, Bragaglia, Tosi.

Open clusters (OC's) are excellent tools to understand the evolution of the disk of our Galaxy from both the chemical and structural points of view. Many of the existing chemical evolution models are able to reproduce well the present-day situation, but differ significantly in the "history" of the chemical enrichment (hence in the involved processes). In particular, they differ in the predictions for the evolution of the abundance gradients: does the gradient slope steepen or flatten with time? From the OC's we can extract fundamental information, since they can be used to describe the run of the various elemental abundances at different ages.

In order to study in more detail the metallicity and age distribution with galactocentric distance, we are analyzing with great accuracy a large sample of open clusters (our goal is to have at least 30 OC's) at various galactic locations and covering a wide range in age and metallicity. Age, distance modulus, reddening and approximate metallicity of the clusters are derived from their Color-Magnitude Diagrams (CMDs) using the synthetic CMD technique and further constrained by the observed luminosity functions. Precise and homogeneous elemental abundances are determined from high resolution spectroscopy.

During 2002, we have completed the interpretation of Cr110 in terms of evolutionary parameters (Bragaglia & Tosi 2003) and pro-

ceeded in that of Be 22, Be 29, NGC 4815 and NGC 6939.

Up to now only about 25 % of the ~80 old OC's have ever been studied with high resolution spectroscopy, and only a handful have abundances of elements other than iron. To widen the sample, we have obtained high-res spectra of red clump stars in a dozen of OC's, with FEROS@1.5m ESO, SARG@TNG, and UVES@VLT: analysis is under way for several clusters (Bragaglia et al. 2003; Carretta et al. 2003). Preparatory work for FLAMES@VLT GTO observations, due in 2003-2004, has been completed in 2002.

This research is in collaboration with Carretta and Gratton (Padova Obs.), Marconi and Andreuzzi (Roma Obs.).

1.1.3 Field Blue Horizontal Branch (BHB) stars and RR Lyrae as tracers of the galactic halo

People involved at OAB: Bragaglia, Cacciari.

The field BHB stars, along with the RR Lyrae variables and the carbon stars, are excellent tracers of the galactic halo stellar population. A detailed knowledge of their chemical and dynamical characteristics is therefore essential to understand how the Galaxy formed (e.g., hierarchical accretion/merging processes).

The questions of whether the high galactic halo is in retrograde rotation and how the velocity dispersion and flattening of the halo vary with height above the galactic plane are still controversial. They could be settled by studying halo stars nearer than about 10 kpc. In collaboration with Kinman (NOAO), Buzzoni (TNG) and Spagna (OATO) we are studying a sample of about 150 BHB and RR Lyrae stars near the North Galactic Pole by means of radial velocities and GSC-II proper motions for which we were granted a GSC-II pilot-program. Furthermore, metallicities are estimated using the ΔS method.

Photometric and spectroscopic data were collected during the last years; in particular spectra were collected in spring 2001 and 2002 (SARG@TNG, LRS@TNG), and one more run is due in spring 2003. Results on the space motions based on about half of our data show that our sample is distinctly retrograde (Kinman et al. 2003, Cacciari et al. 2003).

1.1.4 Resolved stars in the Galactic Bulge

People involved at OAB: Greggio

The study of the CMD of resolved stars in composite stellar populations allows us to derive detailed information on the age and metallicity of the system. Such a study has been conducted for a wide field in the Bulge of the MW, based on ESO (WFI@2.2m, and SOFI@NTT) optical and infrared data. The interpretation of the observed CMDs has been performed with theoretical simulations. This investigation shows that the stars in the Galactic Bulge are old ($\sim$ 10 Gyr), and are distributed over a wide metallicity range. The peak of the distribution occurs at approximately solar metallicity. This study confirms previous suggestions, and puts the conclusions on a more robust basis.

This work has been done in collaboration with people from various institutes: M. Zoccali (PI), A. Renzini, I. Saviane, M. Rejkuba (ESO); S. Cassisi (INAF,OAT); S. Ortolani (Dip. Astron. PD); M. Rich (UCLA); B. Barbuy (Univ. of Sao Paulo, Brazil); E. Bica (Univ. of Porto Alegre, Brazil).

1.2 Globular Clusters

1.2.1 Observational tests of theoretical stellar models

People involved at OAB: Bellazzini, D'Amico, Ferraro, Fusi Pecci, Monaco, Origlia, Possenti

Stellar evolutionary models are often used to derive relevant properties of globular star clusters and galaxies, such as their age and metal content. The Luminosity Function of the stellar sequences in the CMDs, from the MS Turn Off (TO) up to the termination of the Asymptotic Giant Branch (AGB), has been recognized to be the most powerful tool for testing stellar evolutionary models (in particular the accuracy of the input physics, the reliability of canonical assumptions, etc.).

A fully fruitful test requires that the observations be a) *complete*, b) *statistically significant*, and c) *accurate and adequate* for each specific evolutionary sequence. Point (a) means that virtually all the stars in a given area of the cluster are measured down to a given magnitude level, and that reliable corrections for incompleteness can be applied below that level. Point (b) means that observations should cover most of the cluster extension. Point (c) requires infrared observations to measure

the cool RGB stars and UV observations to properly study the blue sequences as the Horizontal Branch and the Blue Stragglers.

In this scenario the following main sub-projects represent a coordinated attack to the problem, in collaboration with Sabbi (Dip. Astr. BO), Rood (University of Virginia, USA), Sills (McMaster University, Canada) and Catelan (Pontificia Universidad Catolica, Chile).

(a) Mass loss along the Red Giant Branch

Mass loss is a crucial parameter in any stellar evolution modeling. The late evolutionary stages of low– and intermediate–mass giant stars are strongly influenced by mass loss processes. Yet, our lack of empirical estimates on mass loss in low-mass RGB and AGB stars remains one of the most serious stumbling blocks for a comprehensive understanding of stellar evolution. In Galactic Globular Clusters (GGCs), theoretical models of HB and RGB stars imply that RGB stars *must* lose $\sim 0.2\,M_\odot$ prior to the HB phase; an additional $\sim 0.1\,M_\odot$ is then expected to be lost on the AGB, before the star evolves down to the white dwarf cooling curve. With the goal of studying the mass loss during the RGB evolutionary stage, a major result has been obtained in this framework. A deep survey of the very central regions of six massive globular clusters has been performed using ISOCAM in the 10 μm spectral region (Origlia et al. 2002, ApJ, 571, 458). A significant sample of bright giants have an ISOCAM counterpart but only $< 20\%$ of them have a strong mid-infrared excess indicative of dusty circumstellar envelopes (see Fig. 1). From a combined physical and statistical analysis we derived mass loss rates and frequency. We find that *i)* significant mass loss (at rates in the range $10^{-7} < dM/dt < 10^{-6} M_\odot\,\mathrm{yr}^{-1}$) occurs only at the very end of the RGB evolutionary stage and is episodic, *ii)* the modulation timescales should be shorter than 1 million years, and *iii)* mass loss occurrence does not show a crucial dependence on the cluster metallicity. A follow-up program using the NASA Space InfraRed Telescope Facility (SIRTF) is under preparation.

(b) The HB morphology

The HB morphology represents a sort of *magnifier* of the mass-loss process occurring along the RGB. In this respect, we have published in the last years a number of interesting results (see Ferraro et al. 1999, Catelan, Ferraro & Rood 2001). This year we presented a new interesting case: M75 (Catelan et al. 2002). This cluster possesses a bimodal HB bearing, striking resemblance to the well-known case

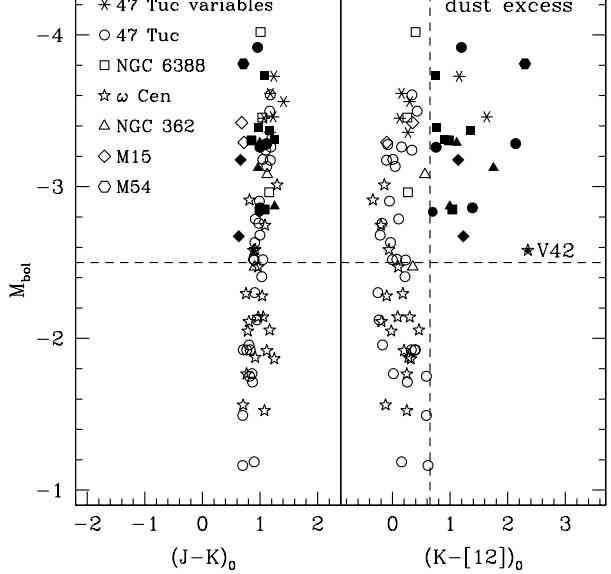


Figure 1: $M_{\rm bol}$, $(J-K)_0$ (left panel) and $M_{\rm bol}$, $(K-[12])_0$ (right panel) de-reddened color–magnitude diagrams down to a bolometric magnitude $M_{\rm bol} \leq -1.0$ of the ISOCAM point sources detected in the observed globular clusters. Sources with $(K-[12])_0 \geq 0.65$ are classified as sources with significant dust excess and are marked with filled symbols. The horizontal, dashed line at $M_{\rm bol} = -2.5$ marks the photometric threshold in the most distant clusters. The vertical, dashed line in the right panel marks the border between where 12 μm emission is dominated by the stellar photosphere or by circumstellar dust. The position of the V42 long period variable of ω Cen is also marked (from Origlia et al. 2002).

of NGC 1851. In addition, we detect a third, smaller grouping of stars on the M75 blue tail, separated from the bulk of the blue HB stars by a gap spanning about 0.5 mag in V. Such a group of stars may correspond to the upper part of a very extended, though thinly populated, blue tail. Thus M75 appears to have a trimodal HB.

(c) Link between stellar populations and dynamics in GGCs

Many new results are now supporting the claim that dynamical evolution of GGCs can affect their stellar populations. Schematically, both the integrated cluster colors and the properties of individual objects confirm the existence of dynamically induced variations in the evolution of many cluster members.

In this scenario, we have started a long term project which aims at using GGCs as a laboratory to study the impact of the (internal) environmental and (external) dynamical effects on the evolution of the cluster stellar population. We obtained UV-HST observations and we are also using UV data retrieved from the HST archive.

There are two main results this year:

NGC6752: by combining WFPC2-HST and ground based Wide Field images we constructed the most extended radial density and brightness profile for this cluster, including, for the first time, detailed star counts in the very inner region (Ferraro et al. 2003). Both the density and the brightness profile of the central region have been found to significantly deviate from *standard* King model, and are compatible with the hypothesis that NGC 6752 is experiencing a post-core collapse **bounce**.

BSS population in the core of 6 GGCs: The central regions of six Galactic Globular Clusters (GGCs) (M3, M80, M10, M13, M92 and NGC 288) have been imaged using *HST-WFPC2* and the ultraviolet (UV) filters (F255W, F336W). The selected sample of clusters covers a large range in both central density ($\log \rho_0$) and metallicity ([Fe/H]). We performed a direct cluster-to-cluster comparison of the Blue Straggler Stars (BSS) population as selected from $(m_{255}, m_{255} - m_{336})$ CMDs. We found the specific frequency of BSS varies greatly from cluster to cluster. The most interesting result is that the two clusters in our sample with the largest BSS specific frequency, namely NGC 288 and M80, have the lowest and the highest central density, respectively. This evidence together with the predictions of theoretical collisional models suggests that both stellar interactions in high density cluster cores and at least one other alternative channel operating in low density GGCs play an important role in the production of BSS. We also note a possible connection between HB morphology and the BSS luminosity function in these six clusters.

1.2.2 Main Sequence Fitting Distances and absolute ages of Galactic globular clusters

People involved at OAB: Bragaglia, Clementini, Fusi Pecci

Extensively applied in the eighties although affected by rather large error bars (± 0.25 mag in distances and ± 4 Gyr in ages) the GC Main Sequence Fitting technique derives distance from the comparison of

the GC Main Sequence to a suitable "template" formed by metal-poor subdwarfs in the solar neighborhood, whose distances are accurately measured via trigonometric parallaxes. This method has been substantially relived by the release of the Hipparcos trigonometric parallax catalogue in June 1997.

The Hipparcos based MSF technique has produced a "stretching" of the GC distances which definitely favors the *long astronomical distance scale*, and, in turn, the derivation of Galactic GCs *younger ages* by 2-3 Gyrs (Carretta et al. 2000, and references therein).

An ESO Large Programme (see Section 1.2.4) has been carried out in 2000 to 2002 to reduce the residual uncertainty in the MSF distances to about ± 0.07 mag (i.e., dominated by the parallax error) and the corresponding errors in the GC ages to ± 1 Gyr, by addressing these effects. The abundance analysis of the NGC 6752, NGC 6397 and 47 Tuc stellar spectra has demonstrated that in these clusters the [Fe/H] values obtained for the TO-stars agree perfectly (within a few per cents) with that obtained for stars at the base of the RGB (Gratton et al. 2001). Moreover, GC metallicities are now on the same scale of field stars, eliminating this source of uncertainty of the MSF distances (Gratton et al. 2003). Finally, the use of a reddening scale homogeneously derived for field and cluster dwarfs from $B-V$ and $b-y$ colours has allowed us to cut down to ~ 0.04 mag the error contribution due to reddening scale. The final error on GC distances is ± 0.06, and in ages ± 1.1 Gyr. From these 3 Galactic GCs, the age of the oldest globulars in our Galaxy is $13.7 \pm 0.8 \pm 0.6$ Gyr (random and systematic errors: Gratton et al., in preparation), fully compatible with the very recent determination of the age of the Universe by WMAP. New observing time has been requested to ESO in period 72 to extend the number of clusters and increase the statistical significance of these results. This work is in collaboration with Carretta, Gratton (Padova Obs.), Grundahl (Aarhus Univ., DK).

1.2.3 ω Centauri

People involved at OAB: Bellazzini, Ferraro, Origlia

ω Centauri is the largest ($M = 4 \times 10^6 M_\odot$, Pryor & Meylan 1993), brightest cluster in the Galactic Halo, and it is the *only* GC which shows indisputed variations in the chemical content of its stars. From this point of view, ω Cen could be considered a *bridge* system between

the genuine globulars, which are unable to retain the gas ejected by their former massive stars, and the dwarf galaxies, which are the least massive self-enriching stellar systems known. We are currently carrying on a long-term project, aimed at performing a detailed photometric and spectroscopic study of the stellar population in ω Cen, which is one of the major projects undertaken at the OAB.

The first surprising result was the discovery of a distinct, anomalous RGB (RGB-a), significantly redder than the bulk of the normal RGB stars (Pancino et al. 2000). Prompted by this result, we have then carried out a vast spectroscopic and photometric observational campaign, using the current generation of instruments available at ESO, on board of HST and at other international telescopes. A spectroscopic screening of the multi-populations of red giants in ω Cen has been carried out by means of high resolution echelle spectra with UVES@VLT and medium-resolution infrared spectra with SOFI@NTT of more than 40 stars. Two main results have been obtained this year. First, the metallicity of the RGB-a has been determined for the first time ($< [Fe/H] >= -0.62 \pm 0.06$), demonstrating that the RGB-a stars are the most metal-rich component of the whole RGB distribution (Pancino et al. 2002). Second, the RGB-a has a lower α-enhancement ([α/Fe]$\simeq +0.1$) with respect to the other red giants in ω Cen (Pancino et al. 2002, Origlia et al. 2003). Supported by the higher [Cu/Fe] abundance for the RGB-a stars, this could be the first indication that SNe type Ia enriched the medium from which these stars have formed, while all the other stars in the cluster show the typical α-enhancement ([α/Fe]$\simeq +0.3$) of halo and globular cluster stars. This can be explained either by *(i)* a self-enrichment scenario, implying a more continuum star formation process as well as some age spread or by *(ii)* a merging scenario in which the main body of the cluster accreted the metal-rich sub-system. The photometric database already published in Pancino et al. (2000) has also been further exploited. The spatial distribution of the different sub-populations (metal-poor, metal-intermediate and RGB-a) has been investigated (Pancino et al. 2003), revealing three main features: *(i)* the RGB-a and intermediate populations are elongated perpendicularly with respect to the main, metal-poor component; *(ii)* the RGB-a is much more centrally concentrated than the other sub-populations and *(iii)* the RGB-a centroid is significantly displaced (by $\sim 1'$) with respect to the main cluster component. In this respect, the most surprising result is the discovery of proper motion peculiarities within ω Cen (Ferraro et al. 2002).

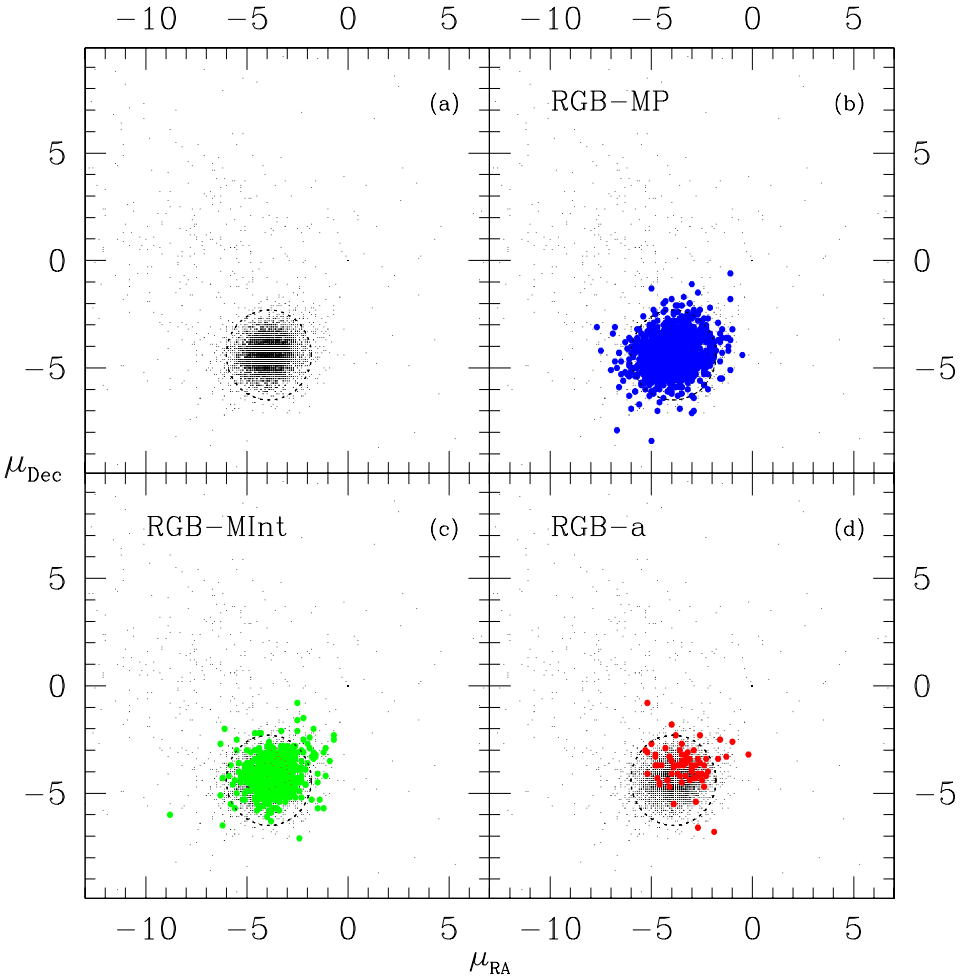


Figure 2: Proper motion plane (μ_{RA}, μ_{Dec}) for stars in ω Cen. *Panel a)* All stars in the Van Leween's catalog with accurate proper motion measurements are plotted (*small dots*). *Panels b,c,d)* Stars belonging to the three RGB sub-populations, namely MP (*(b)*, MInt (*(c)* and RGB-a (*(d)* are marked with large, filled dots. The dashed circle represents the region where stars with a membership probability larger than 99% lie. As can be seen, while the RGB-MP and RGB-MInt proper motion centroids appear to agree with the centroid of the whole cluster population, the RGB-a centroid is significantly displaced (from Ferraro et al. 2002).

By coupling our wide field photometric catalog with the proper motion catalog recently published by van Leeuwen (2000), we were able to probe that the RGB-a stars has a bulk proper motion with respect to the main cluster motion centroid, amounting to $\mid \mu \mid = 0.8$ mas yr^{-1} (see Fig. 2). These works suggest that the RGB-a could have a different dynamical history with respect to the other populations in ω Cen, and that it still maintains its own peculiar dynamical identity within the cluster. A crucial point to discriminate among the self-enrichment and merging scenarios, concerns the relative ages of the various sub-populations. In order to investigate whether an age spread exists among the various sub-components, we are planning to obtain: *(a)* high resolution UVES@VLT spectroscopy of a sample of Sub-Giant Branch (SGB) [6 SGB stars have been already observed in April 2002] and *(b)* high precision FORS@VLT photometry of the central regions of the clusters [the observations have been performed in 2001, Period 68].

This research is in collaboration with Pancino (Dip. Astr. BO), Sollima (Dip. Astr. BO), Pasquini (ESO), and many more.

1.2.4 Abundances in Globular Clusters

(a) Halo Globular Clusters

Stars in each GC, with the exception of ω Cen and possibly of M 22, have generally very homogeneous composition as far as Iron-peak and α-elements are considered, while abundances of lighter elements (from C to Al) show a complex, not yet fully explained, pattern (i.e., CN-CH band strength anti-correlation, Na-O anti-correlation, etc.) not seen in field stars. Proposed explanations have varied from an *in situ* mechanism (e.g., very deep mixing of nuclear-processed material) to an external source of material (either primordial proto-cluster gas or processed material from a polluting companion). Both explanations could work for RGB stars, while main sequence stars require the latter.

(i) Abundances along the RGB
People involved at OAB: Bragaglia, Bellazzini, Ferraro, Monaco.

In the framework of a large programme in collaboration with researchers in Padova and Roma, we aim at deriving accurate abundances for a representative number of giants in several globular clus-

ters by using the multiplex FLAMES facility at the VLT (UVES + GIRAFFE). Our first target has been M 22, since there are reasons to believe that M 22 could have a significant dispersion in metallicity. Even though the effect is going to be smaller than in ω Cen, the detection of such a spread in metallicity would indicate that at least another globular cluster in our Galaxy has experienced the same kind of chemical enrichment history as ω Cen. Such a discovery would be of invaluable help in understanding the mechanism of formation of ω Cen and would shed light on the processes that are at the basis of the halo formation and evolution. We have already secured a set of high resolution UVES spectra for 8 giants in this cluster during an observing run in April 2002, and the data analysis is currently under way.

This work is in collaboration with Pancino (Dip. Astr. BO).

(ii) Abundances of Main Sequence Turn-Off stars
People involved at OAB: Bragaglia, Clementini

Only recently stars near the main sequence Turn-Off (MSTO) have become observable at the necessary S/N and resolution. As part of an ESO Large Programme (PI Gratton), we have acquired with UVES@VLT in 2000, 2001 and 2002 (30 nights in total) high resolution spectra (R$\geq$ 40000) of a large number of stars at the main sequence turn-off and at the base of the sub-giant branch in NGC 6752, NGC 6397, 47 Tuc, NGC 6809 and NGC 7099. Abundance analysis for Fe, Li, and light elements has been completed or is well advanced for the first three clusters (e.g., Gratton et al. 2001, Bonifacio et al. 2002, Carretta et al. in preparation). Further studies on the heavy elements and on the other GCs in our sample are presently being carried out.

The [Fe/H] abundances determined for NGC 6752, NGC 6397 and 47 Tuc, (identical for MSTO and subgiant stars: Gratton et al. 2001, 2003) have removed one of the possible major sources of uncertainty claimed to affect the MSF distances (see Section 1.2.2). Our analysis has also put a strong constraint on sedimentation.

Furthermore, we have found presence of O-Na and Mg-Al anticorrelations in MSTO stars in NGC 6752, (but not in NGC 6397), hence ruling out internal mixing as the cause of such anomalies. Finally, we have studied Li abundances, and found that MSTO stars in NGC 6397 (and O-rich ones in NGC 6752) have Li abundances very close

to the Spite plateau value, supporting the primordial origin of lithium in metal-poor stars (Bonifacio et al. 2002).

This work is in collaboration with Gratton and Carretta (Padova Obs.), Bonifacio (Trieste Obs.), Pasquini (ESO), and many more (see list of publications). New ESO observing time has been requested at ESO in period 72, to extend the analysis to a larger number of clusters.

(b) Bulge Globular Clusters

(i) Abundances from resolved stars
People involved at OAB: Ferraro, Origlia.

Bulge GCs are a fundamental stellar population of our Galaxy and it is most interesting to compare their detailed compositions with the Galactic bulge field population (McWilliam & Rich 1994). For many of these bulge clusters, foreground extinction is so large as to preclude any photometric and spectroscopic optical study. In the last few years we have undertaken a long term project devoted to study a representative sample of Bulge globular clusters in the infrared. Using the IRAC2 infrared camera at the ESO-MPI 2.2m telescope, the SOFI medium-resolution imager/spectrograph at ESO/NTT and the NIRSPEC high-resolution echelle spectrograph at Keck II, we have secured high quality infrared photometry and spectra of 10 globular clusters in the bulge. Other observing time at KeckII has been assigned to this program in the next months. The photometric and the spectral synthesis analysis is in progress. For Liller 1 and NGC 6553 Origlia, Rich & Castro (2002) find [Fe/H] $= -0.3 \pm 0.2$ and [O/H] $= +0.3 \pm 0.1$ (from the OH lines) for the giants in both clusters. We measure strong lines for the α-elements Mg, Ca, and Si, and a general $[\alpha/\mathrm{Fe}] = +0.3 \pm 0.2$ dex has been derived. The composition of the clusters is similar to that of bulge field stars and it is consistent with a scenario in which the clusters formed early, with rapid enrichment.

This reasearch is in collaboration with Rich (UCLA, USA), and E. Valenti (Dip. Astr. BO).

(ii) Abundances from integrated light
People involved at OAB: Greggio.

Spectrophotometric indices measured on the integrated spectra of stellar populations can be used to trace the element abundances of the stars. For example, the evidence that the stellar populations in elliptical galaxies are characterized by supersolar α to Fe abundance

ratios comes from the measurement of their Magnesium and Iron indices, compared to the predictions of models constructed with solar abundance ratios. This conclusion is however based on theoretical models which need calibration versus the relevant observables. In this framework we have collected and analyzed the spectra (ESO, 1.5m) of a sample of 12 GCs in the galactic Bulge, spanning a wide range in metallicity, up to the solar value. The two most metal rich clusters have a spectroscopically confirmed α overabundance, and there are indications of α enhancement also for the other clusters. It is found that the clusters' Magnesium and Iron indices do deviate from the model sequence with solar abundance ratio in the same direction as the Ellipticals. This finding yields empirical support to the claimed α to Fe overabundance in these galaxies. We carried out a thorough investigation of the models, checking their sensitivity to the input parameters, and found that the α overabundance solution is hardly avoidable. For a correct calibration, then, the effect of the abundance ratios on the integrated indices needs to be taken into account in the models.

This work was done in collaboration with Putzia and Saglia (Univ. of Munich), Kissler-Patig and Renzini (ESO), Maraston (MPE-Munich), Ortolani (Univ. of Padova).

1.2.5 The Globular Cluster System of the Andromeda galaxy

People involved at OAB: Bellazzini, Cacciari, Federici, Fusi Pecci, Parmeggiani.

The M31 globular cluster system is the largest sample of GC's found in the Local Group. It is little affected by reddening, at least for a large sub-set of outer objects, and sufficiently close to allow individual stellar observations. M31 offers the unique opportunity of studying the GC system of a spiral galaxy that is similar to (albeit larger than) the Milky Way in very good detail and without some of the limitations that affect the Galactic GC system. The OAB M31 team, in collaboration with scientists of other italian and foreign institutions, is studying the globular clusters in M31 and other galaxies of the Local Group using both photometry (from the UV to the IR bands) and spectroscopy. The scope of the program is to utilize the globular cluster systems to improve our knowledge on the mass, dynamics and chemical evolution of the parent galaxies, and as secondary distance indicators and stellar population templates.

A large sample of confirmed GCs in M31 has been observed with HST with the aim of comparing the characteristics of these stellar populations with those of the Milky Way, and to measure the dependence of the HB luminosity on metallicity for a sample of clusters at the same distance. The CMDs obtained from WFPC2/HST observations for a total sample of 19 GCs in M31 [in collaboration with Rich (UCLA)] reach at least one magnitude fainter than the Horizontal Branch level. Our analysis shows that M31 globular clusters are very similar to the Milky Way globular clusters, and that there is no strong indication of an intemediate age cluster population analogous to those found (for example) in the SMC. These preliminary results have been presented at international conferences, and the papers discussing the various physical and structural characteristics of the clusters are in preparation.

Finally, we are preparing a comprehensive, homogeneous revised catalog of all morphological, spectrophotometric, astrometric and kinematic data for all confirmed and candidate clusters in M31.

1.2.6 Globular Cluster Systems in external galaxies

People involved at OAB: Cacciari, Federici, Galleti

Spectroscopy of extragalactic globular clusters provides a wealth of information on the formation and evolution of their parent galaxies. The aim of this project is to study the globular cluster systems in galaxies of different morphological types (E/S0 and spirals), in order to investigate the existence of stellar sub-populations with different chemical and/or dynamical characteristics, to estimate the galaxy mass and to probe the existence of a dark matter halo.

In this scenario, we have obtained NTT/EMMI multi-slit spectroscopy for 40 known globular clusters in the inner regions of NGC5128, the nearest giant elliptical galaxy, and deep MOS spectroscopy using FORS1 at the VLT of about 75 globular clusters candidates in the Sombrero galaxy (NGC4594), an early-type spiral with a dominant bulge. The results from the NTT observations combined with previous results from multifiber spectroscopy of clusters in the halo show that most of the clusters in NGC5128 are similar in age to the Galactic globulars, and moreover that their metallicity distribution is clearly bimodal, thus confirming the presence of two cluster populations.

The spectra of the globular clusters of NGC4594 have been com-

pletely reduced: fifty-seven candidates out to $\sim 40kpc$ have been confirmed to be bona-fide globular clusters. The metallicities, derived from absorption line indices, confirm a bimodal [Fe/H] distribution, in agreement with the results of the photometry (Moretti et al. 2003). The distribution was fitted with two gaussians peaking at $[Fe/H] \approx -1.7$ and $[Fe/H] \approx -0.7$, very similar to those of globular clusters in our Galaxy. Preliminary results have been presented by Held et al. (2003).

Since efficient spectroscopic observations require a previous identification of a sample of bona-fide globular cluster candidates, and in preparation for a systematic spectroscopic study at the VLT with FLAMES or VIMOS, we have undertaken a wide-field multicolor imaging survey of galaxies of different morphological types (E/S0) as far as the Virgo cluster: NGC 3115, NGC 4526, NGC 4406, NGC 253, NGC 5128, NGC 4594. For one of these galaxies, NGC 253, we have already analysed our 2.2m-WFI BVI images (FoV=33x34 arcmin) and identified about 400 globular cluster candidates that will be observed with VIMOS in autumn 2003 (Galleti et al. 2003). This number of candidates is much larger than the numbers found in all previous surveys of this galaxy, and even taking into account a significant degree of contamination it represents a major improvement over all previous studies. Wide field imaging (BVR) of NGC 4594 was taken with ESO/MPG 2.2m telescope. The sample of highly probable globular cluster candidates selected using color and shape criteria shows a bimodal color distribution, and will be observed with VIMOS during the period 71 in order to confirm its real nature.
This research is in collaboration with Held, Moretti (Padova Obs.) and Testa (Roma Obs.)

1.3 Nearby Galaxies

1.3.1 Magellanic Cloud clusters

People involved at OAB: Ferraro, Origlia

The spectral evolution of a Simple Stellar Population (SSP) and its most evident color glitches are ideal *clocks* for dating primeval galaxies and deriving a suitable, empirical relation between look back time and redshift. Deriving the age of a stellar population implies: (1) the selection of a suitable clock (this requires an accurate time calibration

of *the stellar evolution*), (2) the actual reading of the age (this requires an accurate estimate of the global metallicity of the SSP, since the stellar clock is extremely sensitive to the chemical composition – the so-called age/metallicity degeneracy.

The empirical calibration of the clock which settles the spectral evolution of SSPs and its readability are the primary goals of our project. The globular cluster system of the Magellanic Clouds (MC) provides a unique opportunity to investigate the integrated spectrophotometric behavior of stellar populations as a function of both age and chemical composition. We are tackling these major astrophysical objectives by means of a coordinated spectrophotometric survey on a representative sample of MC clusters, aimed at determining with great accuracy and in a homogeneous way their age, metallicity and overall integrated spectral properties. Our group secured high quality J,H,K photometry of 20 LMC clusters spanning the age range between $\sim$50 Myr and a few Gyr. Populous and complete near-infrared CMDs covering all the RGB extension have been obtained. The high quality and homogeneity of such an infrared database will provide the most accurate empirical determination of the occurrence of the so-called AGB and RGB phase transitions and their contribution to the cluster integrated light in each photometric infrared band–pass and in bolometric. These empirical estimates compared to those of the models will allow to calibrate the integrated magnitude and color glitches in terms of age.

The correct reading of the age from a SSP requires the accurate knowledge of the global metallicity. This major piece of information is still lacking, namely a self-consistent metallicity scale and a detailed description of the abundance patterns of MC clusters. In order to fill such a gap, we started a spectroscopic survey at medium-high resolution in the visual and in the infrared for a representative sample of MC clusters. Such high quality spectroscopic data coupled with the photometric database secured by our group over the last 10 years will allow to calibrate the *evolutionary clock*, a fundamental tool to trace the history of star formation and evolution of primordial galaxies.

This research is in collaboration with Testa (Roma Obs.), and Maraston (Sternwarte, München, Germany).

1.3.2 The accreted component of the Galactic Halo: The Sagittarius Dwarf Spheroidal

People involved at OAB: Bellazzini, Ferraro, Monaco.

There is now a growing body of observational evidences for an inhomogeneous Halo, where the tracks of the slow building up by hierarchical merging of sub-units should be still observable. The Sagittarius dwarf Spheroidal Galaxy (Sgr dSph; Ibata et al. 1994, Nature, 370, 194) is the most evident and striking example of a *real time* accretion event occurring in the Galactic Halo. The main body of Sgr dSph orbits well within the Galactic spheroidal ($R_{GC} \simeq$16 kpc) and shows clear signs of being accreted and disrupted by the Galactic tidal field. Thus, the Sgr dSph is (and has been) one of the major contributors to the stellar content of the whole Galactic Halo.

In this framework, we have started a large photometric survey of this disrupting dSph. At present we have assembled a catalogue comprising V,I photometry and accurate astrometry (to within ± 0.2 arcsec) for $\sim 500,000$ individual stars in a $1 \times 1\,\mathrm{deg}^2$ area centered on the globular cluster M 54, which coincides with the main density peak of the Sgr galaxy. Near-Infrared J,H,K magnitudes for many thousands of stars have been also obtained from the Point Source catalogue of the 2MASS survey. This large database will provide the basis for a detailed study of the chemical composition of Sgr stars to be performed with VLT-FLAMES, within the GTO program of the ITAL-FLAMES consortium. An observational programme to extend the survey to another $1 \times 1\,\mathrm{deg}^2$ field has been approved by ESO.

Meanwhile, the database allowed for the first identification of the RGB bump of the main population of the Sgr dSph (Monaco et al. 2002). This new observational constraint provided the basis for a much more robust characterization of such a population in terms of metallicity and age. It has been concluded that Sgr is dominated by a stellar population having $[M/H] \sim -0.4$ and age ~ 6 Gyr. This study gave the opportunity to reconcile spectroscopic and photometric metallicity estimates that now may be coherently understood within a self-consistent scenario. Detailed analysis of the whole stellar population and of the spatial structure of the galaxy are under way.

It is now established that the disruption of the Sgr dSph left a track of stars (thorned-apart from the original Sgr dSph) that forms a long-lived structure, following the past orbital path of the galaxy, i.e.

the Sgr Stream (Ibata et al. 2001, ApJ, 547, L133). We have started a program to search for possible relations between known globular clusters and the Sgr Stream. As a first important result we have found that the orbit of the Sgr galaxy is a preferential locus in the phase-space for the globular clusters in the range $10 \leq R_{GC} \leq 40$ kpc (Bellazzini, Ferraro & Ibata 2003). We have demonstrated that the observed phase-space clustering is statistically significant, thus indicating that Sgr has left behind in the Galactic halo not only a stream of stars but also some globular clusters. A first pilot search of Sgr Stream stars around candidate Stream clusters provided encouraging results and will be extended in the future. A photometric study of one of the most promising candidates (NGC 5634) has also been performed (Bellazzini, Ferraro & Ibata 2002).

This research is in collaboration with Pancino (Dip. Astr. BO), and with the Trieste Observatory's group (Bonifacio, Molaro, Zaggia) within the ITAL-FLAMES Consortium. The research on the Sagittarius Stream is carried on in collaboration with R. Ibata (Observatoire de Strasbourg).

1.3.3 Dwarf spheroidal galaxies

People involved at OAB: Bellazzini, Ferraro, Origlia

The Local Group (LG) of Galaxies is a unique laboratory to study the properties of the most common types of galaxies in the Universe. Moreover, it offers the opportunity to calibrate the luminosities of *standard candles* – such as Cepheids and RR Lyraes – which can be used to determine the extragalactic distance scale, hence the value of H_0 and the age of the Universe.

Our programme aimed at the revision of the distance scale of the Local Group, based on our new RGB tip calibration (Bellazzini, Ferraro & Pancino 2001), is proceeding. We obtained deep photometry for a number of dwarf galaxies and the results of a comparative study of the Ursa Minor and Draco dSph has been completed (Bellazzini et al. 2002). The most interesting result is the detection of a striking difference in the structure in these otherwise similar galaxies. In particular, UMi shows up significant sub-structures that may be interpreted as signature of strong tidal stress.

Our photometric survey of the evolved population of local dwarf galaxies lead to the discovery of the RGB bump in a number of dSph

galaxies (Sgr, Sex, UMi, Leo II). Such discoveries have opened a new line of research aimed at the interpretation of this observational feature in composite stellar populations, in order to obtain information on the early star formation histories of these galaxies from this new observational constraint (see Bellazzini 2003).

This research is in collaboration with Pancino (Dip. Astr. BO), Sabbi (Dip. Astr. BO), and Oliva (Arcetri/CGG).

1.3.4 Star formation histories in late–type dwarf galaxies

People involved at OAB: Greggio, Origlia, Tosi.

Late–type dwarf galaxies are playing an increasingly central role in understanding galaxy evolution, because their proximity allows one to examine in detail important issues, like the occurrence of galactic winds, the chemical enrichment of the interstellar and intergalactic media, the photometric evolution of galaxies. Besides, their low level of evolution, as implied by the low metallicity and the high gas content, makes these systems the most similar to primeval galaxies and, therefore, the most useful to infer the primordial galaxy conditions. Furthermore, they have been suggested to represent the building blocks of larger galaxies. Understanding how late-type dwarfs evolve and what were their conditions at early epochs is then crucial also for cosmological purposes. It is thus fundamental to derive the star formation history (SFH) in a number of representative systems of the major morphological sub-classes: blue compact galaxies, dwarf irregulars, giant irregulars (Tosi 2002). To this aim we are undertaking a long term project (in collaboration with Angeretti, Dip. Astr. BO, Annibali, Sissa, and Aloisi, Clampin, Leitherer and Nota, Baltimore, USA) to study, from deep and accurate photometric data (ESO-VLT and HST), the stellar populations of a number of dwarfs known to show evidence of galactic winds. So far we have sampled IZw18, NGC 1569 and NGC 1705. HST-ACS time has been allocated to observe SBS1415+437. The resolved stars allow us to derive the intensity as a function of time of the star formation activity and the IMF of these galaxies back to fairly old epochs with the method of synthetic CMDs pioneered by our group and amply tested and applied by the international community.

The procedure of deriving the SFH from synthetic CMDs is ultimately based on the relation between the mass of the stellar popula-

tions and the number of stars counted on the CMD. The connection between the total mass in stars and the star counts in various regions of the CMD has been investigated from a purely theoretical point of view (Greggio 2002), to the end of providing basic relations between the mass in stars and the stars' counts for stellar populations with an age spread. It is found that the bright portion of the CMD allows to recover the star formation history with a fair degree of detail up to look back times of approximately 0.3 Gyr. For older stellar populations, the counts in selected regions of the CMD (RGB, He burning clump, Bright AGB) make it possible to estimate the mass in stars within a factor of 3, for an adopted Initial Mass Function slope.

In 2002 we have completed the study of the SFH in NGC1705 from HST-WFPC2 and HST-Nicmos VIJH data. These data have allowed us to derive the galaxy distance with great accuracy from the red giant branch tip, and to show that this blue compact galaxy has a large fraction of old stars (hence has been strongly active also in remote epochs) and has a population age gradient, with decreasing age for decreasing galactocentric distance. We have applied the synthetic CMD method to concentric regions from the galaxy center to study their SFHs (Tosi et al 2002, Annibali et al. 2003) and found that the SF has been fairly continuous everywhere, but with significant ups and downs in the rate and with clear short quiescent intervals. Our study has let us discover that NGC1705 is experiencing now a new strong SF activity; hence, it should not be defined as a post-starburst, as it was before resolving its individual stars. Further studies on the U and B HST-WFPC2 data have been performed and will be completed soon, confirming the evolutionary scenario mentioned above.

The synthetic CMD method has been applied also to the HST-Nicmos data on NGC1569 (Angeretti et al., in preparation). This has let us derive the SFH at epochs older than those covered by optical data. We have thus found that this galaxy has been extremely active also in the past.

Since NGC1569 and NGC1705 are the only late-type dwarfs with clear observational evidence of galactic winds, in order to better understand this phenomenon and the chemo-dynamical evolution of these systems, we have organized at the Observatory an international meeting fully devoted to the issue of gas flows, inviting the most world-wide experts in the field. The meeting was held in Bologna in January 2002 and turned to be very successful, thanks to the informal atmosphere that favoured honest, through discussions between competitor groups

from all over the world (Europe, Russia, USA, Mexico, Japan, Australia).

Within the collaboration with Schulte-Ladbeck (Univ. of Pittsburg) and Hopp (Univ. of Munich), we have completed the analysis of HST data of Leo A and NGC 4214 (Drozdovky et al. 2002, Schulte-Ladbeck et al. 2002). In both cases we detect a considerable fraction of old stars, and a centrally concentrated young/ intermediate age component. These cases add to the numerous other examples of dwarf galaxies which experienced star formation since the very early epochs. The results are under publication on the Astronomical Journal

Numerical chemical evolution models have been computed (Recchi et al. 2002) for the blue compact galaxy IZw18, based on the SFHs derived by us (Aloisi et al. 1999) applying the synthetic CMD method to HST data. These new generation models take into account the effects of the supernovae explosions on the hydrodynamics of their interstellar medium and the possible onset of galactic winds. Analogous models will be applied in the future to NGC 1705 and the other late-type dwarfs analyzed with our method.

1.3.5 The Field Stellar Populations in M31

People involved at OAB: Bellazzini, Cacciari, Federici, Fusi Pecci.

The HST data that were used to study the GCs as primary targets allowed us also to investigate the surrounding fields, sampling the disc and the halo of M31 towards 16 different lines of sight. The CMDs thus obtained (Fig. 3) allowed us to estimate the metallicities by interpolating the colors of the RGB stars between template globular cluster giant branches of known metallicity. Metallicity distributions were derived for each field, showing the presence of a little and approximately constant fraction of metal-poor stars, and much larger fractions of metal-rich and very metal-rich stars whose relative contributions vary with position and seem to be correlated with the disk and/or with streams or substructures (Bellazzini et al. 2003).

1.4 Pulsating variable stars

Pulsating variable stars are fundamental tools to set the astronomical distance scale, and to sample different stellar populations in galaxies. Their periods, amplitudes, and shapes of the light curve are exquisitely

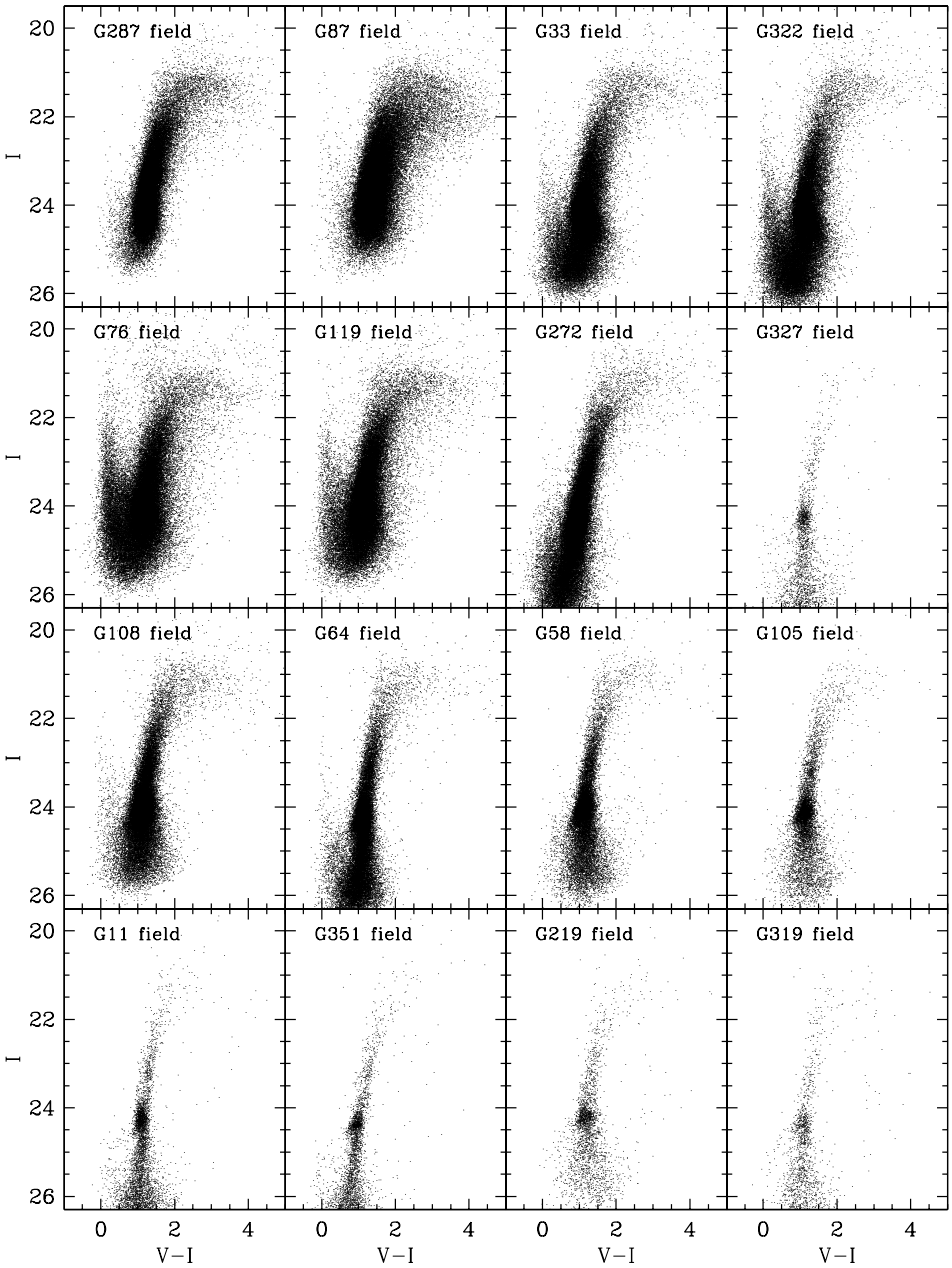


Figure 3: $(I, V-I)$ Color-Magnitude Diagrams obtained from HST/WFPC2 data for sixteen M31 fields. The diagrams are shown in order of increasing projected distance from the major axis of M31 (Bellazzini et al. 2003).

sensitive to the stellar structural parameters (mass, luminosity, effective temperature, chemical composition). Therefore pulsating stars represent a unique opportunity to probe the distance scale, the formation mechanisms and the chemical evolution of galaxies, through the study of the luminosity and luminosity-metallicity relation of the RR Lyrae stars; the Period-Luminosity (PL) and Period-Luminosity-Color (PLC) relations of Anomalous, Type II, and Dwarf Cepheids; the period distribution of the RR Lyrae variables, and the double-mode pulsators.

Population II variable stars and their role in establishing the astronomical distance scale have been a major field of study at the OAB since 1984 (e.g. Cacciari et al. 1987). A number of new projects have been started in more recent years (e.g. "The VSNG project", Clementini 2003, astro-ph/0303067), in collaboration with researchers of Padova, Napoli and Merate Observatories, to map out the variable star content in a number of Local Group (LG) galaxies of different morphological type.

RR Lyrae stars trace the oldest stellar component in galaxies and are the primary Population II distance indicators in the LG. Their absolute visual magnitude M_V(RR) sets the luminosity of the horizontal branch (HB) and its dependence on metal abundance, usally described as a linear relation: $M_V(RR)=\alpha\times$ [Fe/H] + β. The zeropoint of this relation constrains the GGC distances and absolute ages through the Turn-Off luminosity calibration, providing in turn a lower limit to the cosmic age. The slope gives clues on the GGC relative ages and on the time scale of Galactic halo formation and early evolution. There is now a growing consensus on a zero point β $\sim$0.6 at [Fe/H]=-1.5 (Cacciari & Clementini 2003, astro-ph/0301550) which supports the *long astronomical distance scale* (see Clementini et al. 2003). However, the slope α and its uniqueness are still a matter of debate, with literature values in the range from 0.30 mag/dex to 0.18-0.20 mag/dex (Cacciari 1999, Carretta et al. 2000) and empirical (Rey et al. 2000) and theoretical (Caputo et al. 2000) evidences for a non-linearity of the M_V(RR)-[Fe/H] relation for GGCs.

1.4.1 β from the Baade-Wesselink method

People involved at OAB: Cacciari, Clementini.

The zeropoint of the luminosity-metallicity relation of the Galactic

RR Lyrae stars is investigated using the Surface-Brightness and Infrared Flux versions (Cacciari et al. 1992) of the Baade-Wesselink (BW) method to determine the absolute luminosity of the RR Lyrae variables. We are testing the effects on the technique of the most recent model atmospheres with various approximations in the treatment of convection, different values of turbulent velocity and more complete and accurate opacity tables, as well as the use of the instantaneous gravity along the pulsation cycle (Cacciari et al. 2000). We are currently reducing the high resolution spectra and the IR (K-band) photometry obtained with SARG and ARNICA at the TNG, for a few RR Lyrae stars in M3. The accurate radial velocity and infrared light curves we are deriving will be used to apply the BW method directly on RR Lyraes in this very interesting GC.

1.4.2 α from metal abundances of RR Lyrae stars in the LMC and in Sculptor

People involved at OAB: Bragaglia, Clementini, Maio.

The slope of the luminosity-metallicity relation followed by RR Lyrae stars can be directly measured using a population of RR Lyrae variables all at the same distance, and spanning a suitable range in metal abundance. *RR Lyrae stars in external galaxies* play a key role in this respect, since they can be considered at the same distance from us, are numerous, and generally span large metallicity ranges. The slope of the luminosity-metallicity relation for RR Lyrae stars in the Large Magellanic Cloud (LMC) bar has been investigated in collaboration with Carretta, Gratton (Padova Obs.) and Di Fabrizio (TNG), using low resolution spectroscopy obtained with FORS1@VLT for a large sample of RR Lyrae stars in the bar of the LMC. These spectroscopic data have allowed us to measure metallicities accurate to $\sim$ 0.15-0.20 dex using a revised version of the ΔS index, Preston (1959; Gratton et al. in preparation) for a sample of about 100 RR Lyrae variables. The derived metal abundances range from -0.5 to -2.1 with an average value of [Fe/H]=-1.48 ± 0.03. Individual metallicities were combined with the high quality photometric data by Clementini et al. (2003) to determine the slope of the luminosity-metallicity relation of the LMC field RR Lyrae stars: ΔM_V(RR)/[Fe/H]=0.214$\pm$0.047. This mild slope is in very good agreement with the one obtained by recent results on the HB luminosity of GCs in M31, and with results from

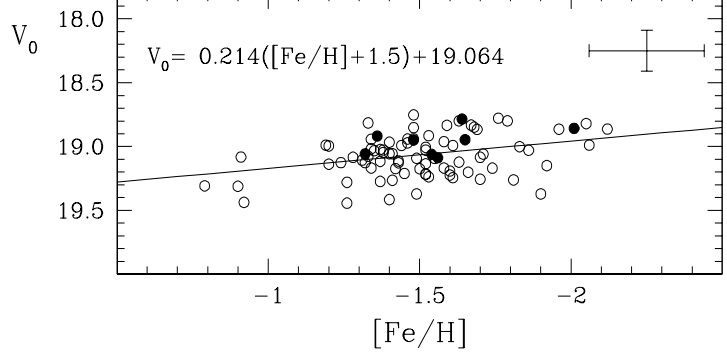


Figure 4: Luminosity-metallicity relation for field RR Lyrae stars in the LMC, from Clementini et al. (2003).

the BW analysis of MW field RR Lyrae stars (Fernley et al. 1998), implying that the same luminosity-metallicity relation for HB stars is valid in these three different environments, and that a significant age-metallicity dependence is likely to exist in the family of the GGCs. The luminosity-metallicity relation defined by the LMC field RR Lyrae stars is shown in Figure 4.

In the same observing run, spectra were also obtained for 350 LMC clump stars. They have been fully reduced and are currently being analyzed. The metal distribution of the LMC red clump stars in our sample will be used to address the controversial issue of the red clump absolute magnitude dependence on chemical composition, which so far limits its use as a distance indicator.

New observing time (10 hours VLT+FORS2) has been recently assigned to obtain multi-slit spectroscopy of about 220 RR Lyrae stars in the dwarf spheroidal galaxy Sculptor. The comparison with our recent results for the LMC will provide a clearcut proof on whether the slope of the luminosity-metallicity relation for RR Lyrae stars is universal, with fundamental bearings upon the entire Population II distance scale.

1.4.3 Distance to the Large Magellanic Cloud

People involved at OAB: Bragaglia, Clementini, Maio.

The luminosities of RR Lyrae and clump stars in the bar of the LMC and their role in measuring distances have being investigated in col-

laboration with Carretta, Gratton (Pd Obs.) and Di Fabrizio (TNG).

B,V,I light curves have been obtained for 125 RR Lyrae stars, 4 Anomalous Cepheids, 11 Classical Cepheids, 11 eclipsing binaries, and one δ Scuti star, in two fields located close to the bar of the LMC. The full catalogue of the individual photometric measurements and light curves is provided in Di Fabrizio et al. (2003, in preparation). The global pulsational properties of the sample, as well as a very accurate estimate of the average apparent luminosity of the LMC RR Lyrae and clump stars and independent estimate of the local LMC reddening have been obtained from these photometric data. Our findings have been compared to previous results in literature. In particular, the straightforward comparison with OGLE photometry for the LMC clump stars allowed us to derive a clump distance modulus to the LMC about 0.15-0.20 mag longer than found by the OGLE team.

The dereddened apparent average luminosity of the LMC RR Lyrae stars defined by our study has been combined with a number of independent determinations of the absolute luminosity of RR Lyrae stars, to obtain estimates of the distance to the LMC. The derived values are only 1 σ shorter than provided by the Population I distance indicators and make it possible to reconcile the *short-* and *long-distance scales* on a common value for the distance modulus of the LMC of $\mu_{\rm LMC}$=18.515$\pm$0.085 mag (Clementini et al. 2003).

In collaboration with M. Marconi (Napoli Obs.) the extensive and detailed grid of nonlinear convective pulsation models of RR Lyrae stars computed by Bono et al. (2001) and Marconi et al. (2003, in preparation), is being used to reproduce the observed light curves of *ab*- and *c*-type pulsators in our LMC RR Lyrae sample. This will provide an independent estimate of the distance to the LMC (Marconi & Clementini 2003, in preparation). Figure 5 shows an example of the theoretical modeling of the light curve of an RRab variable in the LMC.

δ Scuti variables are late A and F-type stars that populate the instability strip near or slightly above the zero-age main-sequence. Since they obey a period-luminosity relation they can be utilized as standard candles to find distances. In collaboration with McNamara (Brigham Young Univ.) we are using the improved version of the period-luminosity relation for δ Scuti stars recently defined by McNamara (2000) to derive an independent estimate of the distance to the LMC based on the δ Scuti star identified in one of our LMC fields

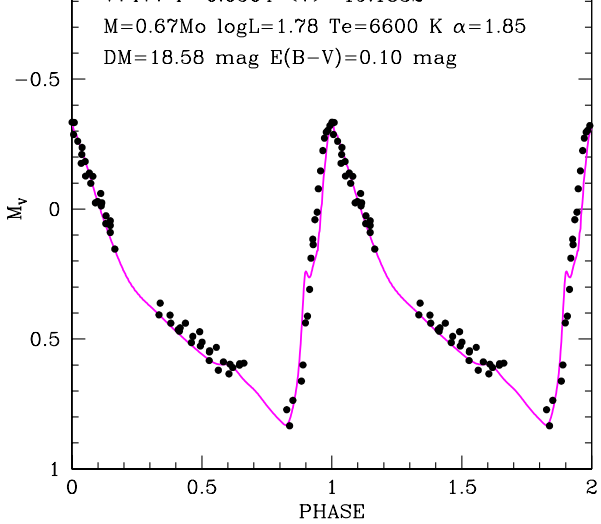


Figure 5: Theoretical modeling of the V light curve of the field RR Lyrae star V7477 in the LMC, from Marconi & Clementini (2003, in preparation).

(Clementini & McNamara 2003, in preparation).

1.4.4 Variable stars in Local Group galaxies

People involved at OAB: Baldacci, Clementini, Maio.

The key role of Population II pulsating variable stars (RR Lyrae stars, in particular) as tracers of the oldest population (and therefore of the epoch of galaxy formation) in resolved Local Group galaxies has been confirmed by their discovery in several LG dwarfs. By comparing the properties of Population II variables in nearby galaxies with those of the Milky Way variables, the metallicity and age of the oldest population can be estimated.

The detection and study of the short period pulsating variables in a number of Local Group Galaxies (Leo I, NGC 6822, Phoenix, Fornax, Ursa Minor and Sagittarius) is being carried out (see Clementini 2003, astro-ph/0303067) in collaboration with Held, Saviane, Momany and Rizzi (Padova Obs.), Poretti (Merate Obs.), Marconi, Ripepi (Napoli Obs.), Di Fabrizio (TNG), Smith (MSU), Catelan (PUC), Pritzl (NOAO).

a) Leo I

Based on multicolour WFI@2.2m time series photometry, RR Lyrae stars and Anomalous Cepheids have been detected for the first time in Leo I dwarf spheroidal galaxy. The Optimal Image Subtraction Method package ISIS2.1 (Alard 2000) run on the 8 CCDs of the 2.2m WFI mosaic allowed us to detect about 250 variables in this galaxy. RR Lyrae stars represent about 4/5 of the sample. The detection of RR Lyrae stars provides unambiguous evidence for the presence of old metal-poor stars all the way to the innermost regions of this composite stellar system, and opens the possibility to derive accurate distances to Leo I via these primary distance indicators. Anomalous Cepheids represent about 1/5 of our variable star sample in Leo I. They trace the intermediate age ($t \sim 5$ Gyr) stellar component and appear to be more centrally concentrated (Baldacci et al. 2003).

b) NGC6822

Time series B,V photometry was obtained of an area covering about 1/4 of NGC6822 dwarf irregular galaxy using VLT+FORS1. We detected about 450 candidate variable stars in this galaxy. In particular, we obtained the first identification of RR Lyrae stars tracing the presence of an old stellar component in NGC 6822. Measurements of the average luminosity of these variables provided the first estimate of the distance to this galaxy based on a Pop. II indicator: $(m - M)_0$=23.36 $\pm$0.17. Our new data show a significant population of small-amplitude, short-period variable stars filling the instability strip starting at luminosities only a few tenths of a magnitude brighter than the RR Lyrae stars. Cepheids with such low luminosities, small amplitudes, and short periods have not been found before in any dwarf irregular galaxy. Given the extended star-formation history of NGC 6822, these variables are likely to originate from a population of intermediate-age, metal-poor He-burning stars younger and more massive than RR Lyrae stars. Results from the analysis of the NGC 6822 variable stars fainter than $V \sim 23$ mag have been published (Clementini et al. 2003).

c) Fornax

We obtained B,V time series photometry of a 33' $\times$ 34' area North to the Fornax dSph center using the Wild Field Imager (WFI) of the 2.2 m ESO-MPI telescope. Candidate variables were identified using the package ISIS 2.1 (Alard 2000). We detected 525 candidate variable stars in the more central fields. The vast majority of these variables are

RR Lyrae stars, however we also identified Anomalous and Population II Cepheids, and a number of Dwarf Cepheid variables. We estimate that the total number of variable stars in Fornax is of about 1000 (lower limit; Maio et al. 2003, astro-ph/0303666).

We detected 70 candidate variables in the cluster Fornax 3. Most of them fall on the cluster HB, hence they are RR Lyrae stars. This is the first detection and measure of the variable stars in one of Fornax dSph galaxy globular clusters. We also detected 4 candidate variables in the scarcely populated cluster Fornax 6, an object whose actual nature still needs to be investigated. Photometric reductions and analysis of the full dat set are in progress.

d) Phoenix

Feasibility tests have been performed on existing VLT+FORS1 data for the Phoenix dwarf irregular galaxy and many candidate RR Lyrae stars have been identified. They will be the target of follow up observations. This study is in collaboration with Held, Momany, Rizzi (Padova Obs.).

1.4.5 RR Lyrae stars in globular clusters

People involved at OAB: Bellazzini, Cacciari, Clementini, Baldacci, Maio.

In merging scenarios the Galaxy halo was made up of accreted dwarf Spheroidal Galaxies (dSph's) similar to the known satellite of the Milky Way (MW). A number of GGCs thus may originate from dSph's that were accreted by the MW and should have properties that were directly inherited from their "ancestors". A puzzling feature of the GGCs is that they sharply divide into two distinct Oostheroff types according to the mean periods of their RR Lyrae stars and the relative proportions of fundamental and first overtone-mode pulsators (Oosterhoff 1939). In the MW there are no clusters filling the gap between Oostheroff type I and type II objects. This is not true of the LMC clusters which, instead have mean periods that fill the Oosterhoff gap. The Galaxy cannot have been assembled from LMC-like protogalactic fragments.

High quality BVI photometric observations were taken in November 2001 of the clusters NGC362 and NGC1904 for a detailed study of their RR Lyrae variables and the second-parameter effect. These

data are presently being reduced and analysed, in collaboration with M. Catelan (Pontificia Universidad Catolica de Chile).

A very detailed analysis of the RR Lyrae stars in M3 is presently being performed in collaboration with Corwin (Univ. of North Carolina). Mostly based on Fourier decomposition of the light curves, this study is showing the impact and characteristics of the Blazhko stars, the presence of a good number of evolved stars and their properties, as well as the characteristics of the main variable star population.

1.4.6 Double-mode and anomalous RR Lyrae stars

People involved at OAB: Bragaglia, Clementini, Merighi, Tosi

Double-mode RR Lyrae stars (RRd's) pulsate simultaneously in the fundamental and the first-overtone radial modes, while evolving across the HB instability strip. They provide information on the mass, mass-metallicity relation and on the direction and rate of HB evolution.

The photometric and high resolution spectroscopic study of a sample of RR Lyrae which exhibit anomalous scatter and large amplitude variations of their light curves is continuing, in collaboration with Carretta and Gratton (Padova Obs.), Ivans and Sneden (Univ. Texas), Marconi (Napoli Obs.), Smith (MSU), and Wilhelm (Southwestern Un.). The observational campaign conducted on CM Leo and BS Com with the 1.52m telescope in Loiano, the 60 cm of the Michigan State University, the 40 cm of the Southwestern University, and the 2.7 m telescope of the McDonald Observatory (for spectroscopy) has been completed.

From the full photometric and spectroscopic dataset, CM Leo has been found to be a very regular *c*-type RR Lyrae with metal abundance [Fe/H]=-1.94±0.2. The photometric and radial velocity curves of CM Leo have been compared with the prediction of convective pulsational models producing an average absolute magnitude M_V=0.47. This value, once corrected for evolutionary and metallicity effects, leads to a true distance modulus of the Large Magellanic Cloud of μ_0=18.43 mag (Di Fabrizio et al. 2002).

The new high resolution spectroscopic data obtained in 2002 for BS Com are presently being reduced. Analysis of the full photometric data set is in progress, and clearly shows that the star has at least two different pulsation modes excited at the same time: BS Com is very

likely to be the seventh double-mode RR Lyrae star discovered so far in the field of our Galaxy.

Reanalysis of Corwin & Carney (2001) time series data for the GC M3 using the image subtraction method (Alard 2000), has lead to the discovery of three new double-mode RR Lyrae stars in this cluster. Two of the newly discovered RRd's lie in the Petersen diagram (Petersen 1973) well separated from all previously known RRd's, in positions implying large spread in mass and/or heavy element mass fraction among the M3 HB stars. Three of the M3 RRd's have changed their dominant pulsations mode in a one year time-span, thus suggesting that these stars are undergoing a rapid evolutionaty phase, and that both redward and blueward evolution may take place among HB stars in this Oosterhoff type I cluster. This study is in collaboration with Corwin (Univ. of North Carolina at Charlotte), and Carney (Univ. of North Carolina at Chapel Hill). Full discussion of the results is presented in Clementini et al. (2003, in preparation).

1.5 Eclipsing binaries

People involved at OAB: Bonifazi, Lolli.

The study of binary systems provides powerful tools to get fundamental stellar parameters (M,R,L) and consequently to test stellar structure and evolution. With the Loiano 60cm and 152cm and the Russian SAO 600cm telescopes many binary systems have been observed and their light curves have been collected. Moreover we have derived the precise timing of the light minima of systems exhibiting apsidal motion [DR Vul, V380 Cyg, RR Lyn, AK Her, ER Vul, BF Aur], that can be correlated to the mass distribution in the stellar interiors. The interesting W UMa-type systems RW Com and XY Leo were observed with the Loiano 152 cm telescope, along with the PCV NN Ser and the CV TT Ari. Spectra for NN Ser were also collected at the 6 m BAT. The analyses of the light curves are performed with the Wilson-Price (Barone et al., 1988) program based on the Wilson-Devinney (1971) model. In the year 2002, after the implementation of the computer code on a particularly performing CPU (Athlon XP 1800+), we have attempted to reproduce the fit of light curves with parameters known from the literature. The very good results obtained encouraged to apply the code on a somewhat more complicated sys-

tem: the spotted star XY Leo. Very preliminary results are being obtained and the work is in progress.

Our team includes Guarnieri, Bartolini, Piccioni and Cosentino (Univ. Bologna), Beskin (SAO), Milano (Univ. Napoli) and Barone (Univ. Salerno).

1.6 Planetary Nebulae

People involved at OAB: Stanghellini

1.6.1 Planetary Nebulae in the Magellanic Clouds

This project is a major effort started in 1997, aimed to study the morphology and all the nebular and stellar properties of the Magellanic Cloud (MC) PNs. In collaboration with B. Balick (U. of Washington), C. Blades (STScI) and D. Shaw (NOAO) a series of observing programs to probe PN morphology in extra-galactic environments have been successfully executed. We use optical STIS slitless spectroscopy in snapshot mode, obtaining information on multi-wavelength morphology, size, ionization, and central star spectra of about 100 LMC and 30 SMC PNs (about one half the known PNs in those galaxies). Furthermore, we use UV spectroscopy to study the carbon emission and the central stars spectra of a subsample of 30 LMC PNs. From the study of the database, we have obtained the following results:
- PNs in the LMC and the SMC can be classified in the same morphological classes as Galactic PNs, i.e., symmetric (round and elliptical) and asymmetric (bipolar, bipolar core, quadrupolar, and poitsymmetric) (Stanghellini et al. 1999, Shaw et al. 2001, Stanghellini et al. 2002b, 2003). Thus, qualitatively, a similar set of processes is responsible for the PN shapes, independent on the galaxy type and metallicity.
- The abundance of Ne, Ar, and S in asymmetric LMC PNs is higher that in symmetric PNs. Since these elements are not created nor destroyed during the evolution of PN progenitors, this is an indication that the asymmetric PNs are the progeny of metal-enriched stellar populations (Stanghellini et al. 2000).
- The physical radii of the LMC PNs trace their evolution reasonably well. This has been shown by building the HR diagram equivalent for emission line objects (Stanghellini et al. 2002b). The asymmetric PNs

are found in all but the earliest evolutionary stages, confirming their massive nature.
- There is a strong correlation between surface brightness (in major emission lines) and radius for LMC and SMC PNs (Shaw et al. 2001; Stanghellini et al. 2003). Preliminary work shows that the MC-calibrated Galactic PN distance scale is much more accurate than the currently used statistical scales (e.g., Cahn et al. 1992).
- The ratio of symmetric to asymmetric PNs is lower for the LMC than for the SMC. This result indicates that bipolar evolution is rare in low-metallicity environments. The reason for the disparity may lie in the nature of dust at different metallicities. It may also indicate that in the LMC there is recent star formation, but less so in the SMC.
- We observe very different PN [OIII] 5007 line flux distributions in the LMC and SMC. This lead us to infer that the cooling mechanisms vary with metallicity of the nebulae. Accurate photoionization models for the SMC and LMC PNs, constrained by the stellar evolutionary models for LMC and SMC post-AGB stars (Vassiliadis & Wood 1995), encompass our findings very well (Stanghellini et al 2003). This result has implication in the use of the PN luminosity function as a secondary distance indicator, since these luminosity functions might not be stable for different metallicities.
- Our MC database is the most complete, uniform, homogeneous PN sample to date, in any environment.

1.6.2 Ultra-compact SMC HII regions

Our STIS snapshot survey of SMC PNs was aimed at observing all known ($\sim$ 60) PNs previously identified in that galaxy. Given the nature of HST snapshot observations, only 30 targets were actually observed. Of those, two turned out to be misclassified PNs, and are indeed H II regions. An additional H II region was observed within the frame of these observations. A preliminary analysis of these H II regions show that they are extremely compact (the largest one is less than 3 pc across), extremely reddened (much higher than the typical SMC H II region), and well populated star forming regions. Previously, only three of very compact H II regions were known in the SMC (Heydari-Malayeri 1999; Testor 2001), all of them less reddened and compact than our findings. The importance of studying the ultra-compact H II regions in the SMC is multi-fold. First, they offer an ideal laboratory to study star formation in a low-metallicity

environment. Second, the small sizes of these regions, compared to the average SMC H II regions (50 to 270 pc) are indicative of a very recent star formation process (Elmegreen 2000). Third, the low reddening toward the SMC, together with the high resolution of HST, allow us to measure the physical parameters of the ionizing stars, to build the appropriate evolutionary diagrams, and to study star formation at very low metallicity.

1.7 Pulsars

People involved at OAB: D'Amico, Ferraro, Possenti

Five interesting results were achieved during this year by the Bologna Pulsar Group, namely: (a) the discovery of the most displaced millisecond pulsar with respect to the center of the globular cluster hosting it; (b) the measurement of the highest central mass to light ratio ever observed in a globular cluster; (c) the discovery of a pulsar with a surface magnetic field larger than twice the critical quantum field; (d) the discovery of the pulsar undergoing the greatest "glitch" ever observed; (e) the surprising companion to the binary millisecond pulsar in NGC 6397.

(a) The most displaced millisecond pulsar in a globular cluster

While performing a deep search at 1.4 GHz for millisecond pulsars in globular clusters with the Parkes 64-m (210-ft) radio telescope (operated by the Australia Telescope National Facility), we have found five millisecond pulsars in the globular cluster NGC 6752. Soon after discovery, we started a large program of "timing" observations. They consist in cycling pointings (repeated over many months or years) of the times of arrival of the pulsations from a given source. By using this procedure, one can derive accurate measurements of the rotational parameters of the pulsars, of its position and eventually of its apparent motion in the sky.

It resulted that the binary pulsar PSR J1911-5958A is located at more than 6 arcmin from the center of the cluster NGC 6752, corresponding to more than 70 core radii (or about 3.3 half mass radii): it is the most offset pulsar (with respect to the center of the cluster) ever detected in a globular. Remarkably, this cluster hosts also the second most displaced pulsar ever observed, namely the single pulsar

PSR J1911-6000C.

Pulsars are among the most massive objects in a globular cluster and therefore energy equipartition (giving less velocity to the most massive species) tends to constrain them deep into the cluster potential well. More conventional scenarios for the formation of PSR J1911-5958A (those involving a primordial binary, or an exchange interaction with cluster binary stars) are unable to explain its position. Whence, the intriguing hypothesis that it has been propelled in the cluster outskirts due to a dynamical encounter with a binary comprising two stellar mass black-holes.

(b) The high central M/L of NGC 6752

All the five millisecond pulsars in NGC6752 display peculiarities: besides the offset positions of the two aforementioned pulsars, "timing" observations revealed that the three pulsars (all single) located in the central regions of the cluster are experiencing a very high acceleration. This is not a new feature for the pulsars detected in globular clusters and it is routinely interpreted as the effect of the cluster potential well on the pulsar motion. In this hypothesis, one can estimate the amount of mass (enclosed within the projected position of the pulsars) necessary to produce that acceleration. Combining that with an updated brightness profile of the cluster, we got a firm, lower limit of M/L=6 for the central projected mass to light ratio (V band) for NGC 6752. Core collapsed clusters usually display central mass-to-light ratios in the range 2-3.5. The difference between these typical values and the M/L measured in this cluster using pulsar timing implies the presence of an extra-amount of about 1000 solar masses of low luminosity matter in the inner 0.08 pc of NGC 6752. A wide scientific debate has been raised about the nature of this unseen matter (a very high concentration of neutron stars, heavy white dwarfs or black-holes?), making NGC 6752 a primary target for attempting to find signatures of the presence of black-holes in globular clusters. In order to understand the origin of the strong MSP acceleration in NGC 6752, and to verify the presence of possible unusual non-thermal dynamics occurring into the cluster core, a set of high resolution, ultra-deep observations is in progress with FORS1@VLT and with the Advanced Camera for Surveys (ACS) on board of HST, with the aim of identifying the optical counterparts to the binary MSPs.

(c) The pulsar with the highest surface magnetic field

Traditional pulsar emission theories posited that radio emission

is suppressed above the quantum critical field of 4.4×10^{13} Gauss. We have discovered a pulsar, PSR J1847-0130, with a spin period of 6.7 sec, a characteristic age of 83000 years and a surface magnetic field of 9.4×10^{13} Gauss, larger than twice the quantum critical value. Moreover, both period and magnetic field of PSR J1847-0130 are well within the range of the values seen in the so-called Anomalous X-ray Pulsars (AXPs), none of which displays pulsating radio emission. This observation strongly challenges all the proposed pictures for describing the origin of the radio emission from radio-pulsars and shows that magnetic field and spin period alone cannot be responsible for the lacking of radio emission from the AXPs.

This very interesting pulsar has been detected during the Parkes multibeam pulsar survey, currently being carried out using the 13-beam 1400-MHz receiver on the Parkes 64-m (210-ft) radio telescope. This is resulting the most fruitful pulsar survey ever, already counting 680 discoveries.

(d) The pulsar undergoing the largest observed glitch

Another remarkable discovery from the Parkes multibeam pulsar survey is that of the pulsar PSR J1806-2125, having a spin period of 0.4 sec and characteristic age of 65000 years. Between October 1999 and December 2000 this pulsar underwent an increase in rotational frequency of $\Delta\nu/\nu \approx 16 \times 10^{-6}$. The magnitude of this "glitch" is about 2.5 times greater than any previously observed in any pulsar and 16 times greater than the mean glitch size. The existence of such large and rare glitches offers new hope for attempts to observe thermal X-ray emission from the internal heat released following a glitch, and suggests that pulsars which previously have not been observed to glitch may do so on long timescales.

(e) The surprising companion to the binary MSP in NGC 6397

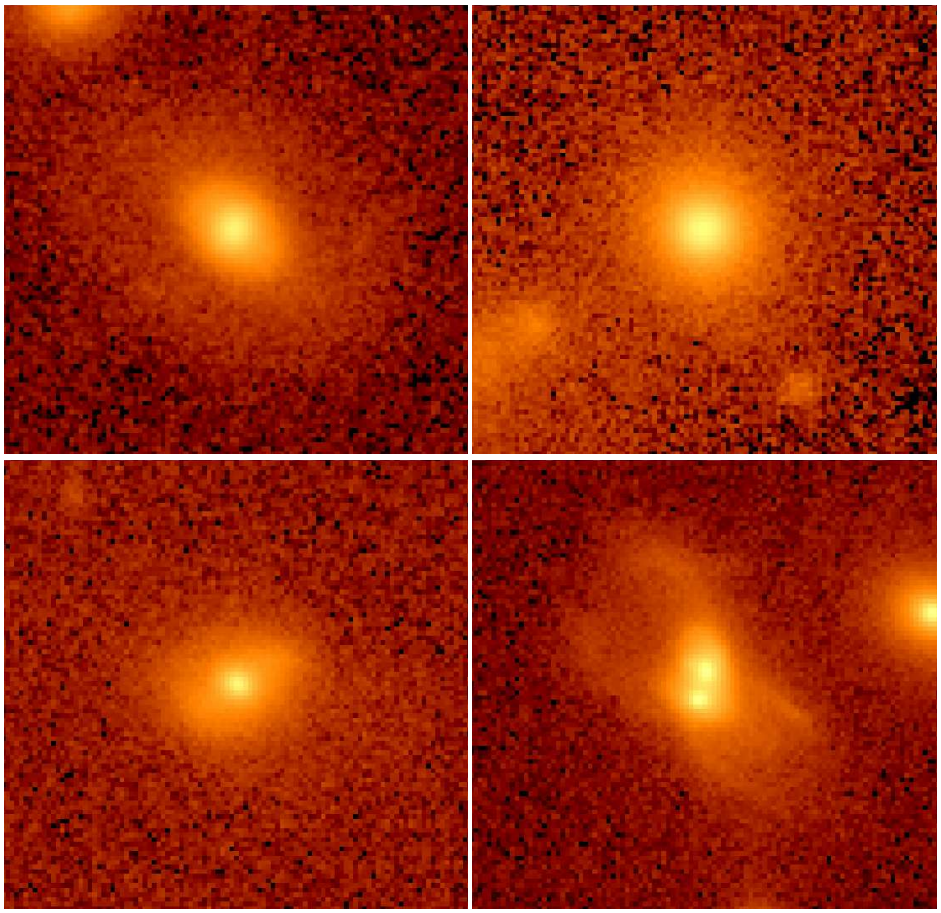
A few years ago we started a long-term programme which takes advantage of the current generation of astronomical instruments (from ground and from space) in a coordinated effort to fully understand the formation mechanism and evolution of MSPs in globular clusters.

In the framework of this project, we identified the optical counterpart to a MSP companion in the globular cluster NGC 6397 (Ferraro et al., 2001) This MSP binary system contains a tidally deformed star. This is the first case of a MSP in a binary system with such an exotic companion and it could represent the first detection of a new-born MSP. The discovery of this system, thanks to the unusual brightness

of the companion (V=16.6), allowed us unprecedented detailed spectroscopic observations, opening a new unexplored window to the study of MSPs in clusters. During the last year we have performed phase resolved spectroscopy at high resolution (with UVES@UT2) which allowed us to determine the detailed light curve shape, the radial velocity curve and many orbital parameters of this binary system (Ferraro et al. 2003). These observations have shown a surprising detection of strong HeI absorption lines, completely unexpected in a low-temperature star as the MSP companion. This feature implies the existence of atmospheric regions at $T > 10,000K$, significantly warmer that the rest of the star. The intensity of the lines correlates with the orbital phase, suggesting the presence of a small spot onto the companion surface, heated by the millisecond pulsar flux. We are now also performing the analysis of the complex structure of the Hα emission line which will allow us to map the structure of the gas released by the donor star (Sabbi et al. 2003a) and the complete abundance pattern screening of the companion, which will contribute to understand the true nature of the companion (Sabbi et al. 2003b, in preparation).

This research is in collaboration with Burgay (Dip. Astr. BO) and Sabbi (Dip. Astr. BO).

2 Extragalactic Astronomy and Cosmology



Four examples of K_s imaging obtained at VLT with ISAAC. The targets are **X-ray Bright Optically Normal Galaxies** (XBONG, Comastri et al., 2002), selected by the HELLAS2XMM survey in the hard X-ray (2–10 keV) band. The four galaxies do not show any AGN signature in the optical spectra, but have relatively high X-ray luminosities ($L_X > 10^{41}$ erg s^{-1}). The near infrared morphology is intriguing: we have two elliptical galaxies with classical r$^{1/4}$ profiles (upper row), one galaxy with disky profile and faint spiral arms (Sa?, lower left) and an interacting/merging galaxy with double nucleus (lower right). In the last image the seeing is 0.4 arcsec (FWHM) and the two nuclei are only 0.8 arcsec apart.

People involved at OAB:

- *Scientific staff:* S. Bardelli, A. Cappi, P. Ciliegi, L. Ciotti, A. Comastri, H. de Ruiter, P. Londrillo, R. Merighi, M. Mignoli, L. Origlia, L. Pozzetti, R. Sancisi, G. Stirpe, G. Zamorani, V. Zitelli, E. Zucca;
- *Fellows:* E. Calabrese, F. Fraternali, S. Giacintucci, B. Lanzoni, F. Pozzi.

Observational extragalactic astronomy has traditionally been one of the main themes of research at the Bologna Observatory. It includes a wide range of subjects, from the structure and evolution of "normal" galaxies, to the physical properties of active galactic nuclei (AGNs) to observational cosmology.
The extragalactic research at the Bologna Observatory is characterized by a multiwavelength approach: while optical astronomy is the main field at the Observatory, some of the scientific staff specialize in X-ray observations of AGNs, and others find their main interest in radio studies of galaxies and quasars.
Much of this research is based on an intensive use of the most advanced instruments available today: the X-ray satellites Chandra and XMM–Newton, the ESO optical/NIR telescopes (including VLT), the Westerbork, VLA and ATCA radiotelescopes.

2.1 Structure and evolution of galaxies

The structure of galaxies is studied either from a theoretical point of view (including numerical modeling) or by radio observations of neutral hydrogen.

2.1.1 Theoretical studies and numerical simulations

People involved at OAB: Cappi, Ciotti, Lanzoni, Londrillo, Zamorani.

L. Ciotti, in collaboration with G. Bertin (University of Milan and Scuola Normale Superiore, Pisa) and M. Del Principe (graduate student of SNS–Pisa) reexamined the question of whether a systematic non-homology could be partly responsible for the correlations that define the Fundamental Plane. They found that elliptical galaxies should

not be considered homologous dynamical systems and that neither the strict homology nor the constant stellar mass–to–light solution are a satisfactory explanation of the observed Fundamental Plane.

L. Ciotti, P. Londrillo and C. Nipoti (PhD student, Astronomy Dept., University of Bologna), by using N-body simulations of galaxy models characterized by observationally motivated density profiles, and also allowing for the presence of live, massive dark matter halos, explored the relations between the Fundamental Plane thinness and tilt and the amount of radial orbital anisotropy. In fact, the problem of the compatibility between the observed thinness of the Fundamental Plane and the wide spread of orbital anisotropy admitted by galaxy models has often been raised. The main results of this work are that galaxy models that are radially anisotropic enough to be found outside the observed Fundamental Plane (with their isotropic parent models lying on the Fundamental Plane) are unstable, and their end-products fall back on the Fundamental Plane itself. Also, they found that a systematic increase of radial orbit anisotropy with galaxy luminosity cannot explain by itself the whole tilt of the Fundamental Plane, because the galaxy models become unstable at moderately high luminosities: at variance with the previous case their end–products are found well outside the Fundamental Plane itself.

Following this work, L. Ciotti, P. Londrillo and C. Nipoti concluded numerical simulations of dissipationless merging of stellar systems, aimed at exploring the consequences of merging between gas-free, spheroidal systems. In particular, they studied the dynamical and structural characteristics of hierarchical merging between equal-mass stellar systems, and compared the properties of the end-products with the most important structural and dynamical scaling relations obeyed by spheroids. The main result is that the FP tilt is marginally conserved, but both the Faber-Jackson and the Kormendy relations are *not* conserved.

L. Ciotti and B. Lanzoni, with the aid of Monte-Carlo numerical simulations based on fully analytical, oblate galaxy models with adjustable internal dynamics, explored the importance of projection effects in producing the observed thickness of the Fundamental Plane when seen edge-on. The results indicate that a substantial part of this thickness is due to *intrinsic* variations from galaxy to galaxy of their intrinsic properties, while projection effects have only a minor contribution.

L. Ciotti, in collaboration with G. Bertin, developed a new analyti-

cal method to construct explicit, triaxial density-potential pairs, to be used in the description of structural and dynamical properties of elliptical galaxies. This method is also of considerable help in the numerical implementation of the Schwarzschild method of orbital superposition. Following this work, L. Ciotti, in collaboration with Z. Haiman and J.P. Ostriker (Princeton University), developed a robust method to derive the duty cycle of QSO activity based on the empirical QSO luminosity function and on the present-day linear relation between the masses of supermassive black holes and those of their spheroidal host stellar systems. The main result is that the duty cycle is substantially less than unity, with characteristic values in the range $3 - 6 \times 10^{-3}$, in excellent agreement with the theoretical results presented above.

B. Lanzoni, A. Cappi, L. Ciotti, and G. Zamorani, in collaboration with G. Tormen (Astronomy Dept., University of Padova), investigated the physical origin of the scaling relations observed for nearby galaxy clusters, by means of high-resolution N-body simulations of massive dark matter halos. Under the assumption of a reasonable trend of the mass-to-light ratio with the cluster total luminosity, the DM halos are found to reproduce not only the Fundamental Plane, but also the luminosity-radius and the luminosity-velocity dispersion relations. Such a result is interpreted in the context of the cosmological collapse of density fluctuations, given the known homology of dark matter halos and the assumed M/L ratio, while the comparison with the analogous scaling relations defined by elliptical galaxies suggests that merging and gas dissipation must have had a non negligible role in the formation and evolution of these objects. While waiting for deep photometric and spectroscopic surveys, the possible evolution of the cluster scaling relations with redshift is also discussed.

2.1.2 Neutral hydrogen studies

People involved at OAB: Fraternali, Sancisi.

I. High velocity gas and HI halos of spiral galaxies.

F. Fraternali, R. Sancisi and T. Oosterloo (NFRA, The Netherlands) have concluded their study of the kinematics of the cold and hot gas in the spiral galaxy NGC 2403 (F. Fraternali, PhD thesis, University of Bologna). Such a study revealed halo gas (neutral and ionised) rotating more slowly ($\sim$ 20–50 km s^{-1}) than the gas in the

disk. It also revealed powerful outflows (up to 200 km s^{-1}) of ionised gas and diffuse X-ray emission from hot gas (2–8 $\times$ 10^6 K). These results point at galactic fountain phenomena.

Recently, a new HI study of the edge-on spiral galaxy NGC 891 has been started. This galaxy has been observed with the Westerbork Syntesis Radio Telescope (WSRT) with much higher sensitivity (5 times lower rms noise) than the previous observations. The new data reveal a very extended HI halo with HI emission up to 10–15 kpc from the plane of the disk. This halo gas shows a lower rotation velocity (25–100 km s^{-1}) than the gas in the plane.

A deep 21 cm line survey with the Westerbork Radiotelescope (16$\times$ 12 hrs integration) has been carried out by R. Boomsma (Kapteyn Institute, University of Groningen), T. Oosterloo, R. Sancisi and T. van der Hulst (Kapteyn Institute, University of Groningen). The HI data show the presence of several large holes in the HI layer and of large complexes of high velocity clouds. Some of these are clearly associated with the holes.

F. Fraternali and T.S. van Albada (Kapteyn Institute, University of Groningen) have started a theoretical study of the halo gas in spiral galaxies. They are considering the process of galactic fountains using a simple ballistic approach.

II. Dark Matter. Rotation curves, HI warps

G. Battaglia (undergraduate student, University of Bologna), F. Fraternali, R. Sancisi and T. Oosterloo have studied the HI dynamics of the spiral galaxy NGC 5055. This galaxy has a prominent, highly symmetric warp extending out to 46 kpc from the centre. New WSRT observations show the presence of spiral arms in the region of the warp and hints of anomalous gas in the inner region of the galaxy. The rotation curve of NGC 5055 shows a decline between 10 and 20 kpc, close to the edge of the stellar disk. The luminous matter (stars and gas) dominates in the inner parts (optical disk) of this galaxy.

R. Swaters (Johns Hopkins Univ.) and R. Sancisi have continued their study of dark and luminous matter in the central parts of spiral galaxies. The rotation curves (optical and HI) can be fully explained with the presence of luminous matter.

2.2 Active galactic nuclei and star-forming galaxies

2.2.1 Optical studies

People involved at OAB: de Ruiter, Stirpe, Zitelli.

I. Emission lines and variability of AGN.

G. Stirpe, in collaboration with A. Robinson (University of Hertfordshire) and D. Axon (Rochester Institute of Technology), is continuing the analysis of a sample of broad-line AGN observed spectroscopically in Hα and Hβ, covering a wide range of intrinsic luminosity and redshifts (up to $z \sim 2.5$), with the purpose of studying the distribution of properties of the Broad Line Region and the possible causes of the line profile diversity. The database of measured emission line parameters created from the detailed analysis of the spectra is revealing trends such as a tendency of the forbidden lines to have increasing blueshift with respect to the systemic velocity and lower equivalent width when their FWHM is larger. This trend is particularly evident in Narrow Line Seyfert 1 galaxies.

Within a collaboration led by A. Marconi (Arcetri Observatory), G. Stirpe is taking part in the monitoring of 2 high-luminosity, high-z QSOs with the ESO VLT, with the purpose of measuring the emission line vs. continuum light curve lag and thus obtain an estimate of the size of the Broad Line Region. These are the highest luminosity AGN monitored in this fashion, which means extending this technique to what are probably the most massive known black holes. Photometric and spectroscopic observations in the K band have been made on a monthly timescale starting in 2001. Preliminary light curves have been obtained from the first two years of data. They reveal variations of $\sim$10% in both the continuum and Hα line flux, but no lag can yet be measured without extending the monitoring for several more years.

In collaboration with P. Marziani and R. Zamanov (Padova Observatory), G. Stirpe is completing the reduction of Hβ spectra of a sample of high-z QSOs, obtained at the ESO VLT in the near-IR bands. These spectra will be used to extend to high luminosities and high redshifts the parameter ranges of the Boroson-Green Eigenvector 1, which correlates various properties of AGN emission lines.

H. De Ruiter, in collaboration with J. Lub (Leiden Observatory)

constructed a database containing many hundreds of photometric and spectroscopic measurements for a sample of about 15 type 1 and type 2 Seyferts in the southern hemisphere, based on fourteen years of observations. These data have now been made available for the general astronomical community: the calibrated spectra can be inspected directly on the WEB[1], or downloaded (in FITS format). Animations that show the lightcurves of a spectral region around 5000 Å are now available at the same WEB page.

II. HST images of B2 radio galaxies.

H. De Ruiter, in collaboration with A. Capetti (Torino Observatory), P. Parma and R. Fanti (IRA–CNR, Bologna), and R. Morganti (NFRA, The Netherlands), is studying HST images (in two colours, V and I) of about 60 radio galaxies selected from the B2 sample of low luminosity radio galaxies. Brightness profiles were fitted to all galaxies, and these were used to obtain a detailed mapping of the (circum)-nuclear dust.

III. The environment of AGN.

V. Zitelli, in collaboration with P. Focardi and B. Kelm (Astronomy Dept., University of Bologna), is continuing the study of the relationship between nuclear activity and environment for active galactic nuclei. Ample evidence has been reported in the local universe of a complex environment around active galactic nuclei and up to $z \sim 3$. However, while it is well established that radio loud quasars, radio galaxies and BLLacs reside in denser than average regions, the role of the environment and of interactions on Seyfert galaxies is to some extent still controversial. The complexity of the discussion increases because the samples used are limited in number. To limit the statistical uncertainty we adopt a strategy based on the analysis of a statistically significant sample of nearby AGN and appropriate control samples selected on the basis of criteria independent of morphology and environmental properties. A sample of about 300 physical compact groups has been extracted applying an automatic code to 3-D galaxy catalogues. The global properties of active galactic nuclei are analyzed, in particular Seyfert incidence within compact groups has been determined (Focardi et al., 2002). From the analysis it clearly

[1] *http://www.bo.astro.it/~deruiter/seyf_spectable.html*

emerges that Seyfert 2 are preferentially associated to compact groups displaying relatively high velocity dispersion and a large number of neighbours. The properties of compact groups hosting an AGN member as compared to those that do not are presently investigated.

2.2.2 Near-IR studies

People involved at OAB: Comastri, Origlia.

I. Probing the starburst-AGN connection.

Optical and UV studies have established the existence of a starburst-AGN connection in Seyfert 2 galaxies, a connection which is believed to extend to the epoch of the formation of bulges and ellipticals. Seyfert galaxies are excellent local laboratories in which this connection can be probed in considerable detail. Their relative proximity allows not only for high S/N, but also for 0.1–1 kpc spatial resolution, thus sampling more closely the physics of the central engine and its environment. In analogy with the booming progress in the research on distant star-forming ("Lyman break") galaxies, which is very much based upon knowledge acquired through careful study of nearby starbursts, understanding the role played by starbursts in Seyferts will provide crucial guidelines for the interpretation of the high z universe, while simultaneously advancing our knowledge of these complex and physics-rich systems. Near IR (1–2.5 μm) spectroscopy offers a unique opportunity to tackle this issue more closely, with the advantages that it allows to detect starbursts even in Seyfert 1's and to sample dust embedded starbursts (neither of which can be done at shorter wavelengths), while simultaneously providing reliable stellar population diagnostics. There are a few major key features in this spectral range to investigate both the stellar and the nebular components: many absorption lines due to neutral metals (Fe, Si, Mg, Ca, Al, Na), molecules (CO, OH) and Pβ, Brγ, [FeII] 1.64 μm in emission, from which it is possible to derive line fluxes, broadening (velocity dispersions) and equivalent widths. During two successful observational campaigns at the ESO NTT with SOFI and at the TNG with NICS in July and August 2001, we secured medium-resolution IR spectra of more than 20 active galaxies. Following the successful methodology developed by our group in a few pioneering works (Origlia et al., 1993, Oliva et al., 1995, 1999) we are undertaking the following analysis:

• quantify the contribution of both stellar and non-stellar components (usually hot dust) by analyzing the associated dilution of a few representative absorption features;
• estimate the reddening towards the stellar population and line emitting region through the stellar $H-K$ color and the H recombination line ratios;
• assess the metallicity of the stars through the strength of the absorption features;
• measure the dynamical mass and the stellar mass-to-light ratio, enabling us to put tight constraints on the age of the dominant population.
These diagnostics will allow us to check whether a genuine starburst is present in the nuclear region and compare the age of the nuclear stellar populations in Seyfert 1's and 2's, thus providing a strong test of the unified model. More generally, this will allow us to explore the use of the age of the stars as a clock for nuclear activity and thereby assess the occurrence of evolution within and between activity classes.

This work is carried out in collaboration with E. Oliva (Arcetri Obs. – TNG); R. Maiolino (Arcetri Obs.); R.M. Gonzalez Delgado (IAA, Granada, Spain); R. Cid Fernandez (UFSC, Brazil); T. Storchi-Bergmann (UFRGS, Brazil).

II. Metal enrichment in starburst galaxies.

The near-IR stellar luminosity of starburst galaxies is dominated by massive red supergiants. Such a stellar continuum generally largely dominates over the gas and dust emission (Oliva & Origlia 1998, Origlia & Oliva 2000), while in the visual range the nebular emission strongly dilutes the stellar absorption lines and dust can heavily obscure the central regions where most of the burst activity is concentrated. Their absorption spectra show many atomic and molecular lines which can be used to infer reliable abundances of key metals (e.g. C, O, Fe and other α-elements). Metals locked in the stellar atmosphere of red supergiants trace the abundances just prior to the last burst of star formation. On the other hand, the hot gas in the nuclear region, probed by X-ray observations, is heated by type II SN explosions and therefore is related to the gas just enriched by the new generation of stars. The X-ray spectra obtained by the new generation of X-ray telescopes (Chandra and XMM–Newton) have a quality high enough to set good constraints on the metallicity of the hot gas in

starburst galaxies and possible spatial gradients. During a successful observational campaign at the TNG with NICS in December 2002, we secured medium-resolution IR spectra of 4 starburst galaxies observed with Chandra and/or XMM–Newton, to infer reliable abundances of Fe, C, O, Si, Mg, Ca and Al and to obtain a detailed screening of the most important abundance patterns, namely [C/Fe] and α/Fe], of the pre-burst medium, locked into the stellar photospheres. By comparing the metallicity of the hot gas with the pre-burst metallicity determined by the IR spectra of red supergiants we can constrain the star formation history and witness the enrichment of the interstellar medium by a single burst of star formation.

This work is carried out in collaboration with P. Ranalli (Astronomy Dept., University of Bologna), R. Maiolino and A. Marconi (Arcetri Obs.).

2.2.3 X-ray studies

People involved at OAB: Comastri.

I. X-ray observations of AGN.

Thanks to the superb imaging capabilities of the detectors onboard the *Chandra* satellite it was possible to study with unprecedented accuracy the X-ray emission from lobes and jets in radiogalaxies.

We find evidence of non-thermal X-ray emission from the radio lobes of the powerful radio galaxy 3C 219 which is fitted fairly well by a combination of inverse Compton scattering of Cosmic Microwave Background radiation and of nuclear photons with the relativistic electrons in the lobes. The comparison between radio synchrotron and IC emission yields a magnetic field strength significantly lower (by about a factor 3) than that calculated under minimum energy conditions; the source energetics are then dominated by the relativistic particles.

The X-ray luminous and spatially resolved knot along the jet of the steep spectrum radio-loud quasar 3C 207 is best fitted by an extremely flat power law spectrum. By combining *Chandra* observations with VLA data it is concluded that Inverse Compton scattering of the Cosmic Microwave background photons provides a good description of the observations. The energy distribution of relativistic electrons is consistent with that expected from shock acceleration.

This work is carried out in collaboration with G. Brunetti (IRA–

CNR, Bologna) and G. Setti (Astronomy Dept., University of Bologna).

II. X-ray studies of star-forming galaxies.

The possibility that the 2–10 keV luminosity of starburst galaxies can be a reliable star-formation indicator has been suggested on the basis of a detailed analysis of a well defined sample of nearby star-forming galaxies observed by Beppo–SAX and ASCA. The linear correlation between hard X-ray, far infrared and radio luminosities allowed us to propose a simple formula to derive the star formation rate as a function of the 2–10 keV luminosity. Deep *Chandra* observations of a sample of radio-selected star-forming galaxies in the Hubble Deep Field North show that the same relation holds also at high ($0.2 < z < 1.3$) redshift. The X-ray/radio relations also allowed to derive the X-ray number counts down to very faint fluxes from the radio LogN–LogS function. The contribution of star-forming galaxies to the X-ray background can then be estimated and is of the order of a few percent with a robust upper limit of about 10 percent.

This work is carried out in collaboration with P. Ranalli and G. Setti (Astronomy Dept., University of Bologna).

2.3 Surveys and Observational Cosmology

A large fraction of the staff of the Observatory is involved in surveys of extragalactic objects. Some of these surveys are ongoing long-term projects, but quite a few have started only recently, or will start in the near future, and will require telescope time with new generation optical telescopes like the VLT.

As an aid to observational cosmologists de Ruiter has made available (on the WEB) a collection of cosmological formulas. For a number of models (the standard Friedmann model, flat models with non-zero cosmological constant, and some more exotic ones) distances, volumes and look-back times are given as a function of redshift. In many cases the solutions are given in analytical form. The compendium can be found on the WEB[2].

[2] *http://www.bo.astro.it/~deruiter/cosmo/*

2.3.1 The VIRMOS/VLT Deep Survey (VVDS)

People involved: Bardelli, Cappi, Ciliegi, Merighi, Pozzetti, Zamorani, Zucca.

The Bologna Astronomical Observatory is part of the Consortium for the ESO-VLT Instrument VIRMOS (Visual Infra-Red Multi-Object Spectrographs).

The visual spectrograph VIMOS[3] is mounted at VLT-Melipal and saw its first light successfully on February 26, 2002. Commissioning and testing were completed in 2002 and the guaranteed time observations started in Autumn 2002.

The huge multiplex capabilities of VIMOS will allow to assemble redshift databases of large samples of faint galaxies. The Consortium's guaranteed time will be used to perform a deep redshift survey of about 10^5 galaxies selected from both visual (B and I) and infrared (K) defined samples. Given the large number of expected redshift measurements and the expected redshift coverage (up to $z \gtrsim 2$, with a median redshift in the interval 0.6–0.9), this survey will allow to determine with excellent statistics the evolution with redshift of the luminosity functions in different bands for each galaxy type.
Just a few of the crucial issues which it will therefore be possible to address from these data are:
• detailed tests of the predictions of various models of galaxy evolution (e.g. hierarchical versus monolithic models);
• precise estimates, on the basis of a single sample with well understood selection criteria, of the star formation history up to at least $z \sim 2$;
• studies of the still uncertain nature of the extremely red galaxies (EROs), determining which fraction of them is actually associated with old elliptical galaxies at high redshift and which fraction is associated with dusty starburst galaxies.

As a by-product, since no morphological selection will be applied to the objects to be observed, this survey, with its expected ~ 1000 AGNs down to $I \sim 24.0$, will allow the study of the optical luminosity function and evolution of the faint (e.g. Seyfert-like) AGNs in a magnitude range where the selection of AGN candidates with the standard color and morphological criteria is very difficult and, possibly, largely incomplete.

[3] *http://www.astrsp-mrs.fr/virmos/index.html*

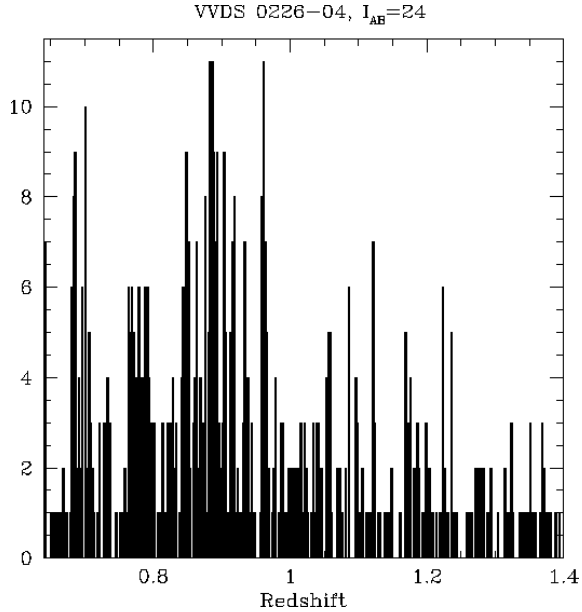


Figure 6: Distribution of first measured redshifts in the VVDS deep field.

The survey, which started in Autumn 2002 with 20 successful observing nights, required a lot of scientific preparation. In particular, during the year 2002 we worked on the following topics:

• We collaborated in the production of the photometric multiband ($BVRI + K$) catalogues which are the starting point of the spectroscopic survey. In particular we applied various tests to these catalogues in order to verify the quality of the data.

• We are working on the development of tools for the scientific analysis of the survey: in particular, we concentrated on the luminosity function analysis, implementing different estimators and testing their statistical robustness on simulated samples with different completeness.

• We compared the results of different cluster finding methods, applying the various algorithms on simulated samples.

• We are working on the preparation of the tools which will be used in the statistical analysis of the galaxy distribution, in particular on the correlation function and high-order statistics; we are presently testing the best methods to correct for incompleteness and observational biases, and the tools for data reduction.

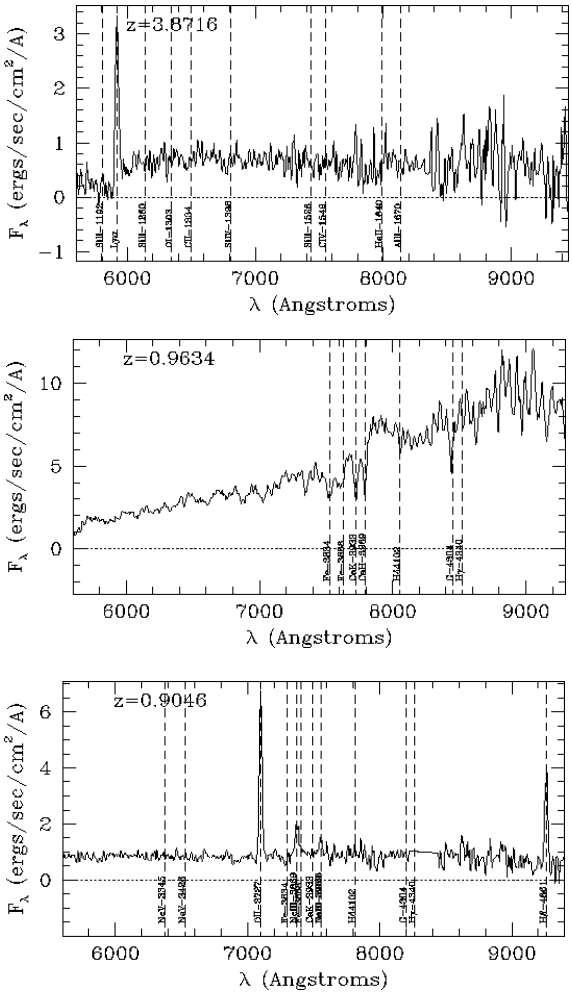


Figure 7: Some example of spectra from the first VVDS observations.

• We are working on the preparation of different models of galaxy evolution in the framework of a Pure Luminosity Evolution (PLE) scenario to be used for comparison with the observed galaxy redshift distribution.

From the first spectroscopic observations, more than 21000 galaxy spectra were obtained: we are currently analyzing part of these data, testing the whole reduction procedure (from the raw data to the monodimensional calibrated spectra) and measuring the redshifts. The distribution of the redshifts already measured is shown in Fig. 6, while in Fig. 7 some spectra from the first observations are presented.

2.3.2 The VIRMOS RADIO survey

People involved: Ciliegi, de Ruiter, Zamorani.

The radio survey has been obtained with the VLA at 1.415 GHz in one of the VIRMOS region where deep $BVRI$ band photometry has been already obtained with the CFHT to a limiting magnitude (5σ) of about 25.5 and, for a fraction of the area, in the U and K bands with the ESO telescopes to a limiting magnitude of 25 and 20 respectively. The VIRMOS VLA radio survey has mapped an area of 1 square degree with a uniform noise of $\sim 85\,\mu$Jy (5σ). A catalogue of radio sources brighter than the local 5σ threshold has been extracted from the 1 degree radio map. It contains 1054 radio sources, 19 of which are considered as multiple, i.e. fitted with at least two separate components. The source counts obtained with this radio catalogue are in very good agreement with those obtained with other surveys. In particular, our point at the faintest flux level (~ 0.1 mJy) is fully consistent (with more robust statistics thanks to the higher number of sources and a large area covered) with the points obtained with a very deep radio observation in the Hubble Deep Field (HDF).

Subsequently, using the already available optical data, we performed a detailed optical identification using a Likelihood Ratio Analysis. We found $\sim$ 730 reliable optical counterparts. The expected number of spurious identifications is ~ 40 leading to an identification percentage of $\sim 70\%$.

The analysis of the multiband properties of the optical counterparts (magnitude distributions and color–color diagrams) is in progress.

2.3.3 The K20 Redshift Survey

People involved at OAB: Mignoli, Pozzetti, Zamorani.

The Bologna Observatory participates, with the observatories of Arcetri, ESO and Rome, in an ESO VLT Large Program (PI Cimatti, Arcetri Obs.), which started in 1999. This program (called K20[4]) aims at deriving the redshift distribution of a galaxy sample complete at $K < 20$ in order to obtain stringent clues on the formation and evolution of present-day massive galaxies. The sample consists of about 500 galaxies selected from a sub-area of the Chandra Deep Field (CDF) and from a field around the quasar 0055−2659 ($z = 3.7$). Seventeen VLT nights have been allocated to this project over a period of two years. The survey makes use of both optical (FORS1/FORS2) and near-IR (ISAAC) spectroscopy. The observations were completed in 2000 and provided spectra of about 90% of the galaxies down to a completeness level of about $K < 20$. The spectroscopic data reduction and analyses have been carried out in parallel at Bologna and Arcetri. The photometric sample and completeness analysis has been presented by Cimatti et al., 2002. The scientific analysis is still in progress and the main results obtained up to now can be summarized as follows:

- From the spectroscopic sub-sample of EROs, we have derived, for the first time, the fractions of old and dusty star-forming galaxies in the ERO population (Cimatti et al., 2002), showing that the two classes are about equally populated. The colors and the average spectrum of old EROs are consistent with a minimum age of ~ 3 Gyr, corresponding to a formation redshift of $z_f > 2.4$, while the average spectrum of the star-forming EROs suggests a substantial dust extinction with $E(B-V) > 0.5$, implying typical star formation rates of 50–150 $M_\odot$/yr and a significant contribution from EROs to the cosmic star-formation density at $z \sim 1$ (Cimatti et al., 2002).

- We have derived information on the different spatial clustering of these two classes of EROs (Daddi et al., 2002), showing a much higher clustering and correlation length for old EROs than for the dusty population.

[4] *http://www.arcetri.astro.it/∼k20/*

- We have completed the comparison between the observed redshift distribution of the whole sample of galaxies and different models of galaxy formation and evolution (Cimatti, Pozzetti et al., 2002). A major result was the discovery of a significant high-redshift tail (32% and $\sim 9\%$ of galaxies at $z > 1$ and $z > 1.5$ respectively), not consistent with current versions of Hierarchical models of galaxy formation.

- We have carried out the determination and analysis of the near-IR (J and Ks band) Luminosity Functions from the spectro-photometric catalog of galaxies down to redshift ~ 1.9 (Pozzetti et al., 2003). The data are consistent with a *mild luminosity evolution* of the whole near-IR LFs and, in particular, *red and early-type galaxies dominate the bright-end of the LF*, and their number density shows at most a small decrease ($< 30\%$) up to $z \simeq 1$, thus suggesting that massive elliptical galaxies were already in place at $z \simeq 1$ and *they should have formed their stars and assembled their mass at higher redshift.* The comparison with the current versions of galaxy formation and evolution models shows that hierarchical models (Cole et al., 2000; Kauffmann et al., 1999) significantly overpredict the density of low luminosity galaxies at $z \leq 1$ and underpredict the density of luminous galaxies at $z \geq 1$ (see Fig. 8), whereas passive evolution models are more consistent with the data up to $z \sim 1.5$.

Presently, in Bologna, we are collaborating with the Rome Observatory to derive the evolution of the Galaxy Stellar Mass Function and completing the analysis of the spectroscopic sample, both studying the properties of the single object spectra, and constructing averaged templates for different spectral classes and/or different redshift bins, with the aim of characterizing a possible spectral evolution. Moreover the K20 survey is triggering several follow up studies in which we are involved. Ultradeep and high resolution spectroscopy was obtained in November 2002 with FORS2 to derive information on previously unidentified EROs and $z > 1.7$ galaxies and to study the kinematics of $z > 1$ galaxies in order to estimate their dynamical masses. The CDFS sub-area of the K20 survey is also a target of the HST+ACS GOODS Treasury Programme (P.I. Giavalisco) and of the SIRTF GOODS (P.I. Dickinson) Legacy Programme. These data will allow to derive new constraints on the masses and evolution of galaxies out to higher redshifts.

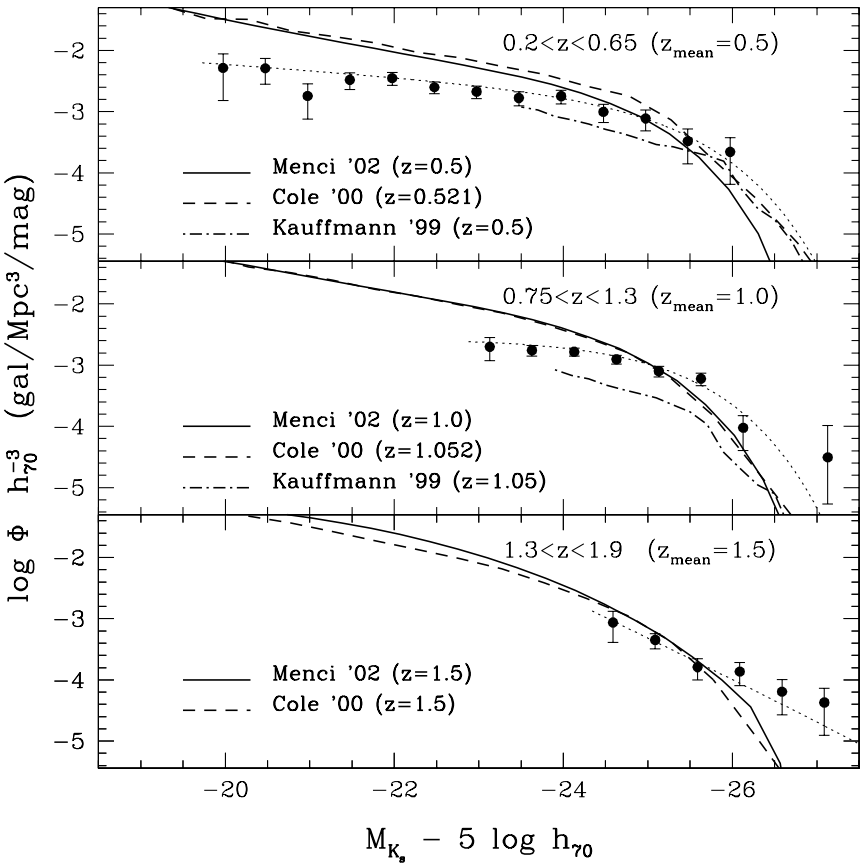


Figure 8: The rest-frame K_s-band Luminosity Function in the redshift bins: $z_{mean} \simeq 0.5$ (top panels) $z_{mean} \simeq 1.0$ (middle panels) and $z_{mean} \simeq 1.5$ (bottom panels) compared to various hierarchical models.

2.3.4 Radio observations of the ESP Survey

People involved at OAB: de Ruiter.

The whole ~ 25 square degree region of the ESO Slice Project was observed at 20 cm with the Australia Telescope Compact Array, using the mosaicking technique (Prandoni et al., 2000, paper I: A&AS, 146, 31; paper II: A&AS, 146,41; paper III: A&A, 365, 392; paper IV: 2001, A&A, 369, 787). The resulting radio catalogue (ATESP) contains about 3000 radio sources down to a 20 cm flux limit of ~ 0.4 mJy. The radio data (including new data at 5 GHz) are now being used for various purposes: (a) determining the radio properties of ESP galaxies (e.g. radio luminosity function of various types of galaxies), (b) deep radio source counts and optical identification of ATESP sources, (c) detailed optical studies of smaller selected areas: at present a sample of almost 70 objects, complete down to $I = 19.0$ has been observed at ESO, and spectroscopic data are available for all objects. Spectroscopy of part of the fainter objects has recently been carried out with the VLT and analysis of the spectra is in progress.

2.3.5 Bright galaxies from WENSS

People involved at OAB: de Ruiter, Stirpe.

The Westerbork Northern Sky Survey has mapped the sky (above declination $+30^{o}$) at 325 MHz (and is complementary to the NVSS survey at 20 cm made by the VLA). The overall catalogue contains about 200000 radio sources with flux density above 15 mJy. Work is in progress at Bologna Observatory to extract from the WENSS catalogue all radio sources associated with "bright" (i.e. $m_r < 16.5$) galaxies. All automatic procedures used in the extraction process have now been tested, and a preliminary list of about 4000 WENSS bright galaxies is available; the final list is expected to be available by the end of 2003. Several spin-off programmes are in progress: a number of possible relic radio sources (characterized by a steep radio spectral index) were selected for further study with the VLA. Second, a number of distorted (bent) radio sources were selected, since they may be used as tracers of distant clusters; the imaging data obtained at ESO are being analyzed at present.

2.3.6 X-ray Surveys

People involved at OAB: Ciliegi, Comastri, Mignoli.

The Beppo-SAX *High Energy Llarge Area Survey* (HELLAS) has surveyed for the first time several tens square degrees of the X-ray sky in the very hard 5–10 keV band. A significant fraction of the 147 serendipitous hard X-ray sources has been the subject of detailed X-ray studies and extensive multiwavelength observations. The radio survey of the entire sample has been recently completed thanks to VLA and ATCA observations at 6 cm (3σ flux limit ~ 0.3 mJy). We found 53 likely X-ray/radio associations, 26 of which are classified as radio-loud objects (Ciliegi, Vignali, Comastri et al., 2003). In agreement with previous results, the identified radio-loud sources are associated mainly with Type 1 AGNs with $\mathrm{L}_{5-10\,\mathrm{keV}} > 10^{44}$ erg s^{-1}, while all the identified Type 2 AGNs and Emission Line Galaxies are radio quiet objects with $\mathrm{L}_{5-10\,\mathrm{keV}} < 10^{44}$ erg s^{-1}. The analysis of the radio spectral index suggests that Type 1 AGNs have a flatter slope ($\langle\alpha_{AGN1}\rangle = 0.25\pm0.1$) than Type 2 AGNs and Emission Line Galaxies ($\langle\alpha_{AGN2}\rangle = 0.69 \pm 0.11$). This result is in agreement with the idea that the core-dominated radio emission from Type 1 AGNs is self-absorbed, while in AGN2 and Emission Line Galaxies the radio emission take place on larger physical scale, without self-absorption.

The HELLAS survey has been extended making use of 15 XMM–Newton public observations covering an area of about 4 square degrees at relatively shallow hard X-ray fluxes ($F_{2-10\,\mathrm{keV}} > 10^{-14}$ erg cm^{-2} s^{-1}). The `HELLAS2XMM` project is carried out in collaboration with the Arcetri Observatory, Rome Observatory, Rome 3 University and IASF–CNR, Milan. The most important scientific objective is to obtain the first reliable evaluation of the luminosity function of hard X-ray selected sources over a wide range of luminosities and redshifts. By integrating this luminosity function we will compute the hard X-ray luminosity density per unit volume due to accretion as a function of redshift. The survey strategy has been designed to be complementary to deep pencil beam surveys by sampling a different portion of the luminosity–redshift plane in order to:

- fill the gap in the luminosity–redshift plane between the local and deep surveys, to obtain a complete measure of the density and evolution of X-ray selected AGN;

- collect a number of sources large enough, for statistical purposes, for which, on the one hand, at least a basic X-ray spectral characterization is achievable and, on the other hand, a redshift (spectroscopic if possible, photometric otherwise) can be measured. It is very important that a sufficient number of sources selected in the hardest possible band is also collected, to reduce the very strong bias against absorbed sources which occurs when selection is made in soft X-rays.

Without this information the separate study of the evolution of obscured and unobscured AGN is hardly feasible.

One third of the HELLAS2XMM fields (covering an area of about 1 square degree) were selected for follow-up observations in the optical band using the ESO 3.6m and VLT and the TNG 3.5m telescopes. The X-ray sample consists of 126 sources with a complete imaging and 80% spectroscopic coverage down to $R = 24$. Clear evidence of luminosity-dependent evolution (low luminosity sources peaking at a later cosmic time) is present, confirming and extending results obtained from deep surveys. At the same time several multiwavelength (radio, sub-mm and near infrared) follow-up programs have been or are being carried out on a fraction of these fields. For two specific fields high spatial resolution Chandra X-ray data are also available.

The most surprising finding is the discovery of a population of presumably obscured AGN which are characterized by values of their X-ray to optical flux ratio (X/O) significantly different from those of optically and soft X-ray selected, spectroscopically identified AGN. The very nature of these objects is at present unknown. Following Comastri, Brusa & Mignoli (2003) we refer to them as unconventional AGN (Fig. 9). It has been found convenient to divide these objects in two groups: the first includes sources that are X-ray weak for their R band magnitudes ($\log(\mathrm{X/O}) < -1$); the second, sources that are optically faint (sometimes below the limits of deep optical images) and relatively X-ray bright ($\log(\mathrm{X/O}) > 1$).

The identification breakdown of the sources in the first group is a mixed bag including emission line galaxies and apparently normal galaxies. A sizeable fraction of the latter, named XBONG (X-ray Bright Optically Normal Galaxies; Comastri et al., 2002b), are particularly intriguing, being characterized by an absorption-dominated optical spectrum and AGN-like hard X-ray luminosities ($\mathrm{L}_{2-10\,\mathrm{keV}} \sim 10^{42-43}$ erg s^{-1}). They are found at moderately low redshift ($z < 1$),

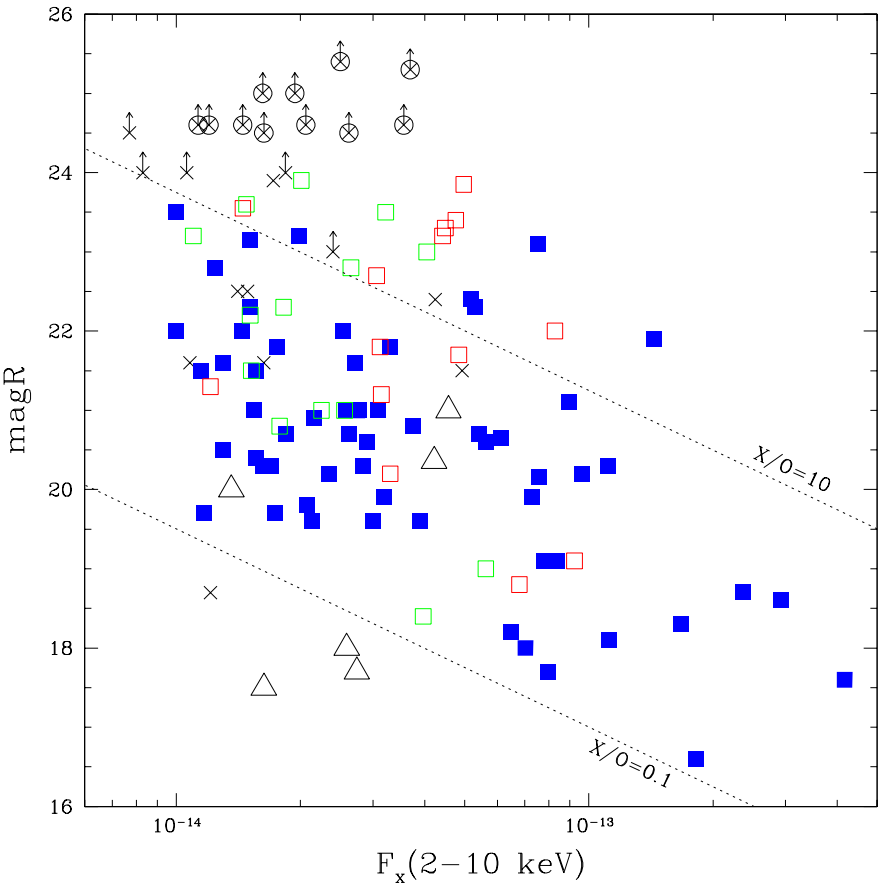


Figure 9: The 2–10 keV flux versus the R band optical magnitude for the sources in the `HELLAS2XMM sample`. The source breakdown is reported with different symbols: filled squares = broad line AGNs; empty squares = narrow line AGNs; triangles = early type galaxies; crosses = unidentified sources.

and are suspected to host a completely obscured AGN, though alternative possibilities are viable. The sources characterized by high values of f_X/f_{opt} are even less understood. Only a handful of them have been spectroscopically identified and turned out to be high-redshift, highly obscured AGN. Interestingly enough, a sizeable fraction of the high X/O sources have extreme near-infrared to optical colors and satisfy the ERO (Extremely Red Objects) color criterium ($R - K > 5$).

This work is carried out in collaboration with M. Brusa (Astronomy Dept., University of Bologna).

2.3.7 Deep Radio Survey in the Lockman Hole

People involved at OAB : Ciliegi, Zamorani.

We have obtained a deep radio image with the Very Large Array at 6 cm in the Lockman Hole, where excellent data are already available at 20 cm, in the far-infrared band, in the near infrared and optical bands and in the X-ray band. The radio noise level in the central part of the field is $\sim 11\mu$Jy. From these data we have extracted a catalogue of 63 radio sources with a maximum distance of 10 arcmin from the field center and with peak flux density greater than 4.5 times the local rms noise. The differential source counts are in good agreement with those obtained by other surveys. The analysis of the radio spectral index suggests a flattening of the average radio spectra and an increase of the population of flat spectrum radio sources in the faintest flux bin. Cross correlation with the ROSAT/XMM X-ray sources list yields 13 reliable radio/X-ray associations, corresponding to $\sim 21\%$ of the radio sample. Most of these associations (8 out of 13) are classified as Type 2 AGN.

Using optical CCD (V and I) and K' band data with approximate limits of $V \sim 25.5$ mag, $I \sim 24.5$ mag and $K' \sim 20.2$ mag, we found an optical identification for 58 of the 63 radio sources. This corresponds to an identification rate of $\sim 92\%$, one of the highest percentages so far available. From the analysis of the colour–colour diagram and of the radio flux–optical magnitude diagram we have been able to select a subsample of radio sources whose optical counterparts are likely to be high redshift ($z > 0.5$) early-type galaxies, hosting an Active Galactic Nucleus responsible of the radio activity. This class of objects, rather than a population of star-forming galaxies, appears to be the dominant population ($\geq 50\%$) in a 5 GHz selected sample with a flux limit as

low as 50 μJy.

We also find evidence that at these faint radio limits a large fraction ($\sim 60\%$) of the faintest optical counterparts (*i.e.* sources in the magnitude range $22.5 < I < 24.5$) of the radio sources are EROs with $I - K' > 4$ and combining our radio data with existing ISO data we conclude that these ERO sources are probably associated with high-redshift, passively evolving elliptical galaxies. The six radio selected EROs represent only $\sim 2\%$ of the optically selected EROs present in the field. If their luminosity is indeed a sign of AGN activity, the small number of radio detections suggests that a small fraction of the EROS population contains an active nucleus.

2.3.8 The ELAIS Survey

People involved at OAB : Ciliegi, Pozzi, Zamorani.

ELAIS is a large European project, involving 19 different institutes, aimed at studying the nature and evolution of the extragalactic sources detected by the Infrared Space Observatory (ISO) in a selected area of the sky (covering 12 sq. deg.). From the analysis of the ISOCAM data in the southern fields, we have obtained samples of sources (~ 500) in the flux range 0.45–150 mJy which we have used to study the statistical properties of infrared sources.

First, from these data we have obtained the 15 μm extragalactic source counts. The large number of extragalactic sources (~ 350) detected over this area between about 0.5 and 100 mJy guarantee a high statistical significance of the source counts in the previously poorly covered flux density range between IRAS and the Deep ISOCAM Surveys. The bright counts in S1 ($S_{15\,\mu\mathrm{m}} \geq 2$ mJy) are significantly lower than other published ISOCAM counts in the same flux range and are consistent with a flat, Euclidean slope, suggesting the dominance of a non-evolving population. At fainter fluxes ($S_{15\,\mu\mathrm{m}} \leq 2$ mJy) our counts do instead show a strong departure from no-evolution models, with a very steep super-Euclidean slope down to our flux limit (~ 0.5 mJy). Strong luminosity and density evolution of the order of, respectively, $L \propto (1+z)^{3.0}$ and $\rho \propto (1+z)^{3.5}$ is needed at least for the population of star-forming galaxies, in order to fit the counts and the redshift distributions observed at different fluxes. A luminosity break around $10^{10.8}$ $L_\odot$ must be introduced in the local luminosity function of starburst galaxies in order to reproduce our sharp increase

of the counts below 2 mJy and the redshift distributions observed for 15 μm sources at different flux levels. The contribution of the strongly evolving starburst population (down to 50 μJy) to the 15 μm cosmic background is estimated to be ~ 2.2 nW m^{-2} sr^{-1}, which corresponds to $\sim 67\%$ of the total mid-infrared background estimate.

In the framework of the follow-up of the ELAIS region, we have studied the optical, near-IR and radio properties of the complete sample of 43 sources detected at 15 μm in the ELAIS field S2. The extragalactic objects in this sample have flux densities in the range 0.4–10 mJy, where 15-μm source counts start diverging from no evolution models. About 90% of the sources (39 out of 43) have optical counterparts brighter than $I = 21$. Eight bright sources have been identified with stars on the basis of imaging data, while for other 22 sources we have obtained spectroscopic data, reaching a high identification percentage (30/43, $\sim 70\%$). All but one of the 28 sources with flux density > 0.7 mJy are identified. Most of the extragalactic objects are normal spiral or starburst galaxies at moderate redshift ($z_{med} \sim 0.2$); four objects are Active Galactic Nuclei. We have used the 15-μm, Hα and 1.4-GHz luminosities as indicators of star-formation rate and we have compared the results obtained in the three bands. While 1.4-GHz and 15-μm estimates are in good agreement, showing that our galaxies are forming stars at a median rate of ~ 40 M$_\odot$ yr^{-1}, the raw Hα-based estimates are a factor $\sim$5–10 lower and need a mean correction of ~ 2 mag to be brought on the same scale as the other two indicators. A correction of ~ 2 mag is consistent with that suggested by the Balmer decrements Hα/Hβ and by the optical colours. Moreover, it is intermediate between the correction found locally for normal spirals and the correction needed for high-luminosity 15-μm objects, suggesting that the average extinction suffered by galaxies increases with infrared luminosity.

Finally, using the deep radio and 15-μm data in the ELAIS regions, we have studied the radio–MIR correlation for the first time at these flux densities and for a sample of this size (~ 100 radio-ISO associations). Our results show that radio and MIR luminosities correlate almost as well as radio and FIR, at least up to $z \simeq 0.6$. Using the derived relation and its spread together with the observed 15-μm counts, we have estimated the expected contribution of the 15-μm extragalactic populations to the radio source counts and the role of MIR starburst galaxies in the well known 1.4-GHz source excess observed at sub-mJy levels. Our analysis demonstrates that IR emitting star-

burst galaxies do not contribute significantly to the 1.4-GHz counts for strong sources, but start to become a significant fraction of the radio source population at flux densities $\leq$ 0.5–0.8 mJy. They are expected to be responsible for more than 60% of the observed radio counts at $\leq$ 0.05 mJy. These results are in agreement with the existing results on optical identifications of faint radio sources.

2.3.9 Deep Extragalactic Surveys in the Marano Field

People involved at OAB: Calabrese, Mignoli, Zamorani.

The *Marano Field* is a southern sky area extensively surveyed in the optical (by means of multicolor imaging, slitless and slit spectroscopy, variability), in the X-rays (with a ROSAT $\sim$ 60 ksec integration) and in the radio band (with the ATCA radio telescope (S_{lim} = 0.2 mJy) at 1.4 and 2.4 GHz). Including the recently performed ISO and XMM observations, it is one of the best studied regions of the sky at all wavelengths.

The existing observations have already provided:

• 70 spectroscopically confirmed AGNs with $B_J \leq 22.5$ (Zitelli, Mignoli, Zamorani, Marano & Boyle 1992, MNRAS, 256, 349).

• A complete sample of 50 X-ray sources with $S_x > 3.7 \times 10^{-15}$ erg-cm^{-2} s^{-1}, derived from one of the deepest ROSAT surveys. Of these, 84% have been optically identified (Zamorani, Mignoli, et al., 1999, A&A, 346, 731). AGNs are by far the dominant class of counterparts of these X-ray sources, representing 71% of the optical identifications obtained.

• A deep radio sample for which $\sim$ 63% of optical photometric identifications and 50% of spectroscopic identifications, at typically $R_{lim} < 23$, were obtained (Gruppioni, Mignoli, Zamorani 1999, MNRAS, 304, 1999); these are still among the highest identification fractions available so far in literature for sub-mJy radio samples.

• A deep optical multicolor catalogue of an area of about 0.15 sq.deg. in the same sky region, has been obtained through CCD photometry at the ESO NTT telescope in the past years. From this catalog faint quasar candidates with magnitudes up to $B = 23.5 \div 24.0$ were selected. A significant fraction of these candidates has been observed spectroscopically with FORS1 at the VLT. The analysis of these data suggests that the efficiency of AGN selection based on the standard criteria (colors + morphology) decreases significantly at $B > 23.0$. At

these magnitudes most of the UV selected, point-like objects turn out to be extremely compact narrow emission line galaxies at $z \sim 0.6$–1.2, with the classical broad line AGNs being only about 20% of the total number of candidates. These new data, allow to firmly estimate the surface density of AGNs at $B \sim 23.5$, where very few data exist, and to test at fainter magnitudes the existing models of luminosity function and evolution, which have now been firmly established on the basis of large samples (2dF survey) limited at $B \sim 21$.

• With the Wide Field Imager (WFI) operating at the 2.2m ESO telescope, the Marano Field has been observed in five optical bands in a wider region, approximately 30×30 sq.arcmin. The data reduction and multi-colour database construction has been completed during this year. This work has been the main subject of an OAB scientific contract obtained by E. Calabrese and financially supported by MIUR grant Cofin–2001. The catalog contains ≈ 55000 objects with photometric ($UBVRI$) and morphological information. In three bands (BVR) the quality of the images is excellent (seeing $\sim$0.8 arcsec) and will permit an optimal separation between point-like (stars, quasars) and extended (galaxies) objects up to $V \sim 24$. The main scientific objectives with these deep and wide photometric data are the following:

- Since the field of view includes nearly the totality of the region covered by the XMM-Newton observations, it will allow to identify a large fraction of faint X–ray sources detected in this field.

- On the basis of the NTT multicolor-selected sample, we will be able to select a sample of about one hundred quasar candidates at $B < 23.5$, and a similar number with $23.5 < B < 24.5$; about 25 of these candidates are expected to be high redshift quasars ($z > 3$), and will form the largest sample of quasars at these magnitudes.

- Of particular interest will be the comparison between the X-ray selected and the optically selected quasar samples, in order to check if the X-ray AGNs would have been identified also on the basis of their optical colors and morphology. To our knowledge the Marano Field is unique in both hard X-ray and multicolor optical coverage, especially in the U band, at these faint flux levels.

- In the catalog we have more than 30000 galaxies detected in all five bands: photometric redshifts, using all the optical bands and the near infrared data obtained by our collaborators (G. Lamer, Potsdam), will be used to study the evolution of the galaxy luminosity function up to $z \sim 1.5$.

2.3.10 Extremely Red Objects

People involved at OAB: Comastri, Mignoli, Pozzetti

Extremely Red Objects (EROs, $R - K > 5$) form a heterogeneous class of sources including high-redshift elliptical galaxies, dusty star-forming systems and heavily obscured AGN. Hard X-ray observations provide a unique and powerful tool to disentangle between the various possibilities. We have considered the 21 spectroscopically identified EROs of the K20 sample in the Chandra Deep Field South which includes 13 "dusty" objects showing at least an emission line and 8 "old" galaxies with an absorption line spectrum typical of early-type galaxies. Only one object is detected in the deep *Chandra* observation: a "dusty" galaxy at $z = 1.327$. The very hard X-ray spectrum and the high X-ray luminosity unambiguosly reveal the presence of an obscured AGN. Stacking analysis of those objects not individually detected in the X-rays suggests that different spectroscopic classes of EROs are characterized by different high-energy properties. Indeed, "dusty" EROs are moderately luminous hard X-ray emitters and their average X-ray spectrum is consistent with that measured for nearby star-forming galaxies. Early-type galaxies among EROs are not detected in the X-rays and their 3σ upper limit on the soft X-ray luminosity is consistent with the emission from nearby elliptical galaxies.

This work is carried out in collaboration with M. Brusa (Astronomy Dept., University of Bologna).

2.4 Galaxy clusters and large-scale structure

2.4.1 The Shapley Concentration

People involved at OAB: Bardelli, Giacintucci, Zucca.

A long term project in which the extragalactic group is involved is the multiwavelength study of the Shapley Concentration, the richest

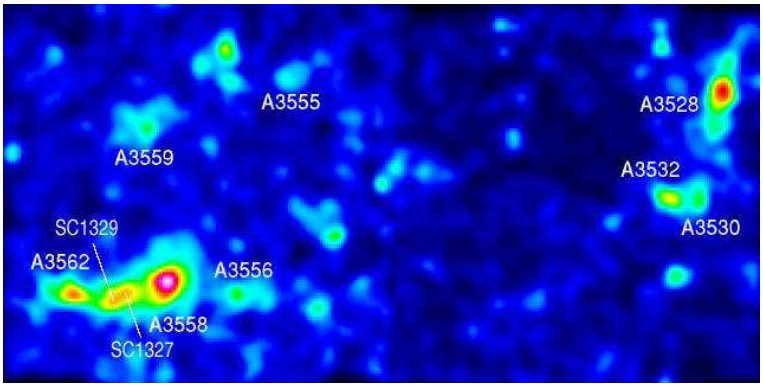


Figure 10: Bidimensional isodensity contours of optical galaxies in the central part of the Shapley Concentration: the A3528 complex is on the upper right, the A3558 complex is on the lower left.

supercluster in the nearby Universe. This study is devoted to investigating the effects of the environment and of the merging phenomena on the physics of clusters and on their galaxy population. In particular, the central part of superclusters are ideal laboratories in which to study dynamical processes, given the high peculiar velocities induced by the density excess.
We focused our attention on the three structures formed by interacting clusters (the A3558 complex, the A3528 complex and the A3571 complex) which dominate the core of the Shapley Concentration (see Fig. 10). In particular from all our data and analyses we concluded that these complexes are part of an evolutionary sequence: the A3528 complex is at the very beginning of a merger event, where the two merging entities have just started "to feel each other"; the A3558 complex is thought to be an advanced merger, where two clusters of similar mass have already undergone the first core–core encounter; the A3571 complex represents the final stage of a merger event, where A3571 itself is the resulting cluster after virialization of the merger.

The main results of this work in the year 2002 were the following:
• In the last years we performed an extensive radio survey in the region of the three cluster complexes, in order to find the effects of major merging events on the radio emission of the galaxy population. The most remarkable result was a significant deficiency of radio galaxies in the A3558 complex (Venturi, Bardelli et al. 2000), consistent with an ongoing merging. In order to better investigate this point we carried

on a deeper survey in the region of A3562 and SC1329-131 at 1.4 GHz, in the A3558 complex. We confirmed the presence of a radio halo and of a head tail radio galaxy at the centre of the cluster A3562. We performed a detailed radio multifrequency study of the head tail galaxy, which is completely embedded in the halo emission (Venturi et al., 2003). The radio halo has an irregular shape, and a largest linear size of ~ 620 kpc, which is among the smallest found in the literature. The source has a steep spectrum, i.e. $\alpha^{1.4\,\mathrm{GHz}}_{843\,\mathrm{MHz}} \sim 2$, and its total radio power, $\mathrm{P}_{1.4\,\mathrm{GHz}} \sim 2 \times 10^{23}$ W Hz^{-1}, is the lowest known to date. The radio power of the halo and the X-ray parameters of the cluster, such as L_X and kT, nicely fit the correlations found in the literature for the other halo clusters, extending them to low radio powers. We found that the total number of electrons injected in the cluster environment by the head tail source is enough to feed the halo, if we assume that the galaxy has been radio active over a large fraction of its crossing time.

• It is known that cluster spiral galaxies tend to have less HI with respect to the field objects. It has been proposed that the dynamical events acting during a merging could be responsible for the HI depletion. In order to check this hypothesis, we started a project aimed at observing the neutral hydrogen content of spirals in the A3558 complex. As pilot observations, we obtained time at the ATCA telescope for the coverage of three fields with exposure time of 12 hours each in a band corresponding to the velocity interval [10700–18000] km s^{-1}. The data are currently in the reduction phase.

This work is carried out in collaboration with T. Venturi, G. Brunetti (IRA–CNR, Bologna), D. Dallacasa (Astronomy Dept., University of Bologna), R. Morganti (NFRA, Dwingeloo) and R.W. Hunstead (Sydney Univ.).

• We analyzed two Beppo-SAX observations of the poor groups SC1327 −312 and SC1329−313, which are in between the two clusters A3558 and A3562, to look for the possible presence of shocks (Bardelli et al. 2002). We derived the gas distribution profiles, the global (*i.e.* within 0.3 Mpc) temperatures and abundances and the temperature profiles and maps for SC1327−312 and SC1329−313. We did not find evidence of regions where the gas is shocked or significantly heated. The image of SC1327−312 seems rather symmetric, while the gas profile of SC1329−313 shows disturbed, comet-like shaped isophotes, with the tail pointing toward A3562 and a compression toward SC1327−312. The presence of multiphase gas in SC1329−313, as claimed by Hanami

et al. (1999) on ASCA data, has been found only at the 2-sigma confidence level. The lack of heating supports the hypothesis that the merging is at a late stage, after the first core–core encounter, when the main shock front had the time to travel to the external regions of the main clusters.
Moreover, we studied A3560, a rich cluster at the southern periphery of the A3558 complex. From a ROSAT–PSPC map we found that the X-ray surface brightness distribution of A3560 is well described by two components, an elliptical King law and a more peaked and fainter structure, which has been modeled with a Gaussian. The main component, corresponding to the cluster, is elongated with its major axis pointing toward the A3558 complex. The second component, centered on the Dumb-bell galaxy which dominates the cluster, appears significantly offset (by about 0.15 h^{-1} Mpc) from the X-ray centroid of the cluster. From a Beppo-SAX observation we derived the radial temperature profile, finding that the temperature is constant (at $kT \sim 3.7$ keV) up to 8 arcmin, corresponding to 0.3 h^{-1} Mpc: for larger distances, the temperature significantly drops to $kT \sim 1.7$ keV. We analyzed also temperature maps, dividing the cluster in 4 sectors and deriving the temperature profiles in each sector: we found that the temperature drop is more sudden in the sectors which point towards the A3558 complex. From VLA radio data, at 20cm and 6cm, we found a peculiar bright extended radio source (J1332−3308), formed by a core (centered on the northern component of the Dumb-bell galaxy), two lobes, a "filament" and a diffuse component. The morphology of the source could be interpreted either with a strong interaction of the radio source with the intracluster medium or with the model of intermittency of the central engine.
• From an X-ray ROSAT–PSPC observation, Schindler (1996) and Henriksen & Jones (1996) found that A3528, the dominant cluster of the A3528 complex, is actually double, with the two components separated by 0.65 h^{-1} Mpc. From a temperature map, these authors concluded that the two clumps are starting to interact, with some evidence of heating of the diffuse gas in the regions of the components facing each other. We observed A3528 with a 16 *ksec* XMM-Newton pointing, which permitted to estimate global temperatures and temperature and abundance profiles (Gastaldello, ..., Bardelli, Zucca et al., 2003, A&A, submitted). We did not confirm the Schindler and Henriksen & Jones claim of gas heating, even if we found some shared diffuse gas. The results of our analysis confirmed our claim that in

the A3528 complex the merging is at the very initial stages.
This work is carried out in collaboration with S. Ettori (ESO), S. DeGrandi (INAF – Milan Obs.), S. Molendi, F. Gastaldello (IASF-CNR, Milan) and T. Venturi (IRA-CNR, Bologna).
Further information about this project can be found on the WEB [5].

2.4.2 Optically selected galaxy clusters at high redshift

People involved at OAB: Bardelli, Zucca.

A sample of a few hundred galaxy cluster candidates has been extracted from the wide angle multicolor ESO Imaging Survey (EIS), using a matched filter algorithm in the I band. The estimated redshift range of these candidates has a high redshift tail reaching $z \sim 1.3$. This sample will allow to determine the structural parameters and the galaxy population characteristics of clusters of different richness in a wide range of redshifts (Da Costa, ..., Bardelli, Zucca et al. 2001, proc. of *ESO workshop on Deep Fields*, Cristiani et al. eds., p.187).
A great effort has been undertaken in order to have a spectroscopic confirmation of a subsample of high redshift EIS clusters. In particular, we confirmed three clusters at $z = 0.81, 1.14, 1.30$ (Benoist, ..., Bardelli, Zucca et al., 2002). It is particularly important that the two systems at $z > 1$ are the most distant clusters identified so far by their optical properties alone. The cluster at $z = 1.30$ coincides remarkably well with the location of a firm X-ray detection ($> 5\sigma$) in a ~ 80 ksec XMM-Newton image (Neumann, ..., Bardelli, Zucca et al. 2003, A&A in press). Moreover, we detected in the same image another X-ray emission from a serendipitously found concentration of infrared galaxies at an estimated redshift of $z = 1.7$. The two emissions are consistent with a point-like profile and therefore are likely to be associated with cluster AGN. However, we cannot exclude that the hot gas emission of the clusters is extremely peaked, as expected for proto-clusters.
This work is carried out in collaboration with L. da Costa and S. Arnouts (ESO), C. Benoist (Nice Observatory), L. Olsen and H. Jørgensen (Copenhagen Observatory), A. Biviano and M. Ramella (INAF – Trieste Obs.), M. Scodeggio (IASF–CNR, Milano), D. Neumann and M. Arnaud (CEA/CEN Saclay).

[5] *http://www.bo.astro.it/~bardelli/shapley/shapley_new.html*

2.4.3 Galaxy clusters and large-scale structure

People involved at OAB: Bardelli, Cappi, Zucca.

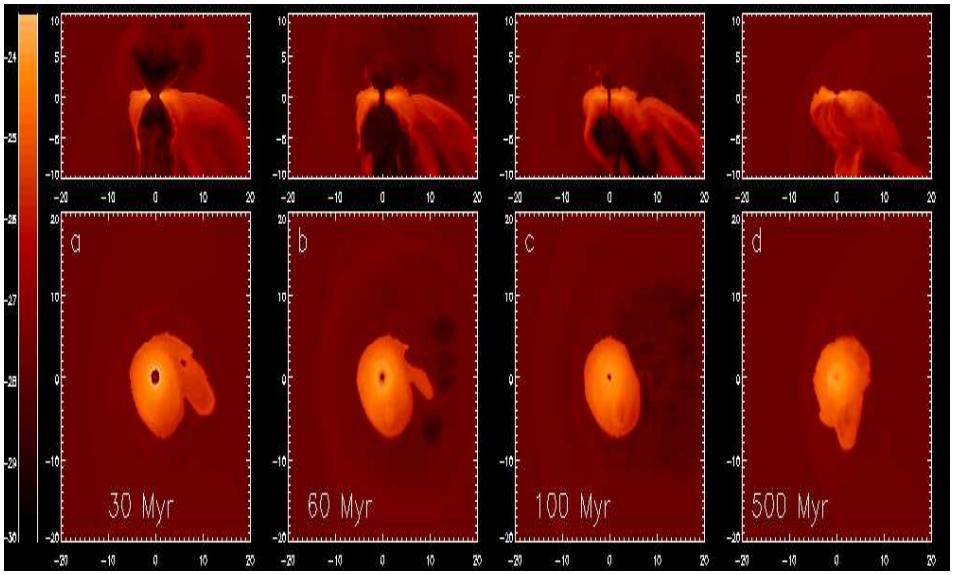
A. Cappi is involved in a project (MUSIC, MUltiwavelength Sample of Interacting Clusters) with researchers at the Observatoire de la Côte d'Azur (Maurogordato, Benoist, Bijaoui, Ferrari, Slezak) and at the CEA/CEN in Saclay (M. Arnaud, J–L. Sauvageot), aiming at a combined optical and X-ray study of galaxy and gas dynamics in a selected sample of galaxy clusters. This project is mainly based on optical observations at the ESO 3.6m and CFHT telescopes, and on X-ray observations with ASCA and ROSAT, and with Chandra and XMM-Newton. A number of results have been obtained for A521, a complex, relatively rich cluster at $z \sim 0.25$, in the middle of two filamentary structures, with on–going merging (Maurogordato, ..., Cappi et al. 2000, Ferrari, ..., Cappi et al. 2003). New spectroscopic observations have increased the number of known redshifts, giving a detailed map of the substructures and dynamics of this complex system, while more imaging and spectroscopic observations are scheduled to study the star-forming galaxies in the cluster and their distribution. A dynamical study is currently carried out also on another, regular cluster, A1413, for which the Sunyaev–Zeldovich effect has also been detected, and on A3921 and A1750. Other clusters will be observed and will form a database suited for a systematic study of merging clusters.

S. Bardelli, A. Cappi and E. Zucca, in collaboration with F. Marini, L. Moscardini (Astronomy Dept., University of Bologna), S. De Grandi (INAF – Milano Obs.) and S. Ettori (ESO) are studying the two clusters A2061 and A2067 in the central region of the Corona Borealis supercluster. These two clusters appear to be separated by 1.8 h^{-1} Mpc on the plane of the sky, suggesting the possible presence of interaction. From two Beppo-SAX observations (50 ksec each), we estimated the global temperatures, the temperature profiles and maps for A2061 and A2067. We did not find evidence of interaction between these two clusters. However, from an analysis of the bi-dimensional distribution of the hot gas, A2061 turned out to be elongated along the axis connecting its two dominant galaxies. Moreover, in-between these two galaxies we found evidence of a significant increase of temperature, due to a shock with a Mach number of 2–3. We speculated that a group of galaxies merged in A2061 and is now near the center of the cluster (Marini, Bardelli, Zucca, ..., Cappi et al., 2003, A&A, submit-

ted). The derived infall velocity is about 2000 km s^{-1}, similar to other cases found in the literature.

A. Cappi also investigates the nature of galaxy systems hosting optically very luminous galaxies (VLGs, $M_B \leq -21$); these VLGs have a correlation length comparable to clusters, but appear to be in poorer systems such as "Local Group-like" groups, as a recent study on SSRS2 VLGs and companions selected from the 2dFGRS has shown (Cappi et al., 2003). This work is carried out in collaboration with C. Benoist, S. Maurogordato (Obs. de la Côte d'Azure) and L.N. da Costa (ESO).

3 Hydrodynamics



Galactic wind in a starburst galaxy. The lower panels refer to the ISM density distribution on the galactic plane. The upper panels refer to the ISM distribution on a plane perpendicular to the galactic plane and containing the rotational axis of the galaxy. The galaxy rotates counter-clockwise and the ICM moves diagonally relative to the galaxy (from top left to bottom right in the upper panels). The first upper and lower panels refer to the end of the supernovae activity: the hole in the galactic plane and the chimney above it are apparent. Successively, the SN ejecta are dragged away by the ICM *wind* and the hole is replenished.

People involved at OAB:

- *Scientific staff:* R. Bedogni, A. D'Ercole, P. Londrillo;
- *Fellows:* A. Marcolini

A. D'Ercole, in collaboration with F. Matteucci (Trieste Univ.), S. Recchi (University of Kiel) and M. Tosi continued the studies about the effects of SN explosions in starburst galaxies. The 2D simulations performed in the past (which take into account two different istantaneous bursts) are able to describe the general chemical and dynamical characteristics of the starburst galaxy IZw18. However, an analysis of the stellar population indicates that the first star burst must be continuous over a time span of several hundreds Myr. We thus are now introducing the possibility of continuous bursts in our code. This is rather easy from a dynamical point of view, but is quite complex to take into account the different chemical composition of the newly formed stars.

In collaboration with A. Marcolini and F. Brighenti (University of Bologna), D'Ercole extended to 3D a previously developed 2D hydrocode and studied the effect of the ram pressure of the IGM on dwarf galaxies and on galactic winds generated by starburst occurring in these galaxies.

Finally, D'Ercole is writing a new hydro code based on a less dissipative scheme in order to obtain more realistic simulations of the interaction between the hot metal rich gas of the galactic winds with the cold, dense ISM. This interaction is crucial for the chemical pollution of the dwarf galaxies.

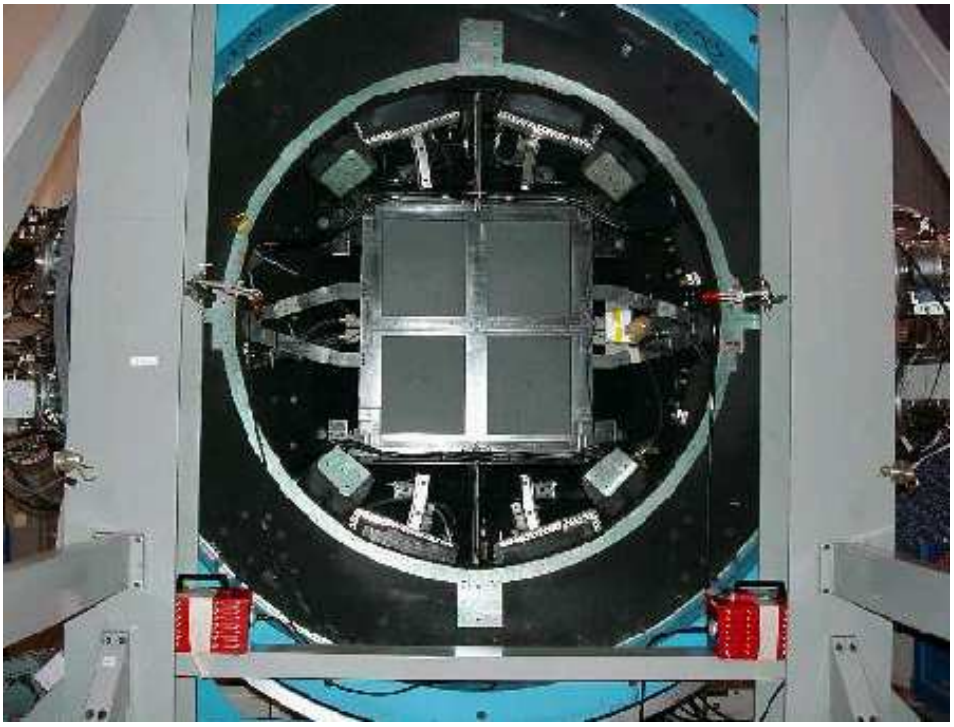
R. Bedogni has computed numerical simulation of SN remnants evolution in cloudy medium both for Type I and Type II Supernovae. Particular attention has been paid for the evolution of the Rayleigh-Taylor instabilities inside the remnants because of the effects of the cooling. More detailed simulations are done for the shock-clouds interactions for a wide range of the density contrast between the cloud and the ambient medium.

R. Bedogni, in collaboration with the A. Di Fazio, (Astronomical Observatory of Rome), introduced the effects of a variable drag, in function of the Mach and Reynold's numbers, in a more general program to obtain the dynamical evolution of a self-gravitating protocloud with turbulence. The fragmentation of a protocloud has been described using a "semi-empirical" model of turbulence.

P. Londrillo wrote a numerical code for 3D relativistic magnetohydrodynamics which is upwind shock capturing and third order accurate.

In collaboration with C. Nipoti (University of Bologna), P. Londrillo also wrote an N-body code in f90 parallelized with MPI and presented in the Convegno di Astrofisica Computazionale (Bologna 5-7 luglio 2002). This code is adopted to study the Fundamental Plane of the elliptical galaxies and its possible connection with merging phenomena.

4 Instruments and Technology



View of the internal part of the VIMOS spectrograph. The focal plane is divided in four quadrants, covering a total area of 220 arcmin^2: in each quadrant a mask is placed, which can contain hundreds of slits. (Picture taken in the integration hall at the Observatoire de Haute-Provence)

People involved at OAB:

- *Scientific staff:* S.Bardelli, C.Cacciari, N.D'Amico, F.Ferraro, R.Merighi, V.Zitelli, E.Zucca,
- *Technical staff:* G.Bregoli, G.Innocenti, P.Montegriffo, E.Rossetti

4.1 The FLAMES project

People involved at OAB: Cacciari, Ferraro, Merighi, Rossetti

The Bologna Observatory is member of the Ital-FLAMES Consortium, including also the Observatories of Trieste, Cagliari and Palermo, that participated to the completion of the FLAMES project. FLAMES is an instrument facility for multi-object spectroscopy developed at ESO. It consists of several components: a Nasmyth corrector, a fiber positioner, a fiber link to the UVES high resolution spectrograph, an intermediate resolution optical spectrograph (GIRAFFE) with its own fibre system, and a coordinating observing software.

As part of the Ital-FLAMES Consortium, the Bologna Observatory has provided the Templates for FLAMES in all observing modes. This activity has been carried out by the contractor E. Rossetti, with assistance from Ferraro and Merighi, in collaboration with personnel at ESO and the Trieste Observatory, and with the coordination of Cacciari, P.I. of the Ital-FLAMES Consortium.

The FLAMES facility is now completed and operational. It was offered to the community with the ESO Call for Proposals of September 2002, and routine observations started on April 1st 2003. Observations for Science Verification (SV) were successfully taken during the period Jan 24 - Feb 2, 2003. The Bologna Observatory participated to SV with observations of red giant stars in the globular cluster NGC 2808 aimed at detecting mass outflows from the atmospheres of these stars (Cacciari in collaboration with F. Fusi Pecci and A. Bragaglia, and with E. Carretta of the Padova Observatory). Fig. 1 shows an example of $\approx$100 GIRAFFE/MEDUSA + 8 UVES fibre allocation on the NGC 2808 globular cluster field. The observed spectra (see Fig. 2) are presently being analyzed with the assistance of E. Rossetti. Guaranteed Time of Observation is planned for end May and Nov 2003, and Feb 2004.

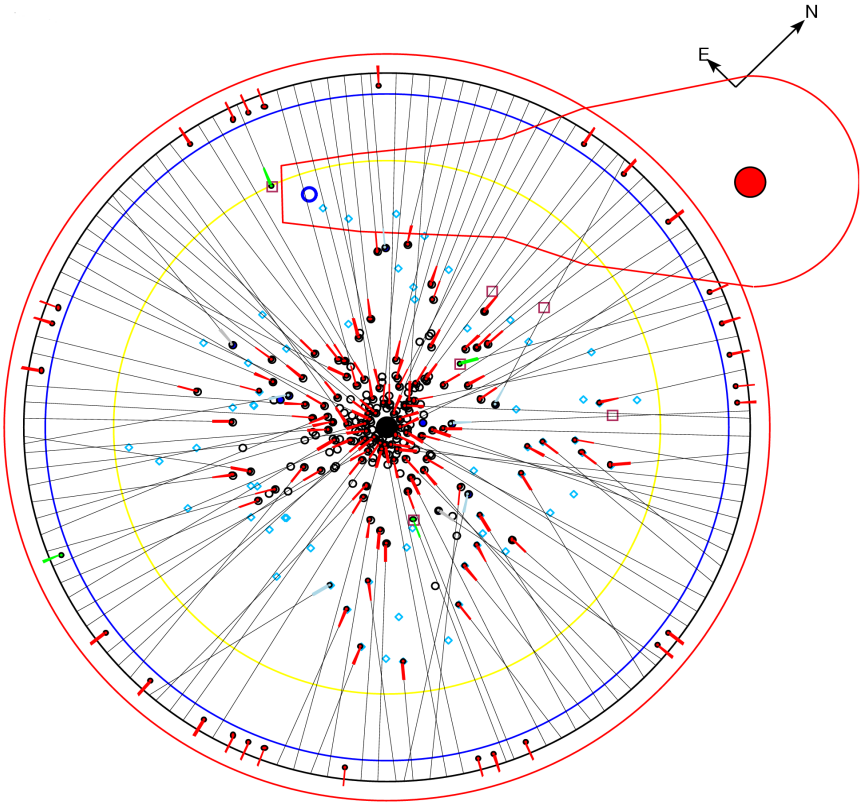


Figure 11: Positioning of ≈ 100 GIRAFFE/MEDUSA + 8 UVES fibres on the NGC 2808 globular cluster field. Also shown is the area obscured by the guide probe.

Figure 12: GIRAFFE/MEDUSA spectra of ≈100 stars in one shot in the NGC 2808 globular cluster field.

4.2 The VIMOS project

People involved at OAB: Bregoli, Lolli, Merighi, Montegriffo, Bardelli, Zucca

The Bologna Observatory is part of the VIRMOS Consortium, which also includes the Observatories of Brera-Merate and Capodimonte, the CNR Institutes of Bologna (Istituto di Radioastronomia) and Milano (Istituto di Astrofisica Spaziale e Fisica Cosmica), and four Institutes in France, namely the Laboratoire d'Astrophysique de Marseille, the Observatoire de Haute-Provence, the Observatoire Midi-Pyrenes and the Institut d'Astrophysique de Paris.

VIMOS is a visible imaging spectrograph with outstanding multiplex capabilities, allowing to take spectra of more than 800 objects in an area of ~ 220 arcmin^2 (four quadrants of about 7×8 arcmin each, see Fig. 3).

The VIMOS instrument has been successfully mounted on VLT UT3 in Paranal: the commissioning of the instrument at the telescope was completed during 2002 and guaranteed time observations started in Autumn 2002.

People at the Bologna Observatory have been involved in the development of the imaging and astrometric facility of the DRS (Data Reduction Software) and of the RTD (Real Time Display). They are also testing the overall performances of the database which handles the data from the VIRMOS/VLT Deep Survey and they are also involved in the development of the scientific software for the analysis of the observed spectra.

4.3 The L3CCD project

People involved at OAB: Bregoli, Ciattaglia, Innocenti

After the production, from Marconi Applied Technologies, of new intensifier CCD sensors available to detect very low levels of light, a collaboration has been established with the Arcetri Observatory to test these sensors and develop their use as imaging photoncounters to be used as wavefront detectors for adaptive optics systems. This activity has started in October 2001 and is carried out in collaboration with Italo Foppiani and Giuseppe Cosentino of the Astronomy Department.

As first step we have interfaced a commercial photon counting controller to a new type of detectors: the L3CCD, an avalanche intensified CCD from E2V (ex Marconi AT) with the aim to develop a low noise wavefront detector for adaptive optics (Foppiani et al. 2002). During the laboratory test of the year 2002, still in analogue mode, it turned out that the system performed as an efficient and almost ready-to-use speckle camera with a duty cicle of 20 msec.

The first tests made at the 152 cm Loiano telescope have involved G. Bregoli and C. Ciattaglia. Bregoli has developed all the optical bench data acquisition software, which required synchronisation among several instruments and great acquisition flexibility to fulfill the specific requirements of fast pixel. Ciattaglia has realised many custom parts for the optical bench and made the whole mechanical interface for the speckle camera, which implied realising suitable lens and filters holders as well as a suitable camera holder. Both projects are still in progress. Innocenti is also involved in the electronic development. During the first tests on sky, made mounting the fully analog camera based on L3CCD at the focal plane of the Loiano 152 cm telescope, we have observed a triple star system having a visual magnitude ranging between 4 and 5 with very encouraging preliminary results.

4.4 New Pulsar system for the 32mt dish

People involved at OAB: D'Amico, Innocenti

The new pulsar data acquistion system will be used at the italian 32mt dish in Medicina to observe Pulsar radio sources. Long term timing

observations of pulsars give information about the interior structure of neutron stars and is useful in the understanding of the evolution of neutron stars. In timing observations, the radio frequency signal needs to be sampled in the time and frequency domain, in order to dedisperse and detect the radio pulses. The radio frequency signal is down converted from the sky frequency of 1.4 or 1.6 GHz into 4 IF bands, each one from 16 to 48 Mhz as required by the front-end filter bank (two adjacent bands for each circular polarization). Each IF band is splitted into 32 1MHz bw channels by the filter bank, square law detected, pass-throw a programmable antialiasing filter, then digitized at 1 bit and by a fast data link built with CERN S-LINK interface; data acquired by a Pentium computer with Linux operating system will be stored on DLT tapes for off-line analysis. Time tag of data acquired is very important, so all operations are synchronized to UTC time reference by GPS receiver and sampling rate clock generator is synch to H-Maser reference.

The parameters of the data acquisition subsystem are:

- 2 x 64 x 1MHz filter bank (left and right polarization) designed at Jodrell Bank Observatory GB
- 128 channel antialiasing filter 2 poles programmable (0.9KHz, 1KHz, 5 Khz, 10Khz)
- 128 channel low frequency integrator (0.5 Hz) for interference monitoring system
- 128 channel 1 bit digitizer
- Synch to H-maser UT clock, programmable sampling rate (10uS-100uS)
- Femb board (digitizer to slink interface, Fpga xilinx based)
- Fast link to Personal computer By E-Slink form Nowoczesna Elektonica (LSC & LDC) & Pci to S-Link by Incaa
- PentiumIII-500MHz 128MB ram, Linux OS Red Hat 6.1
- Data storage on DLT tape unit (up to 20GB on a single tape)
- GPS Motorola Oncore UT+

The system has been calibrated on a number of know pulsars, using the standard timing software for offline analysis, and has shown good performances, although some issues related to the interference clipping need to be solved.

This work is carried on in collaboration with A. Maccaferri (IRA/CNR).

4.5 TNG

People involved people at OAB: Zitelli.

Zitelli (with Ortolani from Padova and Porceddu from Cagliari) is member of the working group "site testing" for the Telescopio Nazionale Galileo (TNG).

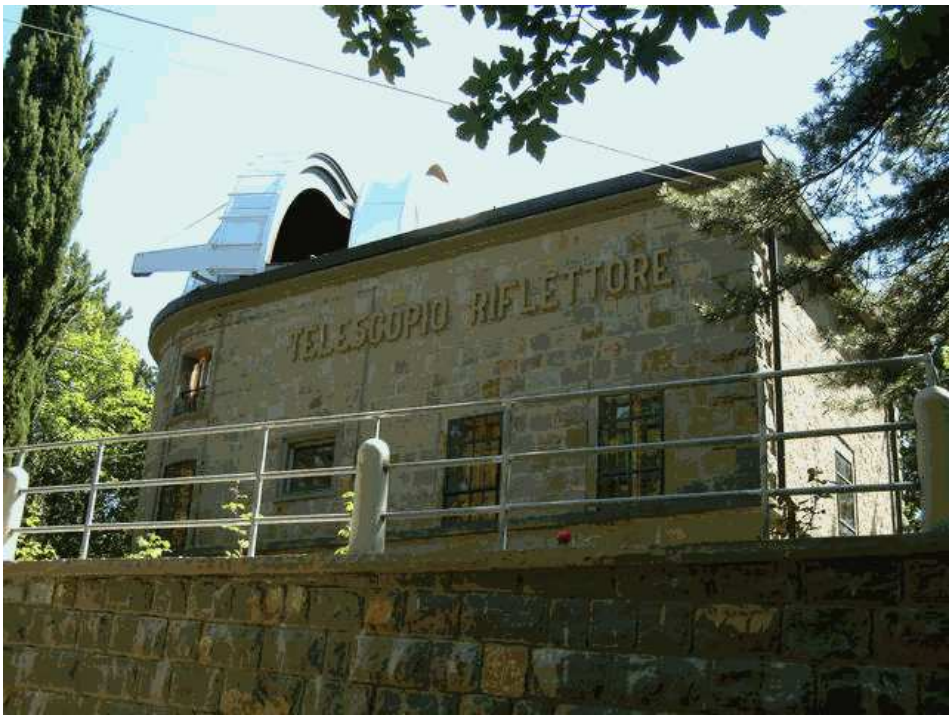
Since Canary islands are under influence of Ocean weather with dominant trade wind from north, specially during summer time, TNG is influenced by the calima effect: the dust coming from Sahara desert. Zitelli with Porceddu and TNG people have collected and analyzed dust data from a statistical point of view. The aim of this experiment is to compare the behaviour of different size of dusts and the meteo parameters to check the influence on astronomical seeing. Results of one year of data have been presented to SPIE 2002 technical meeting in Waikoloa USA.

4.6 A Tunable Filter for TNG

People involved at OAB: Zitelli.

Zitelli, involved in a joint project with PD, Merate, CT and TO observatories to implement a Tunable Filter at one of the instruments permanently mounted at the focal plane of TNG, has presented a final document to conclude the feasibility study . The proposed etalon Tunable Filter provides sequential narrowband images spaced, if combined with Dolores, in the range between 6-21 A, forming the image cube. The other main characteristics of the proposed TF combined with Dolores are: FOV of 240 arcsec (@f/11), resolving power 300-1000 and spectral range 5800-7500 and have the capability to detect faint emission line sources over a useful area on the sky. This instrument combines the flexibility of an ordinary Fabry Perot interference filter to scan in wavelength with the widefield monochromatism of fixed narrowband interference filter.

5 Loiano observing site



The dome of 60cm telescope of the Loiano observing site

Involved people at OAB:

- *Scientific staff:* R. Merighi, V. Zitelli.
- *Technical staff:* S. Bernabei, A. De Blasi, I.Bruni, R. Gualandi, R. Mezzini, I. Muzi, P. Salomoni, G. Bregoli, C. Ciattaglia, G. Innocenti.

Loiano, observing site of the Bologna Observatory, is located at 785 m above sea level and is at 37 km from Bologna. In Loiano are located 3 buildings (two hosting the 152 cm and 60 cm and one the guest house), and 23 hectares of wood. The person in charge of the Loiano observing site is Zitelli.

The **152 cm telescope**, dedicated to G.D. Cassini, was built by REOSC and has been operating since 1976. General description of the Cassini telescope is given in Table 1.

The main focal instruments presently available at the telescope are:

1. A spectrograph/focal reducer: BFOSC (Bologna Faint Object, Spectrograph and camera), based on transmitting optics ranging from 330 to 1100 nm, equipped with a CCD camera EEV 1340x1300

   There are two sets of filters available: a standard Johnson-Kron-Cousins system and a Gunn system.

2. A ""classical"", cooled, five colours Photoelectric Photometer "

3. A two channels photoelectric Photometer (3 colours).

BFOSC has been the most scheduled instrument, with about 80% of the total allocated time, well matching the seeing and the variable meteo conditions of the Loiano site.

The **60cm telescope** was built in 1933 by Zeiss of Jena. It was originally equipped with a photographic camera at the F/3 direct focus. Recently it was modified to a f/20 Cassegrain and is now permanently used for photoelectric photometry with a CCD camera and a "classical" photometer.

Table 1. Cassini telescope

Mount type	English
Optical configuration	Ritchey-Chrètien
Main mirror diameter	152 cm
Focal ratio (main mirror)	F/3
Cassegrain focus	equivalent focal length 1200 cm
	equivalent focal ratio F/8
	scale 16.8 arcsec/mm
	FOV 70 arcmin

5.1 Operations and use of 152 cm telescope

Involved people at OAB: Zitelli, Bernabei, De Blasi, Gualandi, Bruni, Mezzini, Muzi, Salomoni, Bregoli, Ciattaglia, Innocenti.

The 152 cm is regularly dedicated to scientific observations, being available for about 350 nights/year. Since two years both 60 cm and 152 cm Loiano telescopes are also open to students. The statistics of the last years is given in Table 2. Time is allocated every 6 months, starting in January and July, avoiding excessive fragmentation of observing time. The resident staff is composed by 7 technicians. See section 6.4 for an updated situation of the Loiano computer facility. It is possible to have a prereduction of the observations with a PC in a local network with the PC for the observations. MIDAS and IRAF packages are also available.

5.2 Applications to 152 cm Telescope

1. Pizzichini G. et al.: *ToO di GRB in particolare rivelati da HETE*
2. Silvotti, R.: *Secular variation of the pulsation periods*
3. Giovannelli, F. (IAS-CNR) et al.: *Spectrophotometric and photometric observations of X-ray binaries and Interactions with SNRs*

Table 2. Cassini Telescope – Nights used per year

nights/year	1995	1996	1997	1998	1999	2000	2001	2002
used (t>50%)	118	106	122	105	98	110	121	133
used (t<50%)	27	26	19	41	22	38	35	31
used for test	10	37	32	58	33	15	10	6
not used (weather)	169	183	180	142	179	189	163	172
not used (technical)	4	3	1	10	4	1	3	0
not assigned	37	11	11	10	29	13	33	23

4. Marconi, M. et al. (OAN):*Monitoraggio fotometrico di candidati Delta Scuti*

5. Gavazzi, G. (Brera) et al.: *redshift measurements in A1367*

6. Masetti N. (CNR/IASF)et al.: *Spectroscopy of selected old novae*

7. Masetti N. (CNR/IASF)et al.: *Search for the optical counterpart of the X-ray source aSAX J1532.4+7349*

8. Masetti N. (CNR/IASF)et al.: *SN2002 ap in its nebular phase*

9. Polcaro, V.F. (CNR/IASF): *Photometry and Spectroscopy of high mass stars in young open clusters*

10. Polcaro, V.F. (CNR/IASF): *Peculiar object in young open clusters*

11. Israel, G.L. (OAR) et al.: *Optical stydy of a sample of new X-ray pulsators*

12. Nesci R. (Univ. La Sapienza, Roma) and Messaro E.: *Follow up of candidates radio quiet BL Lacs*

13. Andreon S.(OAcapodimonte) et al. :*A possible candidates dwarf in the milky way subgroup*

14. Di Martino M. (OATO) et al.: *The physical nature of trojan asteroids:a spectrosopic and photometric survey of T1*

15. Boattini A. (CNR-IAS): *astrometric follow up program on Near earth objects*

16. Terranegra L. (OACapodimonte), Chavarria C., Moreno M.A.(UNAM,Mexico): "*Spectroscopic study of the PMS group near DL Ori*"

17. Vigotti M. (CNR-IRA): *search of high redshift radio loud quasars*

18. Foppiani I.(Univ.BO) :*test marconi L3CCD*

19. Ripepi V. (OA Capodimonte): *A multisite campaign for delta Scuti PMS V588 Mon and V589 Mon*

20. Bellazzini M. (OABO) : *The variable stars in the Draco dwarf spheroidal galaxy*

21. Van den Berg M. and Tagliaferri G. (OA Brera) : *Photometric and spectroscopic observations of X-ray source in old openn cluster*

- Application for undergraduate students in Astrophysics:

  1. Redfern M.(NUI-Galway-IE): 8 nights (20 students)[6]
  2. Righini (Dep. of Astronomy -Fi): 6 nights (15 students)
  3. Stanga R. (Dep of Astronomy) : 2 nights (10 students)
  4. Gavazzi (Brera): 10 nights (8 students)

- Tests:

  1. Silvotti, R. (OAN): *TTCP photometer*

5.3 Scientific production involving the 152 cm Telescope

1. Di Fabrizio, L. et al, *Anomalous RR Lyrae stars (?). III. CM Leonis*, 2002, MNRAS 336, 841

2. Ripepi,V. et al., *Detection of Delta Scuti/like pulsator in H254, a pre main sequence F Type star in IC348*, 2002, A.&A. 391, 587

3. Masetti,N. et al., *X ray and optical monitoring of th epeculiar source 4U 1700+24/V934 Her*, 2002, A.&A. 382, 104

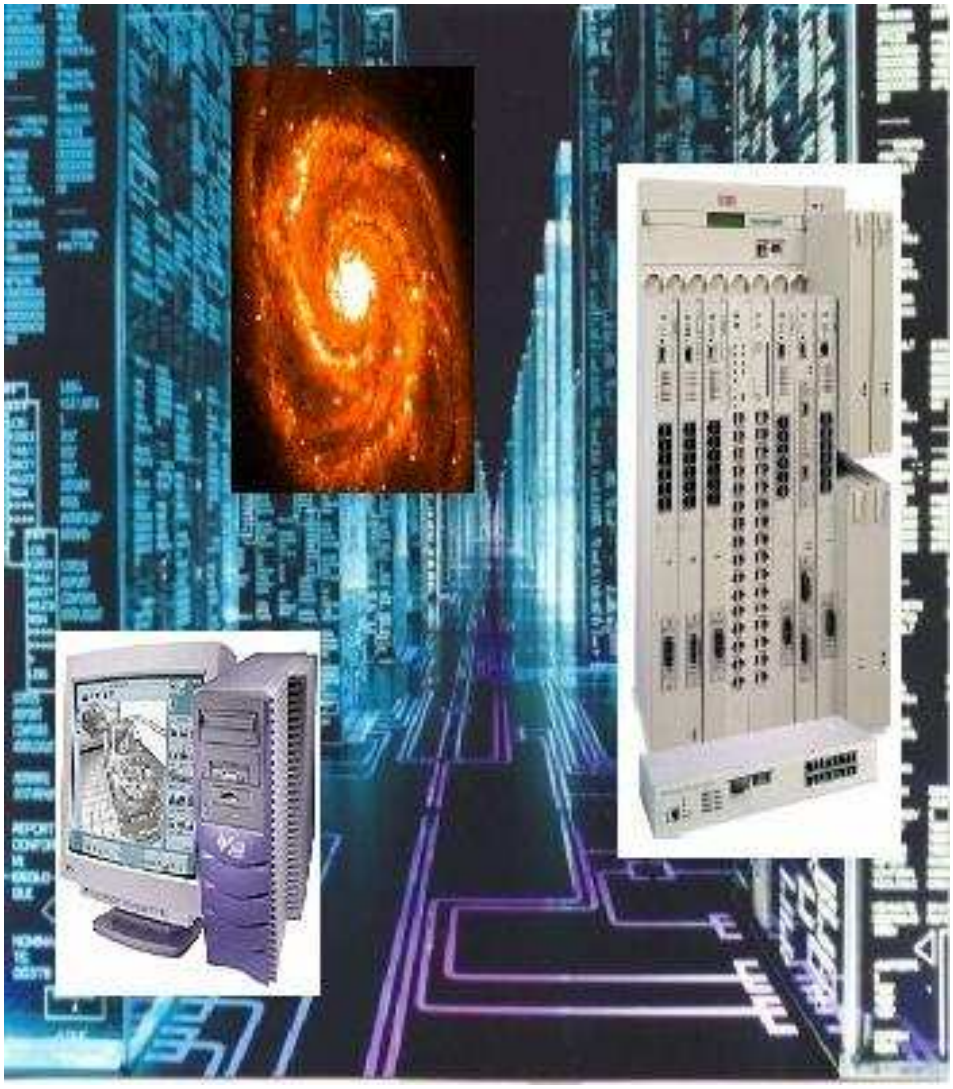
[6] *www.physics.nuigalway.ie/Courses/loiano.html*

4. Silvotti, R. et al., *The temporal spectrum of the sdB pulsating star HS 2201+2610 at 2 ms resolution*, A&A,389, 180

5. Zurita C. et al., *The X ray transient XTE j1859+226 in outburst and quiescence* , 2002, MNRAS

6. Zurita et al., *XTE J1118+480* ,IAU Circ.7678

6 Computer center and computer network



People involved people at OAB:

- *Scientific staff:* F. Delpino, R. Merighi;
- *Technical staff:* R. Di Luca, M. Gatti, M. Lolli, G. Madama, P. Montegriffo, R. Policastro.

The principal activity of the computer center during 2002 has been addressed to the improvement of the computer facilities and network connections. In particular, old computers have been replaced with newer ones or have been hardware updated. For what concerns storage space, new disks have been mounted and new network file server added to the system. A 2Mbit network connection with the Loiano Observatory has beenrealized.

6.1 Computer center improvements

People involved at OAB: Delpino, Di Luca, Gatti, Lolli, Madama, Merighi, Montegriffo, Policastro.

During 2002 the hardware update of the computer center was continued. Old Alpha workstations were replaced by newer ones or with PCs running Linux OS. Several high performance PCs, equipped with AMD Athlon XP 2000+ and 1GBy RAM have been installed, working typically as personal computer facility for large data reduction programs. To this purpose, these machines were also equipped with DAT and CD-RW units, for data backup.

The number of PCs used as Unix-Linux workstations increased during 2002 reaching the number of 100 units, plus several PCs running Win98. Most of them have been updated with CD-RW and SCSI DAT tapes.

6.2 Improvements in the geographic network

6.2.1 Computer networks

People involved at OAB: Delpino, Di Luca.

During the past years work has been done concerning all the relevant aspects of computers networks both at local (LAN) and geographical (MAN and WAN) level with the aim of testing the new generation protocols at OSI level 2 and 3 (pure ATM, ATM LAN emulation, IP next generaion, OSPF). ATM in particular has been tested extensively due to the possibility of realizing multiple high speed connections on the same links, with static or dynamic band partition. That makes ATM attractive for all the environments with the need of multiple and multimedia data transfers (housekeeping data, scientific data, images in sequence, voice and video).

Delpino has drawn up the development model for the project of the new broad-band research network of the Emilia Romagna region, which is based on an private backbone at 1000 Mbit/sec. On that model basis a hierarchical structure, formed by a top level independent backbone interfacing a large number of campus network, has been planned.

6.2.2 Web applications

People involved people at OAB: Delpino, Lolli.

Experiences have been made in the field of object programming, with particular reference to the Java language and C. The former in fact presents advantages as one is interested in developing platform independent Web applications. The trend of extending the field of scientific application usability beyond on the usual local area limits, making them available for the whole Internet community, is presently well established. Nevertheless that implies the use of complex and sophisticated techniques for planning and programming new applications. On the other hand, recently a new interest in applications using data organized inside a database raised up. The different techniques presently available for Web integration of both applications and databases have

been studied and compared. A pilot project, LiREP, is being realized. LiREP is a web application for searching and retrieving astronomical data, images and spectra, from catalogs. It makes use of a web interface and back-end Java scripts to query the database holding catalogs. Several catalogues are yet available using the web interface and the job will be fully accomplished within June 2003. Moreover, using the same technique, a new project for the realization of a metadirectory is in advanced state of realization. That will give users the opportunity to pubblish in Internet their own catalogues and data sets. Finally Delpino is involved in the project of a Directory Service for both the Astronomical Observatory and the Astronomy Department of the University, which will support many istitutional services (Internet mail, single sign-on, security access, ...)

6.3 Improvements in the accessory services

People involved at OAB: Di Luca, Merighi.

Concerning accessory services improvements, two high-quality network printers HP 4050N (17 ppm, 600dpi, auto-duplex unit) have been bought. Their introduction has improved the distribution of printers in the building and decreased the work-load on the existing ones.

6.4 Loiano station

people involved at OAB: Lolli, Gualandi

The Department of Astronomy of the Bologna University has requested and obtained from CESIA (CEntro per lo sviluppo e gestione Servizi Informatici d'Ateneo) the installation of a connection at 2Mit/sec between the Loiano Observatory and the Observatory Headquarter in Bologna. All the computer at the Observatory have been connected and a new network switch has been installed. With this connection it will be possible to install other useful services as voice-over-IP and webcam-server. Moreover, images produced during observation runs can now be immediately downloaded and made available to the observer.

6.5 Routine activities

People involved at OAB: Di Luca, Gatti, Lolli, Madama, Montegriffo, Policastro.

Besides all the activities described above, large part of the work of the computer center staff has been, as usual, devoted to routine activities such as hardware and software maintenance, failures management and user assistance.

Routine operations include:

- backup and user management on the central VMS computer
- backup and user management on computers dedicated to data-reduction
- supply of consumables (toners, paper for printers, magnetic supports for backup etc.)
- printer maintenance
- local network management
- administrative management of the computer center (software and hardware licenses, guarantees, purchases, contracts of maintenance)
- updates and new installations of application software for astronomical data reduction (MIDAS, IRAF etc.)
- management of the Observatory's WWW server

6.6 Other activities

People involved at OAB: Montegriffo.

The computer center staff has carried on other activities during 2002. In particular:

- Original software for data analysis in digital photometry in crowded fields.
  For crowded fields digital photometry, the CATAPACK program (management of photometric catalogues) has been developed. This software provides tools for the handling and management of photometric catalogues. These tools have been designed to be simple in the use and portable to several OS (Compaq True-Unix64, Linux, HP,Sun). These programs will be mainly used in the preparation and execution of scientific programs in the ItalFLAMES Consortium.
  The core of the package is represented by two programs: *CataXcorr* e *CataComb*.

  - *CataXcorr* (Catalogues Cross Correlator) performs *cross-correlations* and roto-translations between an arbitrary number of catalogues. The program can map with high accuracy coordinate transformations between single coordinate systems and a common reference system, independently of any difference in scale, rotation and/or axis inversion, giving, as ouput, plate solutions and calibrations. The most interesting feature of CataXcorr is that it works in a complete automatic way. Solutions are found without any user interaction. This feature is achieved through a pattern recognition algorithm.
  - *CataComb* (Catalogues Combiner) is a program that allow to combine an arbitrary number of catalogues, producing an output catalog containing the desired quantities. Objects in different input catalogues can be combined following a cross-correlation table generated by CataXcorr or by identifier. The main characteristic of CataComb is flexibility: the content of the output file is interely controlled by the user through a syntax analysis algorithm that can understand arithmetic and logical expression of any complexity.

7 Library

Involved people at OAB:

- *Library staff:* K. Alboresi (contractor), M. Marra.

During the year 2002 the "Guido Horn d'Arturo" library has carried on, as it usually does, both ordinary and extraordinary activities. As for the second ones, the 4th astronomy librarians' international conference held in Prague in July (LISA IV) saw our library contributing with a poster paper prepared by the INAF working group on serials (Monica Marra is a member). A national project, Specola 2000, concerning the preservation and inventorying of the Italian astronomical archives, has carried on its activities on the bolognese archive. In a continuing effort to make all of the library's book heritage available also in the national online catalogue SBN, about 600 books published in the first half of the 20th century have been catalogued again. An inventory check was taken on 500 books of the same period. A public report was made for the bolognese astronomers in October, about the local results of the national questionnaire that the Italian astronomical librarians had decided to give astronomers in order to understand better their needs and attitudes about online serials. The ordinary activities have been rather demanding. Over 350 books (both purchases and gifts to the library) have been acquired and catalogued: the expense for the 220 new books bought by the Observatory in 2002 has reached 13.400 euro. The registered users (mostly university students, but of course also the whole local scientific staff and the remaining personnel) have reached and exceeded the number of 800. The book loan remains one of the main ordinary activities. The document delivery service, with its 80 requests managed, has maintained approximately the same amount it had reached in 2001; it remains a well-appreciated service, as well as the inter-library book loan. The serials collection (90 active subscriptions) implies a number of activities such as daily check-in, national catalogue updating, claims to the publishers and binding. Checking-in journal issues by using the software Techlib, which is associated with the national online catalogue ACNP, in addition to the traditional paper check, makes it possible for all users to make sure of the arrival of specific issues in online mode, also from outside the library. The ancient book section has been consulted several times. Some books of this section have contributed to the exhibition "L'antichita' del mondo", held in Bologna. The list of

ordinary activities is completed by the training of the many part-time students employed in the library.

The library staff is composed by Marina Zuccoli and Pietro Candelaresi (Dept. of Astronomy) as well as by Monica Marra and Katia Alboresi (Bologna Astrophysical Observatory, contractor).

8 Outreach and educational activities

Artistic scale reproduction of the Solar System: the starting point in front of the telescope building in Loiano.

People involved at OAB:

- *Scientific staff*: S. Bardelli, R. Bedogni, A. Cappi, L. Ciotti, G. Clementini, A. D'Ercole, E. Delpino, F. Ferraro, F. Fusi Pecci, G. Parmeggiani, R. Sancisi, V. Zitelli;
- *Technical staff*: S. Bernabei, I. Bruni, A. De Blasi, R. Di Luca, R. Gualandi, G. Innocenti.

Over the past years, the Bologna Astronomical Observatory (OAB) has been increasingly involved in outreach and educational activities through seminars, exhibitions and radio/tv programs. The growth of public interest in astronomy and astrophysics has led to a stable partnership between the Observatory and other institutions like the Astronomy Department of University of Bologna, Institute of Radio Astronomy (CNR Bologna), the amateur astronomers of Bologna (A.A.B.) and S. Giovanni in Persiceto (Bo). *Il Parco delle Stelle* and *Con il laser tra le stelle* are two of the most successful activities started in 1996-1997 and enriched, during 2002, with the following events:

- Col Favore del Buio
- Estate Astronomica Bolognese
- A piedi nudi nel parco
- Books and CD
- Il Notiziario Astronomico
- Educational Activities:
  - Modello Sistema solare
  - Conferenze della Specola
  - Concorso Altri Mondi
  - Le conquiste della ricerca spaziale

8.1 Col Favore del Buio

A few years ago, the collaboration between the OAB, the "Assessorato Provinciale alla Cultura" and the Loiano's City Council, led to the creation of *Il Parco delle Stelle*. Views of the most magnificent objects of our skies are organized with the 60-cm Telescope of Loiano, under the supervision of Parmeggiani and Zitelli. This telescope is interesting also by itself because it has kept its original 1930 mechanical structure. After using the telescope, the visitors are invited to observe the sky without instruments while astronomers introduce them to stars, planets, and black holes. Nowadays *Il Parco delle Stelle* is part of *Col Favore del Buio*[7] and is organized in collaboration with the Radio Astronomy Observatory of Medicina (Bo), the Museum of Specola (Department of Astronomy), two non professional observatory "San Giovanni in Persiceto (Bo)" and "Monte San Pietro (Bo)" both of the Associazione Astrofili Bolognese, and the conference hall of the Bologna Planetarium (primary school G. Carducci). The event *il Parco delle Stelle* has been very successful: the schedule for the year 2002 has included more than 50 evening sessions with about 2000 visitors (over 15.000 visitors for "Col favore del Buio"). The 60 cm telescope can be visited in the evenings only if reserved, the 1.52 m (G.D. Cassini) is opened to public only the first Saturday of each month and to schools during the day if reserved.

8.2 Estate astronomica bolognese

The Astronomical Observatory of Bologna and the Department of Astronomy have organized with the support of the City Council of Bologna, in the framework of the summer event *Viva Bologna*, three exhibitions:

- *Serate con il laser ai Giardini Margherita*

  Two *Visite guidate della volta celeste* have been organised at the Giardini Margherita of Bologna on August and September. A laser beam was used to describe the constellations in the sky. Those event were leaded by prof. F. Fusi Pecci, director of OAB. For about 2 hours, with the help of a laser, prof. Fusi Pecci taught the visitors how to orientate themselves in the dark sky.

[7] *www.bo.astro.it/~universo/favore*

- *Incontri con l'Astronomia*

  During the summer period seven astronomy conferences have been held in the Cortile d'Ercole of the Palazzo Poggi, rectorate of the University. Every encounter has been attended by more than 100 persons.

- *Apertura serale del Museo di Astronomia*

  The museum accommodated in the rooms of the ancient Specola (meridian room, turret room and globes room) has been opened for eight evenings with wide public participation.

- *A piedi nudi nel parco*

  With the collaboration of the Provincia di Bologna and Istituzione Villa Smeraldi, on May 18th and September 28th, the Astronomical Observatory of Bologna has organized two evenings dedicated to the observation of the sky: an orientation training with the help of a laser beam.

8.3 Educational Activities

- *Modello di Sistema solare*

  In order to understand the dimensions of our planetary system and the distances to the various planets, the Astronomical Observatory of Bologna, in collaboration with the Department of Astronomy of the University of Bologna, has built a model in scale of Solar System. It starts from the 152 cm telescope building in Loiano and goes along a path in the forest, reaching the second cupola that hosts the historical telescope of 60 cm of diameter. One meter along this path corresponds to 15 million kilometers. To give a better feeling of the dimensions of planets and Sun there is a second unit of measure with one centimeter corresponding to 7000 kilometers.

- *Le conquiste della ricerca spaziale* [8]

  In year 2002 the OAB has organized a new training course for primary and high school teachers and students of astronomy.

[8] *www.bo.astro.it/~universo/webcorso/iapage/html*

This event, called *Le conquiste della ricerca spaziale*, was sponsored by A.S.I. (Agenzia Spaziale Italiana), the Department of Astronomy of the University of Bologna. The training course has begun on March 2002 and will finished on May. 32 teachers and a group of astronomy students attended the courses. The lessons of the training course will be published on "Il Giornale di Astronomia".

- *Conferenze della Specola*

  On every first Wednesday of the month, at the Specola, the old Observatory of Bologna in the town center, there is a seminar on astronomical topics. The audience is mainly composed by students of the advanced Secondary Schools. On average 80/90 people attend the conference. On the web page [9] of the Observatory are available the texts of the conferences.

- *Concorso Altri Mondi*

  People involved at OAB: Parmeggiani

  Altri Mondi is a competition organized by the Italian department of E.A.A.E. (European Association for Astronomy Education) in collaboration with the Department of Astronomy of the University of Bologna, the Astronomical Observatory of Bologna, SAIt (Società Astronomica Italiana), AIF (Associazione per l'insegnamento della Fisica), Divisione Didattica della Società Chimica Italiana, CNR, ADA (Associazione Divulgazione Astrofisica), ANISN (Associazione Nazionale Insegnanti di Scienze Naturali), CIFS (Consorzio Interuniversitario per la Fisica Spaziale), ASI (Agenzia Spaziale Italiana), Alenia Spazio SpA, and Science Centre Extramuseum Torino. Parmeggiani was part of the jury. This event was devoted to students of Primary and Secondary Schools who were asked to send an essay on paper or ipertext about nine primary astronomical topics like: the life in the Universe, the evolution of life on Earth, the research of extraterrestrial life, and so on. The jury received over 100 essays; the top 10 works got a cash prize, while the following 10 got an invitation to the ASI. The observatory has contributed to the realization of the exposition of the jobs of the students kept into

[9] *www.bo.astro.it/~universo/conferenze/index.html*

the primary school Carducci and to the encounter with the astronaut Guidoni with the participation of more than two hundred people.

8.4 Educational and Public Outreach

1. Cappi A., 2003, *Il futuro dell'universo e della vita*, le Stelle n.6, p.32

2. Cappi A., 2002, *I neutrini: quale contributo all'astrofisica dei fotoni?*, saggio scientifico, Premio Internazionale Città di Tocco da Casauria, in press

3. Clementini G., R.G. Gratton, 2002, *The oldest stars and the age of the Universe*, Europe Annual Review, Ed. A. Burgen, Vol. 10, No. 2, p. 237

4. De Blasi A., 2002, *L'Osservatorio Astronomico di Ondrejev*, Nuovo Orione, Vol. 116, p. 48

5. De Blasi A., 2002, *Il sistema visuale Kruger 60: una coppia singolare*, Nuovo Orione, Vol. 120, p. 39

6. De Blasi A., 2002, *Fai un giro tra le stelle*, Quark, Milano, Vol. 12, p.74

7. De Blasi A., 2002, *Le stelle: nascita evoluzione e morte*, Ed. Clueb, Bologna

8. http://www.bo.astro.it/~loiano/NotiziarioAstronomico/index.htm

9 List of Publications

REFEREED PAPERS

2002

1. Baldi A., Molendi S., **Comastri A.**, Fiore F., Matt G., Vignali C., 2002, *The HELLAS2XMM survey: I. The X-ray data and the Log(N)-Log(S)*, ApJ 564, 190

2. **Bardelli S.**, De Grandi S., Ettori S., Molendi S., **Zucca E.**, Colafrancesco S., 2002, *SC1327-312 & SC1329-313: two galaxy groups in-between a major merging event observed with Beppo-SAX*, A&A 382, 17

3. **Bardelli S.**, Venturi T., **Zucca E.**, De Grandi S., Ettori S., Molendi S., 2002, *Abell 3560, a galaxy cluster at the edge of a major merging event*, A&A 396, 65

4. **Bellazzini M.**, **Ferraro F.R.**, Ibata R., 2002, *The Stellar Population of NGC 5634: A Globular Cluster in the Sagittarius dSph Stream?*, AJ 124, 915

5. **Bellazzini M.**, **Ferraro F.R.**, **Origlia L.**, Pancino E., Monaco L., Oliva E., 2002, *The Draco and Ursa Minor Dwarf Spheroidal Galaxies: A Comparative Study*, AJ 124, 3222

6. **Bellazzini M.**, **Fusi Pecci F.**, Messineo M., Monaco L., Rood R. T., 2002, *Deep Hubble Space Telescope WFPC2 Photometry of NGC 288. I. Binary Systems and Blue Stragglers*, AJ 123, 1509

7. **Bellazzini M.**, **Fusi Pecci F.**, Montegriffo P., Messineo M., Monaco L., Rood R. T., 2002, *Deep Hubble Space Telescope WFPC2 Photometry of NGC 288. II. The Main Sequence Luminosity Function*, AJ 123, 2541

8. Benoist C., da Costa L., Jørgensen H.E., Olsen L.F., **Bardelli S.**, **Zucca E.**, Scodeggio M., Neumann D., Arnaud M., Arnouts S., Biviano A., Ramella M., 2002, *Optically-selected clusters at* $0.8 \leq z \leq 1.3$ *in the EIS cluster survey*, A&A 394, 1

9. Bertin G., **Ciotti L.**, Del Principe M., 2002, *Weak homology of elliptical galaxies*, A&A 386, 149

10. Bonifacio P., ... , **Bragaglia A.**, ... **Clementini G.**, 2002, *The lithium content of the globular cluster NGC 6397*, A&A 390, 91

11. Brunetti G., Bondi M., **Comastri A.**, Setti G., *Chandra discovery of extended non-thermal emission in 3C 207 and the spectrum of relativistic electrons*, 2002, A&A 381, 795

12. Brusa M., **Comastri A.**, Daddi E., Cimatti A., **Mignoli M.**, **Pozzetti L.**, 2002, *Extremely Red Objects: An X-Ray Dichotomy*, ApJ 581, L89

13. Brusa M., **Comastri A.**, Daddi E., Cimatti A., **Mignoli M.**, **Pozzetti L.**, 2002, *Extremely Red Objects: An X-Ray Dichotomy*, 2002, ApJ 581, L89

14. Capetti A., Celotti A., Chiaberge, M., **De Ruiter H.R.**, Fanti R., Morganti R., Parma P., 2002, *The HST survey of the B2 sample of radio galaxies: optical nuclei and the FRI/BL Lac unified scheme*, A&A 383, 104

15. Catelan M., Borissova J., **Ferraro F.R.**, Corwin T.M., Smith H.A., Kurtev R., 2002, *M75, a Globular Cluster with a Trimodal Horizontal Branch. I. Color-Magnitude Diagram*, AJ 124, 364

16. **Ciliegi P.**, **Zamorani G.**, Hasinger G., Lehmann I., Szokoly G., Wilson G., 2003, *A deep VLA survey at 6 cm in the Lockman Hole*, A&A 398, 901

17. Cimatti A., Daddi E., **Mignoli M.**, **Pozzetti L.**, Renzini A., **Zamorani G.**, Broadhurst T., Fontana A., Saracco P., Poli F., Cristiani S., D'Odorico S., Giallongo E., Gilmozzi R., Menci N., 2002, *The K20 survey. I. Disentangling old and dusty star-forming galaxies in the ERO population*, A&A 381, L68

18. Cimatti A., **Mignoli M.**, Daddi E., **Pozzetti L.**, Fontana A., Saracco P., Poli F., Renzini A., **Zamorani G.**, Broadhurst T. et al., 2002, *The K20 survey. III. Photometric and spectroscopic properties of the sample*, A&A 392, 395

19. Cimatti A., **Pozzetti L.**, **Mignoli M.**, Daddi E., Menci N., Poli F., Fontana A., Renzini A., **Zamorani G.**, Broadhurst T. et al. , 2002, *The K20 survey. IV. The redshift distribution of Ks<20 galaxies: A test of galaxy formation models*, A&A 391, L1

20. **Ciotti L.**, 2002, *Alcune questioni matematiche riguardanti la dinamica stellare*, Bollettino dell'Unione Matematica Italiana, Sezione A, Serie VIII, IV-A, 97-142

21. Colpi M., **Possenti A.**, Gualandris A., 2002, *The Case of PSR J1911-5958A in the Outskirts of NGC 6752: Signature of a Black Hole Binary in the Cluster Core?*, ApJ 570, L85

22. **Comastri A.**, **Mignoli M.**, **Ciliegi P.**, Severgnini P., Maiolino R., Brusa M., Fiore F., Baldi A., Molendi S., Morganti R., Vignali C., La Franca F., Matt G., Perola G.C., 2002, *The HELLAS2XMM survey: II. probing the nature of X–ray bright, optically inactive galaxies with multiwavelength observations*, ApJ 571, 771

23. Crone M. M., Schulte-Ladbeck R. E., **Greggio L.**, Hopp U., 2002, *The Star Formation History of the Blue Compact Dwarf Galaxy UGCA 290*, ApJ 567, 258

24. Daddi E., Cimatti A., Broadhurst T., Renzini A., **Zamorani G.**, **Mignoli M.**, Saracco P., Fontana A., **Pozzetti L.**, Poli F., Cristiani S., D'Odorico S., Giallongo E., Gilmozzi R., Menci N., 2002, *The K20 survey. II. The different spatial clustering of z = 1 old and dusty star-forming EROs*, A&A 384, L1

25. **D'Amico N.**, **Possenti A.**, Fici L., Manchester R.N., Lyne A.G., Camilo F., Sarkissian J., 2002, *Timing of Millisecond Pulsars in NGC 6752: Evidence for a High Mass-to-Light Ratio in the Cluster Core*, ApJ 570, L89

26. **De Ruiter H.R.**, Parma P., Capetti A., Fanti R., Morganti R., 2002, *HST images of B2 radio galaxies: a link between circumnuclear dust and radio properties?*, A&A 396, 857

27. Di Fabrizio L., **Clementini G.**, ..., **Bragaglia A.**, ..., **Merighi R.**, ..., **Tosi M.**, 2002, *Anomalous RR Lyrae stars(?). III. CM Leonis*, MNRAS 336, 841

28. Drozdovsky I. O., Schulte-Ladbeck R. E., Hopp U., **Greggio L.**, Crone M. M., 2002, *The Dwarf Irregular/Wolf-Rayet Galaxy NGC 4214. I. A New Distance, Stellar Content, and Global Parameters*, AJ 124, 811

29. Elvis M., Risaliti G., **Zamorani G.**, 2002, *Most supermassive black holes must be rapidly rotating*, ApJ 565, L75

30. **Ferraro F.R.**, **Bellazzini M.**, Pancino E., 2002, *Discovery of an Accreted Stellar System within the Globular Cluster ω Centauri*, ApJ 573, L47

31. Fraternali F., Cappi M., **Sancisi R.**, Oosterloo T., 2002, *Diffuse X-ray emission from the spiral galaxy NGC 2403 discovered with Chandra*, ApJ 578, 109

32. Fraternali F., van Moorsel G., **Sancisi R.**, Oosterloo T., 2002, *Deep HI survey of the spiral galaxy NGC 2403*, AJ 123, 3124

33. Garcia-Ruiz I., **Sancisi R.**, Kuijken K., 2002, *Neutral Hydrogen and optical observations of edge-on galaxies: hunting for warps*, A&A 394, 769

34. Georgantopoulos I., Panessa F., Akylas A., Zezas A., Cappi M., **Comastri A.**, *BeppoSAX observations of LINER-2 galaxies*, 2002, A&A 386, 60

35. Gruppioni C., Lari C., Pozzi F., **Zamorani G.**, Franceschini A., Oliver S., Rowan-Robinson M., Serjeant S., 2002, *A New Method for ISOCAM Data Reduction – II. Mid-Infrared Extragalactic Source Counts in the Southern ELAIS Fields*, MNRAS 335, 831

36. Hobbs G., Lyne A.G., Joshi B.C., Kramer M., Stairs I.H., Camilo F., Manchester R.N., **D'Amico N.**, **Possenti A.**, Kaspi V.M., 2002, *A very large glitch in PSR J1806-2125*, MNRAS 333, L7

37. Jehin E., ..., **Origlia L.**, et al., 2002, *Split Comet C/2001 A2 (LINEAR)*, Earth, Moon, and Planets, 90, 147

38. Kuzmin A.D., Kondrat'ev V.I., Kostyuk S.V., Losovsky B.Y., Popov M.V., Soglasnov V.A., **D'Amico N.**, Montebugnoli S., 2002, *Frequency Dependence of the Scattering Pulse Broadening for the Crab Pulsar*, Astronomy Letters 28, 251

39. La Franca F., Fiore F., Vignali C., Antonelli A., **Comastri A.**, Giommi P., Matt G., Molendi S., Perola G.C., Pompilio F., 2002, *The BeppoSAX High Energy Large Area Survey HELLAS - V. The nature of hard X–ray source population and its evolution*, ApJ 570, 100

40. Malizia A., Malaguti G., Bassani L., Cappi M., **Comastri A.**, Di Cocco G., Palazzi E., Vignali C., 2002, *BeppoSAX/PDS identification of the true counterpart of the Piccinotti source H0917-074*, A&A 394, 801

41. Mannucci F., **Pozzetti L.**, Thompson D., Oliva E., Baffa C., Comoretto G., Gennari S., Lisi F., 2002, *The relative abundances of ellipticals and starbursts among the extremely red galaxies*, MNRAS 329, L57

42. Matute I., La Franca F., Pozzi F., Gruppioni C., Lari C., **Zamorani G.**, Danese L., Oliver S., Serjeant S., Rowan-Robinson M., 2002, *The Evolution of type 1 AGN in the IR (15micron). The view from ELAIS-S1*, MNRAS 332, L11

43. Monaco L., **Ferraro F.R.**, **Bellazzini M.**, Pancino E., 2002, *First Detection of the Red Giant Branch Bump in the Sagittarius Dwarf Spheroidal Galaxy*, ApJ 578, L47

44. Morris D.J., Hobbs G., Lyne A.G., Stairs I.H., Camilo F., Manchester R.N., **Possenti A.**, Bell J.F., Kaspi V.M., **D'Amico N.**, McKay N.P.F., Crawford F., Kramer M., 2002, *The Parkes Multibeam Pulsar Survey - II. Discovery and timing of 120 pulsars*, MNRAS 335, 275

45. Nipoti C., **Londrillo P.**, **Ciotti L.**, 2002, *Radial orbital anisotropy and the Fundamental Plane of elliptical galaxies*, MNRAS 332, 901

46. **Origlia L.**, **Ferraro F.R.**, **Fusi Pecci F.**, Rood R.T., 2002, *ISOCAM Observations of Galactic Globular Clusters: Mass Loss along the Red Giant Branch*, ApJ 571, 458

47. **Origlia L.**, Rich R.M., Castro A., 2002, *High-Resolution Infrared Spectra of Bulge Globular Clusters: Liller 1 and NGC 6553*, AJ 123, 1559

48. Palla F., Galli D., Marconi A., **Stanghellini L.**, **Tosi M.**, 2002, *The 12C/13C ratio in the planetary nebula NGC3242 from HST STIS observations*, ApJ 568, L57

49. Pancino E., Pasquini L., Hill V., **Ferraro F.R.**, **Bellazzini M.**, 2002, *High-Resolution Spectroscopy of Metal-rich Giants in ω Centauri: First Indication of Type Ia Supernova Enrichment*, ApJ 568, L101

50. **Possenti A.**, Cerutti R., Colpi M., Mereghetti S., 2002, *Re-examining the X-ray versus spin-down luminosity correlation of rotation powered pulsars*, A&A 387, 993

51. Puzia T. H., Saglia R. P., Kissler-Patig M., Maraston C., **Greggio L.**, Renzini A., Ortolani S., 2002, *Integrated spectroscopy of bulge globular clusters and fields. I. The data base and comparison of individual Lick indices in clusters and bulge*, A&A 395, 45

52. Recchi S., Matteucci F., **D'Ercole A.**, **Tosi M.**, 2002, *Multiple starbursts in Blue Compact Galaxies*, MNRAS 384, 799

53. Schulte-Ladbeck R. E., Hopp U., Drozdovsky I. O., **Greggio L.**, Crone M. M., 2002, *The Oldest Stars of the Extremely Metal-Poor Local Group Dwarf Irregular Galaxy Leo A*, AJ 124, 896

54. **Stanghellini L.**, Shaw R.A., Mutchler M., Palen S., Balick B., Blades J.C., 2002, *Optical Slitless Spectroscopy of Large Magellanic Cloud Planetary Nebulae: A Study of the Emission Lines and Morphology*, ApJ 575, 178

55. **Stanghellini L.**, Villaver E., Manchado A., Guerrero M.A., 2002, *The Correlations between Planetary Nebula Morphology*

and Central Star Evolution: Analysis of the Northern Galactic Sample, ApJ 576, 285

56. Swaters R.A., van Albada T.S., van der Hulst J.M., **Sancisi R.**, 2002, *The Westerbork HI survey of spiral and irregular galaxies. I. HI imaging of late-type dwarf galaxies*, A&A 390, 829

57. Tavecchio F., Maraschi L., Ghisellini G., Celotti A., Chiappetti L., **Comastri A.**, Fossati G., Grandi P., Pian E., Tagliaferri G., Treves A., Sambruna R., 2002, *Spectral Energy Distributions of Flat-Spectrum Radio Quasars Observed with BeppoSAX*, ApJ 575, 137

58. Venturi T., **Bardelli S.**, Zagaria M., Prandoni I., Morganti R., 2002, *Radio emission from the A3571 cluster complex: the final stage of a cluster merger?*, A&A 385, 39

59. Vignali C., **Comastri A.***Disclosing the nature of the Seyfert 2 galaxy NGC 3281: one more Compton thick source*, 2002, A&A 381, 834

2003 and in press

1. **Bellazzini M.**, **Cacciari C.**, **Federici L.**, **Fusi Pecci F.**, Rich R.M., 2003, *The Andromeda Project. I. Deep HST-WFPC2 V,I photometry of 16 fields toward the disk and the halo of the M31 galaxy. Probing the stellar content and metallicity distribution*, A&A, in press (astro-ph/0212531)

2. **Bellazzini M.**, **Ferraro F.R.**, Ibata R., 2003, *Building Up the Globular Cluster System of the Milky Way: The Contribution of the Sagittarius galaxy*, AJ 125, 188

3. Bondi M., **Ciliegi P.**, **Zamorani G.**, Gregorini L., Vettolani G., Parma P., **De Ruiter H.R.**, LeFevre O., Arnaboldi M., Guzzo L., Maccagni D., Scaramella R., Adami C., **Bardelli S.**, Bolzonella M., Bottini D., **Cappi A.**, Foucaud S., Franzetti P., Garilli B., Gwyn S., Ilbert O., Iovino A., LeBrun V., Marano B., Marinoni C., McCracken H.J., Meneux B., Pollo A., **Pozzetti L.**, Radovich M., Ripepi V., Rizzo D., Scodeggio M., Tresse L.,

Zanichelli A., **Zucca E.**, 2003, *The VLA-VIRMOS Deep Field: I. Radio observations probing the μJy population*, A&A, in press (astro-ph/0303364)

4. **Bragaglia A.**, **Tosi M.**, 2003, *Intermediate age open clusters: Collinder 110*, MNRAS, in press (astro-ph/0303662)

5. **Cappi A.**, Benoist C., da Costa L.N., Maurogordato S., 2003, *Nature and Environment of Very Luminous Galaxies*, A&A, in press

6. **Ciliegi P.**, Vignali C., **Comastri A.**, Fiore F., La Franca F., Perola G.C., 2003, *The BeppoSAX High Energy Large Area Survey (HELLAS) – VI. The radio properties*, MNRAS, in press (astro-ph/0302256)

7. **Clementini G.**, Held E.V., Baldacci L., Rizzi L., 2003, *RR Lyrae and short-period variable stars in the dwarf irregular galaxy NGC 6822*, ApJ Letters, in press (astro-ph/0304076)

8. **Clementini G.**, Gratton R.G., **Bragaglia A.**, Carretta E., Di Fabrizio L., Maio M., 2003, *Luminosities and pulsational properties of RR Lyrae variables in the bar of the Large Magellanic Cloud*, AJ 125, 1309

9. **Comastri A.**, Brunetti G., Dallacasa D., Bondi M., Pedani M., Setti G., 2003, *Inverse Compton X-rays from the radiogalaxy 3C 219*, MNRAS 340, L52

10. de Lapparent V., Galaz G., **Bardelli S.**, Arnouts S., 2003, *The ESO-Sculptor Survey: Luminosity Function of galaxies per spectral type at redshifts 0.1-0.5*, A&A, in press (astro-ph/0301339)

11. Del Zanna L., Bucciantini N., **Londrillo P.**, 2003, *An efficient shock-capturing central-type scheme for multidimensional relativistic flows. II. Magnetohydrodynamics*, A&A, in press (astro-ph/0210618)

12. Ferrari C., Maurogordato S., **Cappi A.**, Benoist C., 2003, *Multiple Merging Events in Abell 521*, A&A 399, 813

13. **Ferraro F.R.**, Sabbi E., Gratton R., Possenti A., D'Amico N., **Bragaglia A.**, Camilo F., 2003, *Accurate Mass Ratio and Heating Effects in the Dual-Line Millisecond Binary Pulsar in NGC 6397*, ApJ 584, L13

14. **Ferraro F.R.**, Sills A., Rood R.T., Paltrinieri B., Buonanno R., 2003, *Blue Straggler Stars: a direct comparison of Star counts and population ratios in six Galactic Globular Clusters*, ApJ, in press (astro-ph/0301261)

15. Gilli R., Cimatti A., ... , **Mignoli M.**, ... , **Zamorani G.** et al., 2003, *Tracing the large scale structure in the Chandra Deep Field South*, ApJ Letters, in press

16. Gruppioni C., Pozzi F., **Zamorani G.**, **Ciliegi P.**, Lari C., Calabrese E., La Franca F., Matute I., 2003, *The Radio–Mid-Infrared Correlation and the Contribution of 15-μm Galaxies to the 1.4-GHz Source Counts*, MNRAS, in press (astro-ph/0303116)

17. Lanzoni B., **Ciotti L.**, 2003, *Projection effects on the FP thickness: a Monte-Carlo exploration*, A&A, in press

18. Maraston C., **Greggio L.**, Renzini A., Ortolani S., Saglia R. P., Puzia T. H., Kissler-Patig M., 2003, *Integrated spectroscopy of bulge globular clusters and fields. II. Implications for population synthesis models and elliptical galaxies*, A&A 400, 823

19. Morganti R., Oosterloo T.A., Capetti A., **De Ruiter H.R.**, Fanti R., Parma P., Tadhunter C.N., Wills K.A., 2003, *B2 0648 +27: a radio galaxy in a major merger*, A&A 399, 511

20. Neumann D., Arnaud M., Benoist C., da Costa L., Jørgensen H.E., Olsen L.F., **Bardelli S.**, **Zucca E.**, Arnouts S., Biviano A., Ramella M., 2003, *The origin of X-ray emission from two distant ($z > 1$) cluster candidates with XMM–Newton*, A&A, in press

21. Nipoti C., Londrillo P., **Ciotti L.**, 2003, *Galaxy merging, the Fundamental Plane of elliptical galaxies, and the M_{BH}-σ relation*, MNRAS, in press

22. **Origlia L.**, **Ferraro F.R.**, **Bellazzini M.**, Pancino E., 2003, *A near-infrared spectroscopic screening of the red giant populations in omega Centauri*, ApJ, in press (astro-ph/0303601)

23. Parma P., **De Ruiter H.R.**, Capetti A., Fanti R., Morganti R., Bondi M., Laing R.A., Canvin J.R., 2003, *The HST survey of the B2 sample of radio galaxies: detection of two optical jets*, A&A 397, 127

24. Pellegrini S., Venturi T., **Comastri A.**, Fabbiano G., Fiore F., Vignali C., Morganti R., Trinchieri G., 2003, *The Nuclear Accretion in the FR I Radio Galaxy IC 4296 from Chandra and Very Long Baseline Array Observations*, ApJ 585, 677

25. **Pozzetti L.**, Cimatti A., **Zamorani G.**, ..., **Mignoli M.**et al., 2003, *The K20 survey. V. The evolution of the near-IR Luminosity Function*, A&A, in press

26. Pozzi F., **Ciliegi P.**, Gruppioni C., Lari C., Heraudeau P., **Mignoli M.**, **Zamorani G.**, Calabrese E., Oliver S., Rowan-Robinson M., 2003, *On the nature of the ISO-selected sources in the ELAIS S2 region*, MNRAS, in press

27. Ranalli P., **Comastri A.**, Setti G., 2003, *The 2-10 keV luminosity as a Star Formation Rate indicator*, A&A 399, 39

28. Sabbi E., Gratton R.G., **Ferraro F.R.**, **Bragaglia A.**, Possenti A., D'Amico N., Camilo F., 2003, *The complex Halpha line profile of the bright companion to PSR J1740-5340 in NGC 6397*, ApJ Letters, in press (astro-ph/0304159)

29. Venturi T., **Bardelli S.**, Brunetti G., Giacintucci S., Hunstead R.W., Morganti R., 2003, *The radio halo in the merging cluster A3562*, A&A, in press (astro-ph/0302080)

30. Zoccali M., Renzini A., Ortolani S., **Greggio L.**, Saviane I., Cassisi S., Rejkuba M., Barbuy B., Rich R. M., Bica E., 2003, *Age and metallicity distribution of the Galactic bulge from extensive optical and near-IR stellar photometry*, A&A 399, 931

INVITED PAPERS

2002

1. **Clementini G.**, Gratton R., 2002, *The oldest stars and the age of the Universe*, European Review, Ed. A. Burgen, Vol. 10, No.2, p.237

2. **Possenti A.**, 2002, *New peculiar objects in the millisecond pulsar zoo*, at "270. WE-Heraeus Seminar on Neutron Stars, Pulsars and Supernova Remnants", Physikzentrum Bad Honnef

3. **Stanghellini L.**, Shaw R.A., Mutchler M., 2002, *Magellanic Clouds Planetary Nebulae: An Updated View on Stellar Evolution and Populations*, in "Ionized Gaseous Nebulae", eds. W.J. Henney et al., Mexico City, RMxAC 12, 112

2003 and in press

1. **Cacciari C.**, 2003, *Globular Cluster Distances*, in "New Horizons in Globular Cluster Astronomy", G. Piotto, G. Meylan, G. Djorgowski, M. Riello eds., ASP Conf. Ser. in press

2. **Cacciari C.**, **Clementini G.**, 2003, *Globular Cluster Distances from RR Lyrae stars*, in "Stellar Candles for the Extragalactic Distance Scale", W.Gieren, D.Alloin eds., Lecture Notes in Physics, Springer-Verlag, Berlin-Heidelberg-New York, in press (astro-ph/0301550)

3. **Ferraro F.R.**, 2003, *Multi-wavelength observations of stellar populations in Galactic globular clusters*, in "New Horizons in Globular Cluster Astronomy", G. Piotto, G. Meylan, G. Djorgowski, M. Riello eds., S. Francisco: ASP Conf. Series, in press (astro-ph/0301272)

4. **Stanghellini L.**, 2003, *Planetary Nebulae in the Magellanic Clouds: Probing Stellar Evolution and Populations*, in "Planetary Nebulae: Their Evolution and Role in the Universe", IAU Symposium 209 (in press)

5. **Tosi M.**, 2003, *Understanding dwarf galaxies as galactic building blocks* in "The Evolution of galaxies. III - From simple approaches to self-consistent models", Ap&AS (Kluwer), in press

Lectures at schools

1. Sancisi R., 2002, Lectures on *Dark Matter in Spiral Galaxies*, Italian National School of Astrophysics on Galaxies Cetraro, Italy

2. Sancisi R., 2002, Lectures on *Kinematics and dynamics of galaxies*, NOVA School on Galaxies, Dwingeloo

3. Sancisi R., 2002, Course on *Galaxy Kinematics and Dark Matter*, XIV Canary Islands Winter School of Astrophysics, Dark Matter and Dark Energy in the Universe IAC, Tenerife, Spain

NON REFEREED PAPERS

2002

1. **Bardelli S.**, **Zucca E.**, Baldi A., 2002, *Large-scale distribution and spectral properties of galaxies in the Shapley Concentration*, Proceedings of *Where is the matter? Tracing dark and bright matter with the new generation of large scale survey, Marseille, June 2001,* M.Treyer & L.Tresse eds., Frontier Group, p.220

2. **Bardelli S.**, **Zucca E.**, Venturi T., De Grandi S., Ettori S., Molendi S., 2002, *Merging clusters in the Shapley Concentration*, Proceedings of *Tracing cosmic evolution with galaxy clusters, Sesto Pusteria, July 2001*, S.Borgani et al. eds., ASP conference series vol.268, p.143

3. Bondi M., **Ciliegi P.**, Gregorini L., Vettolani G., **Zamorani G.**, Parma P., **De Ruiter H.R.**, Bertin E., et al., on behalf of the VIRMOS Consortium, 2002 *The VIRMOS-VLA Survey* Proc. of the 3rd Marseille Conference "Where is the matter, tracing dark and bright matter with the new generation of large scale surveys, eds. L. Tresse and M. Treyer, p. 68

4. Bondi M., Parma P., **De Ruiter H.R.**, Fanti R., Laing R., 2002, *Decelerating relativistic radio jets in B2 0755+37*, Proc. of the Oxford Workshop "Particles and Fields in radio galaxies", eds. R.A. Laing and K.M. Blundell, ASP Conference Series, 250, 276

5. Bonoli C., Giro E., Conconi P., **Zitelli V.**, 2002, *A tunable Filter for the TNG*, SPIE Astronomical telescopes and Instrumentation into the New Millenium, Waikoloa, Hawaii

6. Brusa M., **Comastri A.**, Daddi E., Cimatti A., Vignali C., 2001, *An XMM-Newton survey of Extremely Red Objects*, in "Workshop on X-ray Spectroscopy of AGN with Chandra and XMM-Newton", MPE Garching, MPE Report 279, p.267

7. **Cacciari C.**, **Bellazzini M.**, Colucci S., 2002, *The RR Lyrae Variables in M54 and the Sgr Dwarf Galaxy*, in Extragalactic Star Clusters, IAU Symposium 207, D. Geisler, E.K. Grebel and D. Minniti eds., S. Francisco, ASP, p.168

8. **Cacciari C.**, Corwin T.M., Carney B.W., 2002, *A multi-color study of RR Lyrae variables in the globular cluster NGC5272 (M3)*, BAAS 200, 07.06

9. Capetti A., Celotti A., Chiaberge M., **De Ruiter H.R.**, Fanti R., Morganti R., Parma P., 2002, *The HST view of low luminosity radio galaxies*, Proc. Of the conference "Issues in unification of active galactic nuclei", eds. R. Maiolino, A. Marconi and N. Nagar ASP Conference Series 258, p.159

10. **Cappi A.**, 2002, *Testing Cosmological Models with Negative Pressure*, in "Tracing Cosmic Evolution with Galaxy Clusters", Borgani et al. eds., Sesto Pusteria, ASP, vol.268, p.247

11. **Cappi A.**, Benoist C., da Costa L., Maurogordato S., 2002, *The Environment of Optically Very Luminous Galaxies*, in "Lighthouses of the Universe", Gilfanov et al. eds., Garching, Springer, p.123

12. Catelan M., **Bellazzini M.**, **Ferraro F.R.**, **Fusi Pecci F.**, Galleti S., Landsman W. B., 2002, *Age as the Second Parameter in NGC 288/NGC 362?*, in "Extragalactic Star Clusters", IAU

Symposium 207, D. Geisler, E.K. Grebel and D. Minniti eds., S. Francisco: ASP, p.116

13. Catelan, M., Rood, R. T., **Ferraro F.R.**, 2002, *Second Parameter Effects in and between M3 and Palomar 3*, in "Extragalactic Star Clusters", IAU Symposium 207, D. Geisler, E.K. Grebel and D. Minniti eds., S. Francisco, ASP, p.113

14. **Clementini G.**, **Bragaglia A.**, Di Fabrizio L., Maio M., Carretta E., Gratton R., Held E.V., Momany Y., Rizzi L., Saviane I., 2002, *RR Lyrae variables in Local Group Galaxies: LMC, Leo I. New results and distances to those galaxies*, in "Radial and Nonradial Pulsations as Probes of Stellar Physics", C.Aerts, R.Bedding, J.Christensen-Dalsgaard eds., IAU Coll. 185, ASP Conf. 259, p.124

15. **Clementini G.**, **Federici L.**, **Cacciari C.**, **Bellazzini M.**, Corsi C., Smith H.A., 2002, *RR Lyrae variables in Local Group Galaxies: M31*, in "Radial and Nonradial Pulsations as Probes of Stellar Physics", C.Aerts, R.Bedding, J.Christensen-Dalsgaard eds., IAU Coll. 185, ASP Conf. 259, p.128

16. Colpi M., Gualandris A., **Possenti A.**, 2002, *Is NGC6752 hiding a double black hole binary in its core?*, in "New Horizons in Globular Cluster Astronomy", eds. G. Piotto, G. Meylan, G.Djorgovski M. Riello

17. **Comastri A.**, Brusa M., **Ciliegi P.**, **Mignoli M.**, Vignali C., Severgnini P., Maiolino R., Fiore F., La Franca F., Matt G., Perola G.C., Baldi A., Molendi S., 2002, *X–ray bright optically quiet galaxies: the case of P3*, Issues in Unification of Active Galactic Nuclei, ASP Conference Proceedings, Roberto Maiolino, Alessandro Marconi, and Neil Nagar eds., San Francisco, ASP 258, p.199

18. Ferrari C., Maurogordato S., Benoist C., Slezak E., Arnaud M., **Cappi A.**, 2002, *New evidences of merging for the galaxy cluster Abell 521*, in "Tracing Cosmic Evolution with Galaxy Clusters", Borgani et al. eds., Sesto Pusteria, ASP, vol.268, p.363

19. **Ferraro F.R.**, 2002, *Searching for Collision Products in Galactic Globular Cluster Cores*, in "Stellar Collisions, Mergers and their Consequences", M. Shara ed., S. Francisco, ASP Conf.Ser., 263, p.179

20. **Ferraro F.R.**, Pancino E., **Bellazzini M.**, 2002, *The Bologna Key Project on ω Centauri*, in "Omega Centauri, A Unique Window into Astrophysics", F. van Leeuwen, J.D. Hughes, G. Piotto eds., S. Francisco, ASP Conf.Ser., 265, p.407

21. Fiore F., Matt G., La Franca F., Perola G.C., Brusa M., **Comastri A.**, **Mignoli M.**, **Ciliegi P.**, Severgnini P., Maiolino R., Baldi A., Molendi S., Vignali C., *Optical identification of sources from the HELLAS2XMM survey*, in "Issues in Unification of Active Galactic Nuclei", Roberto Maiolino, Alessandro Marconi, Neil Nagar eds., San Francisco, ASP 258, p.205

22. Gruppioni C., **Zamorani G.**, **Ciliegi P.**, Pozzi F., Lari C. and Franceschini A., 2002, *The 15-μm Extragalactic Source Counts and the MIR-Radio Correlation*, Proc. of the Fifth Italian Conference on AGNs, Como
www.merate.mi.astro.it/ gabriele/agn5/agn5.html

23. Gualandris A., Colpi M., **Possenti A.**, 2002, *Unveiling black holes ejected from globular clusters*, in "New Horizons in Globular Cluster Astronomy", eds. G. Piotto, G. Meylan, G.Djorgovski, M. Riello

24. Kaspi V.M., McLaughlin M.A., Stairs I.H., Lorimer D.R., Kramer M., Lyne A.G., Manchester R.N., Camilo F., Hobbs G., **Possenti A.**, **D'Amico N.**, Faulkner A.J., 2002, *A Radio Pulsar with an Ultra-High Magnetic Field*, AAS, HEAD meeting 35, 2009

25. Kuijken K., Bender R., Cappellaro E., ..., **Greggio L.**et al., 2002, *OmegaCAM: the 16k×16k CCD camera for the VLT survey telescope*, The Messenger 110, 15

26. Le Fèvre O., Vettolani G., Maccagni D., Mancini D., Mazure A., Mellier Y., Picat J.P., Arnaboldi M., **Bardelli S.**, Bertin E., Busarello G., **Cappi A.**, Charlot S., Chincarini G., Colombi

S., Garilli B., Guzzo L., Iovino A., LeBrun V., Longhetti M., Mathez G., Merluzzi P., McCracken H.J., Pellò R., **Pozzetti L.**, Radovich M., Ripepi V., Saracco P., Scaramella R., Scodeggio M., Tresse L., **Zamorani G.**, **Zucca E.**, 2002, *The VIRMOS-VLT Deep Survey*, in "Where is the matter? Tracing dark and bright matter with the new generation of large scale survey", Marseille L.Tresse & M.Treyer eds., Frontier Group, p.83

27. Lorimer D.R., Camilo F., Freire P., Kramer M., Lyne A.G., Manchester R.N., **D'Amico N.**, 2002, *Millisecond Radio Pulsars in 47 Tucanae*, in "Radio Pulsars", eds. M. Bailes, D.J. Nice, S.E. Thorsett

28. **Mignoli M.**, **Zamorani G.**, Marano B., 2002, *A Faint Quasar Survey in the Marano Field*, in "Lighthouses of the Universe: The Most Luminous Celestial Objects and Their Use for Cosmology", Proceedings of the MPA/ESO, p.590

29. Murgia M., Parma P., Fanti R., **De Ruiter H.R.**, Ekers R.D., Fomalont E.B., 2002, *A multi-frequency study of the radio galaxy NGC 326*, Proc. of the Oxford Workshop "Particles and Fields in radio galaxies", eds. R.A. Laing and K.M. Blundell, ASP Conference Series, 250, p.380

30. Parma P., Murgia M., **De Ruiter H.R.**, Fanti R., 2002, *The lives of FRI radio galaxies*, Proc. Of the workshop "Life cycles of radio galaxies, Baltimore, eds. J. Biretta, A.M. Koekemoer, E.S. Perlman and C.P.O'Dea, New Astronomy Reviews 46, 313

31. Pasquini L., Avila G., Blecha A., **Cacciari C.**, Cayatte V., Colless M. et al., 2002, *Installation and Commissioning of FLAMES, the VLT Multifibre Facility*, The Messenger 110, 1

32. Pellegrini S., **Ciotti L.**, 2002, *Recovering true metal abundances of the ICM*, in "Chemical Enrichment of Intracluster and Intergalactic medium", F. Matteucci and R. Fusco-Femiano eds., ASP Conference Series 253, p.65

33. Pirzkal N., De Marchi G., Hook R.N., **Ferraro F.R.**, 2002, *A search for short period variables in the core of NGC 288*, AAS Meeting 201, p.713

34. Pooley D., Lewin W., Homer L., Anderson S., Margon B., Verbunt F., Kaspi V., **D'Amico N.**, Gaensler B., Portegies Zwart S., van der Klis M., McMillan S., Makino J., Fox D., Filippenko A., Hut P., 2002, *The Close Binary Population of Globular Clusters Revealed by Chandra*, AAS Meeting 201

35. Porceddu I., Buffa F., Ortolani S., **Zitelli V.**, 2002, *The Galileo Telescope at ORM:site characterization*, in "Astronomical Site Evaluation in the Visible and radio range", J. Vernin, Z. Benkhaldoun and C. Munoz Tunon eds., Marrakech, ASP 266, p.432

36. Porceddu I., **Zitelli V.**, Buffa F., Ghedina A., 2002, *Dust Pollution monitoring at the TNG telescope*, in "SPIE Astronomical telescopes and Instrumentation into the New Millenium", Waikoloa, Hawaii

37. **Possenti A.**, 2002, *The peculiar millisecond pulsars in the globular clusters NGC 6397 and NGC 6752*, in "270. WE-Heraeus Seminar on Neutron Stars, Pulsars and Supernova Remnants", eds. W. Becker, H. Lesch, J. Truemper, MPE Report 278

38. Prandoni I., Gregorini L., Parma P., **De Ruiter H.R.**, Vettolani G., Wieringa M., Ekers R.D., 2002, *The nature of the faint radio population*, Proc. of the 3rd Marseille Conference "Where is the matter, tracing dark and bright matter with the new generation of large scale surveys, L.Tresse and M.Treyer eds., p.73

39. Recchi S., Matteucci F., **D'Ercole A.**, 2002, *Galactic Winds in Starburst Irregular Galaxies*, R. Fusco-Femiano & F. Matteucci eds., San Francisco, ASP 253, p.397

40. Rich R.M., Corsi C.E., **Bellazzini M.**, **Federici L.**, **Cacciari C.**, **Fusi Pecci F.**, 2002, *A Survey of M31 Globular Clusters using WFPC2 on board HST*, in "Extragalactic Star Clusters", IAU Symposium 207, D.Geisler, E.K.Grebel, D.Minniti eds., S. Francisco, ASP, p.140

41. Spagna A., **Cacciari C.**, Drimmel R., Kinman T.D., Lattanzi M.G., Smart R.L., 2002, *Galaxy structure and kinematics towards the NGP*, in "Gaia Spectroscopy, Science and Technology", Ed. U.Munari, ASP Conf.Ser. 298, p.137

42. Stairs I.H., Manchester R.N., Lyne A.G., Kramer M., Camilo F., Kaspi V.M., **D'Amico N.**, 2002, *Constraining the Orbital Geometry of the PSR J1740-3052 System*, AAS Meeting 201

43. Stairs I.H., Manchester R.N., Lyne A.G., Kramer M., Camilo F., Kaspi V.M., **D'Amico N.**, 2002, *The Massive Binary Pulsar J1740-3052*, in "Radio Pulsars", eds. M. Bailes, D.J. Nice, S.E. Thorsett

44. Venturi T., **Bardelli S.**, Zagaria M., Prandoni I., Morganti R., 2002, *Radio emission from the A3571 cluster complex in the Shapley Concentration*, Proceedings of "Tracing cosmic evolution with galaxy clusters", Sesto Pusteria, S.Borgani et al. eds., ASP Conf.Ser. 268, p.455

45. Venturi T., Pellegrini S., **Comastri A.**, Morganti R., Vignali, C., 2002, *The accretion process in the nucleus of the radio galaxy PKS 1333-33*, "6th European VLBI Network Symposium on New Developments in VLBI Science and Technology", Bonn, E.Ros, R.W. Porcas, A.P. Lobanov, J.A. Zensus eds., p.165

46. **Zucca E.**, **Bardelli S.**, Baldi A., 2002, *Large-scale distribution and spectral properties of galaxies in the Shapley Concentration*, in "Tracing cosmic evolution with galaxy clusters", Sesto Pusteria, S.Borgani et al. eds., ASP Conf.Ser. 268, p.463

2003 and in press

1. Angeretti L., **Pozzetti L.**, **Zamorani G.**, 2003, *Selection Effects in Surface Brightness in Deep Surveys*, proceedings of the conference "A new era in cosmology", University of Durham, UK, 11-15th September 2001, eds. T. Shanks and N. Metcalfe, in press

2. Baldacci L., **Clementini G.**, Held E.V., Rizzi L., 2003, *NGC 6822: detection of variable stars with ISIS2.1*, in "Variability with Wide Field Imagers", Lampedusa, Mem.SAIt, in press (astro-ph/0303094)

3. Baldacci L., Matonti F., **Clementini G.**, Rizzi L., Held E.V., Di Fabrizio L., Momany, Y., Saviane, I., 2003, *Variable stars and stellar populations in the Local Group: Leo I and NGC 6822*, in "Stars in Galaxies", La Palma, Mem.SAIt, M.Bellazzini, A.Buzzoni, S. Cassisi eds., in press

4. Baldacci L., Rizzi L., **Clementini G.**, Held E.V., Momany Y., Di Fabrizio L., Saviane I., 2003, *The distance to NGC 6822 from its RR Lyrae's*, in "New horizons in Globular Cluster Astronomy", ASP Conf. Ser., G.Piotto, et al. eds., in press

5. Baldi A., Molendi S., **Comastri A.**, Fiore F., Matt G., Vignali C., for the HELLAS2XMM collaboration *The log(N)-log(S) and the Broadband Properties of the Sources in the HELLAS2XMM Survey*, Proceedings of the Symposium: "New Visions of the X-ray Universe in the XMM-Newton and Chandra Era", ESTEC The Netherlands , in press (astro-ph/0201525)

6. **Bellazzini M.**, 2003, *The RGB Bump in dwarf Spheroidal galaxies: discovery and perspectives*, in IV National Workshop on Stellar Astrophysics - Stars in Galaxies, A. Buzzoni, S. Cassisi and M. Bellazzini Eds., Mem. SAIt, in press (astro-ph/0303331)

7. **Bragaglia A.**, 2003, *Old Open Clusters*, in "Stars in galaxies", La Palma, Mem.SAIt, M.Bellazzini, A.Buzzoni, S. Cassisi eds., in press

8. **Bragaglia A.**, **Tosi M.**, Marconi G., Di Fabrizio L., 2003, *Old Open Clusters as Tracers of Galactic Evolution*, in 'Observed HR Diagrams and stellar evolution: the inteplay between observational constraints and theory', Coimbra, ASP Conf. Ser., T.Lejeune, J.Fernandez eds., in press

9. Brunetti G., **Comastri A.**, Dallacasa D., Bondi M., Pedani M., Setti G. *Chandra detects inverse Compton emission from the radio galaxy 3C 219*, Proceedings of the Symposium: "New Visions of the X-ray Universe in the XMM-Newton and Chandra Era", ESTEC The Netherlands, in press (astro-ph/0202373)

10. Brunetti F., **Marra M.**, Olostro Cirella E., Schiavone L., 2003, *The Cost and Use of Serials in Italian Astronomical Libraries*

ASP Conf. Ser., in press

11. Cacciari C., Kinman T.D., **Bragaglia A.**, Buzzoni A., Spagna A., 2003, *The vertical structure of the Halo rotation*, in 'Stars in galaxies', La Palma, 7-11 marzo 2003, Mem.SAIt, M.Bellazzini, A.Buzzoni, S. Cassisi eds., in press

12. **Cappi A.**, 2003, *The Cosmology of Edgar Allan Poe*, in "Cosmology through Time", Roma, Mem. SAIt, in press

13. **Cappi A.**, 2003, *Testing Cosmological Models with Negative Pressure*, in "On the nature of Dark Energy", Proceedings of the XVIII IAP Colloquium, in press

14. Cappi M., Di Cocco G., Panessa F., Foschini L., Trifoglio M., Gianotti F., Stephen J., Bassani L., Dadina M., **Comastri A.**, Della Ceca R., Filippenko A.V., Ho L.C., Makishima K., Malaguti G., Mulchaey J., Palumbo G.G.C., Piconcelli E., Sargent W., Weaver K., **Zamorani G.**, *First Results from a XMM-Newton Survey of a Distance-Limited (D¡22 Mpc) Sample of Seyfert Galaxies: I- the AGNs*, Proceedings of the Symposium: "New Visions of the X-ray Universe in the XMM-Newton and Chandra Era", ESTEC The Netherlands, in press (astro-ph/0202245)

15. Carretta E., Gratton R., **Bragaglia A.**, **Tosi M.**, Marconi G., 2003, *Metallicity of old open clusters*, in "Observed HR Diagrams and stellar evolution: the inteplay between observational constraints and theory", Coimbra, ASP Conf. Ser., T.Lejeune, J.Fernandez eds., in press

16. Cimatti A., Daddi E., **Mignoli M.**, **Pozzetti L.**, ..., **Zamorani G.**et al., 2003, *The K20 survey: New Light on Galaxy Formation and Evolution*, ESO Messenger 111, 29

17. **Ciotti L.**, Haiman Z., Ostriker J.P., 2003 *What does the local black hole mass distribution tell us about the evolution of the quasar luminosity function?* in: ESO Astrophysics Symposia: "The mass of galaxies at low and high redshift", R. Bender and A. Renzini, eds. (Springer-Verlag), p.106

18. **Clementini G.**, 2003 *The VSNG project: variable stars in nearby galaxies*, in "Variability with Wide Field Imagers", 16-20 sept. 2003, Lampedusa, Mem.SAIt, in press (astro-ph/0303067)

19. **Clementini G.**, **Bragaglia A.**, Maio M., Carretta E., Gratton R., Di Fabrizio L., 2003, *CMDs, RR Lyrae's, clump stars and reddening in the LMC* in 'Observed HR Diagrams and stellar evolution: the inteplay between observational constraints and theory', Coimbra, ASP Conf. Ser., T.Lejeune, J.Fernandez eds., in press

20. **Comastri A.**, Brusa M., **Ciliegi P.**, **Mignoli M.**, Fiore F., Maiolino R., Severgnini P., Baldi A., Molendi S., Vignali C., La Franca F., Matt G., Perola G.C., 2003, *On the nature of X-ray Bright Optically Normal galaxies*, Proceedings of the Symposium: "New Visions of the X-ray Universe in the XMM-Newton and Chandra Era", ESTEC, The Netherlands, in press (astro-ph/0203019)

21. **Comastri A.**, Brusa M., **Mignoli M.**, and the HELLAS2XMM collaboration, 2003, *Unconventional AGN in hard X-ray surveys*, Proc. workshop "X-ray surveys in the light of the new observatories", Astronomische Nachrichten 324, 28

22. **Comastri A.**, Ranalli P., Brusa M., 2003 *Beyond the X-ray background with XEUS*, in "XEUS - studying the evolution of the hot universe", held at MPE Garching, G.Hasinger et al. eds., MPE Report 281, 19

23. Djorgovski S.G., Côté P., Meylan G., Castro S.M., **Federici L.**, **Parmeggiani G.**, **Cacciari C.**, **Fusi Pecci F.**, Rich R.M., 2002, *Correlations of Globular Cluster Properties: Their Interpretations and Uses*, in "New Horizons in Globular Cluster Astronomy", eds. G. Piotto, G. Meylan, G. Djorgowski & M. Riello, ASP Conf. Ser. in press

24. Ferrari C., Maurogordato S., Benoist C., **Cappi A.**, Slezak E., 2003, *MUSICS: MUlti–wavelength Sample of Interacting Clusters*, in Clusters of Galaxies: Probes of Cosmological Structure and Galaxy Evolution, eds.J.S.Mulchaey, A.Dressler, A.Oemler,

Carnegie Observatories Astrophysics Series, Vol.3, in press www.ociw.edu/ociw/symposia/series/symposium3/proceedings.html

25. Focardi P., Kelm B., **Zitelli V.**, Sarti G., 2003, *Seyfert Galaxies in Compact Groups*, AGN Meeting, Como, in press

26. Fraternali F., **Sancisi R.**, Oosterloo T., *The HI halo of spiral galaxies*, 2002, Proceedings of JENAM 2002 "The unsolved Universe: challenges for the future", Porto, Portugal, in press

27. Fraternali F., Oosterloo T., **Sancisi R.**, van Moorsel G., 2002 *Anomalous HI in spiral galaxies*, Proceedings of Conference "Seeing Through the Dust", Penticton (Canada), in press

28. Galleti S., **Cacciari C.**, **Federici L.**et al., 2003, *Search of globular clusters in external galaxies*, in "Stars in Galaxies", Mem. S.A.It. in press

29. Gratton R.G., ..., **Bragaglia A.**, ... , **Clementini G.**, ..., 2003 *Distances, Ages and Metal Abundances in Globular Cluster Dwarfs* in 'Observed HR Diagrams and stellar evolution: the inteplay between observational constraints and theory', Coimbra, ASP Conf. Ser., T.Lejeune, J.Fernandez eds., in press

30. Gratton R.G., Carretta E., **Bragaglia A.**, **Clementini G.**, Grundahl F., 2003 *New determination of the distances to NGC6397, NGC6752, and 47 Tuc based on main sequence fitting*, in 'New horizons in Globular Cluster Astronomy', ASP Conf. Ser., G.Piotto, G.Meylan, G.Djorgovski, M.Riello eds., in press

31. Held E.V., Moretti A., **Federici L.**, **Cacciari C.**, Rizzi L., Testa V., 2002, *VLT spectroscopy of globular clusters in the Sombrero galaxy*, in "Extragalactic Globular Cluster Systems", ESO Workshop, in press (astro-ph/0210687)

32. Kinman T.D., Cacciari C., **Bragaglia A.**, Buzzoni A., Spagna A., 2003, em The vertical structure of the Halo rotation, in 'JENAM 2002: Galactic Dynamics Workshop', Porto (astro-ph/0211243)

33. Lanzoni B., **Cappi A.**, **Ciotti L.**, 2003, *High-resolution resimulations of massive DM halos and the Fundamental Plane of*

galaxy clusters, in "Astrofisica computazionale in Italia: modelli e metodi di visualizzazione", R. Capuzzo-Dolcetta ed., Mem. S.A.It., in press

34. **Lanzoni B.**, **Cappi A.**, **Ciotti L.**, **Zamorani G.**, 2003 *Il Piano Fondamentale degli ammassi di galassie in simulazioni ad alta risoluzione* in VII Congresso Nazionale di Cosmologia, in press

35. Lari C., Vaccari M., Rodighiero G., Fadda D., Gruppioni C., Pozzi F., Franceschini A., **Zamorani G.**, 2002, *The LARI Method for ISO-CAM/PHOT Data Reduction and Analysis.* Proc. of the Symposium: Exploiting the ISO Data Archive: Infrared Astronomy in the Internet Age, Sigũenza, June 24 - 27, 2002. Eds. C. Gry et al. – ESA SP-511, in press

36. Londrillo P., Nipoti C., **Ciotti L.**, 2003, *A parallel implementation of a new, fast algorithm for N-body simulations*, in "Astrofisica computazionale in Italia: modelli e metodi di visualizzazione", Mem.SAIt, in press

37. Maio M., Baldacci L., **Clementini G.**, Greco, C., Gullieuszik, M., Held, E.V., Poretti, E., Rizzi, L., **Bragaglia A.**, Carretta E., Di Fabrizio L., Gratton R.G., Taribello, E., 2003 *Distance scale and variable stars in Local Group Galaxies: LMC and Fornax*, in 'Stars in Galaxies' La Palma, 7-11 marzo 2003, Mem.SAIt, M.Bellazzini, A.Buzzoni, S. Cassisi eds., in press (astro-ph/0303666)

38. Maio M., **Clementini G.**, **Bragaglia A.**, Carretta E., Gratton R.G., Di Fabrizio L., 2003, *Variable stars in the LMC: the photometric catalogue* in "Variability with Wide Field Imagers', Lampedusa, in press

39. Mazzali P. A., Turatto M., Annibali F., Recchi S., Nomoto K., Tosi M., **Greggio L.**, **D'Ercole A.**, Matteucci F., 2003, *Nucleosynthesis, the late stages of stellar evolution, chemical and dynamical evolution of late-type galaxies*, Memorie della Società Astronomica Italiana 74, 379

40. Moretti A., Held E.V., Rizzi L., Testa V., **Federici L.**, **Cacciari C.**, 2002, *Wide field photometry of the M104 globular cluster system*, in "Extragalactic Globular Cluster Systems", ESO Workshop, in press (astro-ph/0210689)

41. Muccione V., **Ciotti L.**, 2003, *Elliptical galaxies interacting with the cluster tidal field: origin of the intracluster stellar population*, in "Astrofisica computazionale in Italia: modelli e metodi di visualizzazione", R. Capuzzo-Dolcetta ed., Mem. S.A.It., in press

42. Muccione V., **Ciotti L.**, 2003, *Collisionless evaporation from cluster elliptical galaxies*, in "Galaxies and Chaos", G. Contopoulos and N. Voglis, eds., Springer-Verlag, in press

43. Neumann D., Benoist C., Arnaud M., daCosta L., Jørgensen H.E., Olsen L.F., **Bardelli S.**, **Zucca E.**, Arnouts S., Biviano A., Maurogordato S., Scodeggio M., Ramella M., 2002, *The detection of X-Ray Emission from two high redshift ($z > 1$) clusters with XMM–Newton*, Proceedings of "New visions of the X-ray Universe in the XMM–Newton and Chandra era", ESTEC, The Netherlands, November 2001, F.Jensen et al. eds., ESA SP-488, in press

44. Nipoti C., **Londrillo P.**, **Ciotti L.**, 2003 *Galaxy merging and the Fundamental Plane of elliptical galaxies* in "The mass of galaxies at low and high redshift", ESO Astrophysics Symposia, R. Bender and A. Renzini, eds. (Springer-Verlag), p.70

45. **Origlia L.**, Rich R.M., 2003, *High resolution infrared spectra of bulge globular clusters*, Mem. SAIt 74, 177

46. **Pozzetti L.**, **Zamorani G.**, Cimatti A., **Mignoli M.**et al., 2003, The evolution of the near-IR Luminosity to $z \simeq 1$ in the K20 redshift survey, proceedings of the ESO/USM Workshop "The Mass of Galaxies at Low and High Redshift", Venice (Italy), eds. R. Bender and A. Renzini, p.138

47. **Pozzetti L.**, ..., **Zamorani G.**, ..., **Mignoli M.**et al., 2003, *The evolution of the near-IR Luminosity Function from K20 survey* in "Galaxy Evolution: Theory and Observations", Cozumel

(Mexico), Aprile 8-12, 2002, Eds. V. Avila-Reese, C. Firmani, C. Frenk, & C. Allen, RevMexAA SC, in press

48. Ranalli P., **Comastri A.**, Setti G., 2003, *The 2-10 keV luminosity as a Star Formation Rate indicator*, Proceedings of the Symposium "New Visions of the X-ray Universe in the XMM-Newton and Chandra Era", ESTEC, The Netherlands, in press (astro-ph/0202241)

49. Rizzi L., Held E.V., Saviane I., Momany Y., **Clementini G.**, Bertelli G., 2003, *Wide field H-R diagrams of Local Group Galaxies*, in "Observed HR Diagrams and stellar evolution: the inteplay between observational constraints and theory", Coimbra, ASP Conf. Ser., T.Lejeune, J.Fernandez eds., in press

50. **Tosi M.**, **Greggio L.**, Annibali F., 2002, *Coimbra experimente on CMD analysis: report from Group 12*, in 'Observed HR diagrams and stellar evolution: the interplay between observational constraints and theory', T.Lejeune & J.Fernandes eds, ASP Conf.Ser., 274, in press

51. **Tosi M.**, **Greggio L.**, Annibali F., Aloisi A., 2002, *Star formation histories of late-type dwarfs outside the Local Group*, in 'Observed HR diagrams and stellar evolution: the interplay between observational constraints and theory', T.Lejeune & J.Fernandes eds, ASP Conf.Ser., 274, in press

10 Observing Campaigns

Radio Telescopes

1. ATCA, 21cm, *Search for HI emission in the merging complex A3558*, PI: T.Venturi, CoI: **Bardelli S.**et al., 24 hrs, January–March 2002

2. GMRT, 235 MHz, 327 Mhz, 610 Mhz, *Low frequency study of the radio halo in the merging cluster A3562*, PI: T.Venturi, CoI: **Bardelli S.**et al., 20 hrs, January–February 2003

3. VLA, *The radio nature of XMM X-ray source*, PI: **P. Ciliegi**, CoI: **A. Comastri**, M.Brusa, A.Baldi, C.Perola, P.Severgnini, C.Vignali, 4 hrs, June 2002

4. VLA, *Dying radio sources* P.I.: M. Murgia, CoI: **De Ruiter H.R.**, 50 hrs, 2002

ESO

VLT

5. ESO VLT + FORS1, *Optical identification of faint hard HELLAS2XMM sources*, PI: F. Fiore CoI: A. Baldi, S. Molendi, **Comastri A.**, **Mignoli M.**, M. Brusa, **Ciliegi P.**, F. La Franca, G. Matt, G.C. Perola, P. Severgnini, R. Maiolino, C. Vignali, 27 hrs, April–September 2002, service mode

6. ESO VLT + FORS1, *Hunting for the optical counterpart to the binary millisecond pulsar companion in the outskirts of NGC 6752*, PI: **F.R. Ferraro**, CoI: E. Sabbi, **N. D'Amico**, A. Possenti, 3hrs, 2002, service mode

7. ESO VLT + FORS2, *A new member of the Cocal Group behind the globular cluster 47 Tuc?*, PI: **M. Bellazzini**, CoI: **F.R. Ferraro**, E. Pancino, 3.5hr, 2002, service mode

8. ESO VLT + FORS2, *The first building blocks in the Local Group: probing the oldest stellar populations in Dwarf Galaxies through the metal distribution of the RR Lyrae stars in Sculptor*, PI: **G. Clementini**, CoI: **A. Bragaglia**, E. Carretta, R. Gratton, E. Held, V. Ripepi, L. Rizzi, 2hrs + 8hrs 2003, service mode

9. ESO VLT + FORS2, *Spectroscopic Confirmation of* $5 < z < 6.5$ *galaxies*, PI: Daddi, CoI: Fontana, Broadhurst, Cimatti, Cristiani, D'Odorico, di Serego Alighieri, Giallongo, Gilmozzi, Menci, **Mignoli M.**, Nonino, Poli, **Pozzetti L.**, Renzini, Rosati, Saracco, Vernet, **Zamorani G.**, 1 night, October 2002

10. ESO VLT + FORS2, *Pushing to higher redshifts the study of old ellipticals and dust-obscured star-forming galaxies*, PI: Daddi, CoI: Cimatti, Broadhurst, Daddi, di Serego Alighieri, Fontana, Giallongo, **Mignoli M.**, Poli, **Pozzetti L.**, Renzini, Vernet, **Zamorani G.**, 1 night, October 2002

11. ESO VLT + FORS2, *Tracing the history of galaxy mass assembly: searching for massive galaxies at* $z = 1$, PI: Cimatti, CoI: Broadhurst, D'Odorico, Daddi, di Serego Alighieri, **Mignoli M.**, **Pozzetti L.**, Renzini, Saracco, Vernet, **Zamorani G.**, 1 night, November 2002

12. ESO VLT + FORS2, *Spectroscopic Confirmation of XMM sources in the Marano deep survey field*, PI: Lamer, CoI: **Zamorani G.**, **Mignoli M.**, Hasinger, Wagner, Staubert, Wilms, Giedke, Lehmann, Brunner, 3 nights, November 2002

13. ESO VLT + FLAMES, *GTO It#1, Understanding the chemical enrichment history of massive globular clusters: omega Centauri and M22*, PI: **F.R. Ferraro**, CoI: E. Pancino, **M. Bellazzini**, **L. Origlia**, **C. Cacciari**, L. Monaco, 2 nights, May 2003

14. ESO VLT + FLAMES, *GTO It#4, Multiobject spectroscopy of Galactic Open Clusters of different ages and metallicity*, PI: R. Pallavicini, CoI: **A. Bragaglia**, F. Damiani, G. Micela, I. Pillitteri, L. Prisinzano, S. Randich, S. Sciortino, **M. Tosi**, 1 night, May 2003

15. ESO VLT + FLAMES, *GTO It#5, Understanding the chemical enrichment history of massive globular clusters: omega Centauri and M22*, PI: P. Bonifacio, CoI: **Bellazzini M.**, P. Di Marcantonio, **Ferraro F.R.**, L. Girardi, 1 night, May 2003

16. ESO VLT + ISAAC, *What powers X-ray luminous optically quiet galaxies? A near infrared search for the AGN signature*, PI: **Comastri A.**, CoI: M. Brusa, **Ciliegi P.**, **Mignoli M.**, R. Maiolino, P. Severgnini, F. Fiore, F. La Franca, G. Matt, G.C. Perola, A. Baldi, S. Molendi, C. Vignali, **Pozzetti L.**, 6 hrs, service mode, April-September 2002

17. ESO VLT + ISAAC, *Shedding light on the dark side of accretion with ISAAC: deep K imaging of extreme X-ray sources*, PI: **M. Mignoli**, CoI: M. Brusa, **P. Ciliegi**, **A. Comastri**, **L.Pozzetti**, F. Cocchia, F. Fiore, F. La Franca, G. Matt, G.C. Perola, R. Maiolino, A. Baldi, S. Molendi, P. Severgnini, 12 hrs, September 2002

18. ESO VLT + ISAAC, *Supermassive Black Holes in High Redshift Quasars*, PI: A. Marconi, CoI: D.J. Axon, A. Capetti, K. Horne, A. Robinson, M. Salvati, **G.M. Stirpe**, 21 hrs, 2002

19. ESO VLT + UVES, *Distances, Ages, and Metal Abundances in Globular Cluster Dwarfs*, Large Programme, PI: R. Gratton, CoI: ..., **A. Bragaglia**,..., **G. Clementini**, ..., 6 nights UVES, July 2002

20. ESO VLT + UVES, *Star formation history in omega Centauri: disentangling the age-metallicity degeneracy of the multiple populations*, PI: E. Pancino, CoI: **F.R. Ferraro**, L. Pasquini, V. Hill, **M. Bellazzini**, L. Monaco, 3 nights, March 2002

21. ESO VLT + UVES, *The properties of dusty red giants in globular clusters*, PI: J. Th. van Loon, CoI: **L. Origlia**, J. R. Marshall, M. Matsuura, A. Zijlstra, 2 nights, July 2003

22. ESO VLT + UVES, NTT + EMMI, SUSI2, *The true nature of the anomalous bright companion to the eclipsing millisecond pulsar in NGC6397*, PI: **Ferraro F.R.**, CoI: N. D'Amico, R.Gratton,

F. Camilo, **A. Bragaglia**, A. Possenti, E. Sabbi, 7h UVES, 4h EMMI, 8h SUSI2 in 2002, service mode

23. ESO VLT + VIMOS, *A spectroscopic study of the globular clusters in the Sculptor spiral galaxy NGC253*, PI: **Cacciari C.**, CoI.: **Federici L.**, S. Galleti, E.V. Held, A. Moretti, 6 hrs, 2003, service mode

24. ESO VLT + VIMOS, *Globular clusters in the outer halo of the Sombrero galaxy*, PI: E. Held, CoI: A. Moretti, **Federici L.**, **Cacciari C.**, L. Rizzi, V. Testa, S. Galleti, 13.5 hrs, 2003, service mode

25. ESO VLT + VIMOS, *The VIRMOS/VLT Deep Survey (VVDS)*, PI: O. Le Fèvre & G. Vettolani, CoI: **Zamorani G.**, **Bardelli S.**, **Cappi A.**, **Pozzetti L.**, **Zucca E.**, **Ciliegi P.**, **De Ruiter H.R.**et al. (VIRMOS Consortium), 30 nights (GTO), October–December 2002

NTT

26. ESO NTT + EMMI, *Assessing the redshift distribution of radio quasars* PI: I. Prandoni, CoI: G. Vettolani, **De Ruiter H.R.**et al., 3 nights, September-October 2002

27. ESO NTT + EMMI, *Search for magnetic fields in the central stars of planetary nebulae*, PI: **Stanghellini L.**, CoI: Ferrario, Vennes, Wickramasinghe, 2 nights, February 2003

28. ESO NTT + SOFI, *Infrared imaging of distant (z>* 1.0*) EIS cluster candidates*, PI: M.Scodeggio, CoI: **Bardelli S.**et al., 2 nights, September 2002

29. ESO-NTT + SOFI, *Star formation history in dwarf galaxies: the AGB/RGB stars in NGC3109 as tracers of intermediate age population*, PI: E. Pompei, CoI: Brillant, Marconi, **Tosi M.**, Vanzi, 17 hrs, February 2003

30. ESO NTT + SOFI, *The nature and evolution of infrared galaxies: bridging optical and SIRTF-SWIRE data with near-infrared*

observations of the ELAIS-S1 field, PI: Cimatti CoI: Berta, Ciliegi, Comastri, Daddi, ... , Maiolino, **Mignoli M.**, Poli, **Pozzetti L.**, ... , **Zamorani G.**, 4 nights (october 2002) + 2 nights (november 2002)

31. ESO NTT + SOFI, *Public Imaging Survey*, PI: Krautter, CoI: Arnaud, Boehringer, Dennefeld, Elbaz, Franx, Guzzo, Ibata, Jorgensen, La Franca, Meisenheimer, Morganti, Soucail, Surdej, **Zamorani G.**, ..., 8 nights (April 2002) + 3 nights (September 2002) + 5 nights (October 2002) + 6 nights (December 2002)

3.6m

32. ESO 3.6m + EFOSC2, *Star-formation within the merging galaxy cluster A3921: multi-object spectroscopy*, PI: Ferrari; CoI: Arnaud, Belsole, Benoist, Bijaoui, **Cappi A.**, Maurogordato, Pelló, Prugniel, Sauvageot, Slezak *Star-formation within the merging galaxy cluster A3921: multi-object spectroscopy*, 2 nights, October 2002

33. ESO 3.6m, *Study of the Nature of the 15 micron Strongly Evolving Population through Optical Spectroscopy*, PI: I. Matute, CoI: Gruppioni C., Pozzi F., La Franca F., Lari C., **Zamorani G.**, Franceschini A., Oliver S., 3 nights, October 2002

34. ESO 3.6m + EFOSC *Study of the Nature of the 15 micron Strongly Evolving Population through Optical Spectroscopy*, PI: Matute, CoI: Gruppioni, Pozzi, La Franca, Lari, **Zamorani G.**, Franceschini, Oliver, 3 nights, October 2002

35. ESO 3.6m + EFOSC *The evolution of the milliJansky 15 micron populations*, PI: Matute, CoI: La Franca, Gruppioni, Pozzi, Lari, **Zamorani G.**, Franceschini, Oliver, 2 nights, September 2002

2.2m

36. ESO 2.2m + WFI, *BVI imaging of three open clusters for follow-up spectroscopy with FLAMES*, PI: R. Pallavicini, CoI: S. Randich, L. Prisinzano, E. Franciosini, **A. Bragaglia**, 3hrs, 2002, service mode

37. ESO 2.2m + WFI, *Analysis of a merging cluster at z=0.247 and its large scale environment: deep multicolor wide-field imaging of Abell 521*, PI: Benoist; CoI: Arnaud, **Cappi A.**, Ferrari, Maurogordato, Plionis, Slezak, Vandame, 4.5 hrs, October 2002

38. ESO 2.2m + WFI, *Dynamics & star formation within merging clusters of galaxies: multi–color imaging of Abell 1750*, PI: Maurogordato; CoI Arnaud, Belsole, Benoist, Bijaoui, **Cappi A.**, Ferrari, Plionis, Sauvageot, Slezak, Vandame, 1.5 hrs, October 2002

39. ESO 2.2m + WFI, *The luminosity function of hard X-ray selected, highly obscured accreting sources*, PI: F. Fiore, CoI: **Comastri A.**, M. Brusa, P. Ciliegi, M. Mignoli, R. Maiolino, F. Cocchia, F. La Franca, G. Matt, G.C. Perola, A. Baldi, S. Molendi, C. Vignali, B. Wilkes, P. Green, 24 hrs, service mode

40. ESO 2.2m + WFI, *Completing the pre-FLAMES public survey of the tidally disrupted Sagittarius dwarf spheroidal*, PI: **F.R. Ferraro**, CoI: M. Bellazzni, L. Monaco, E. Sabbi, E. Pancino, E. Valenti, P. Bonifacio, 8.2hrs, 2002, service mode

41. ESO 2.2m + WFI, *A deep + shallow U imaging survey: preparation to the VIRMOS Deep redshift Survey*, PI: Arnaboldi, CoI: Garilli, Guzzo, Le Fevre, Maccagni, Mazure, Picat, Radovich, Ripepi, Scaramella, Vettolani, **Zamorani G.**, 40 hrs, April 2002, 23 hrs, October 2002

42. ESO 2.2m + WFI, *Public Imaging Survey*, PI: Krautter, CoI: Arnaud, Boehringer, Dennefeld, Elbaz, Franx, Guzzo, Ibata, Jorgensen, La Franca, Meisenheimer, Morganti, Soucail, Surdej, **Zamorani G.**, da Costa, Arnouts, Groenewegen, Hatziminaoglou, Hook, Madejsky, Mignani, Rite, Slijkuis, 30 hrs, April 2002

43. ESO 2.2m + WFI, *Public Imaging Survey: WFI follow-up of XMM-Newton Serendipitous Fields*, PI: Krautter, CoI: Arnaud, Boehringer, Dalton, Dennefeld, Elbaz, Franx, Guzzo, Ibata Jorgensen, La Franca, Lawrence, Meisenheimer, Morganti, Soucail, Surdej, **Zamorani G.**, da Costa, Arnouts, Hatziminaoglou, Rite, Sikkema, Slijkuis, Vandame, 30 hrs, October 2002

44. TNG + DOLORES, *Optical identification of hard (2-10 keV) X-ray HELLAS2XMM sources* PI: F. La Franca, CoI: **Comastri A.**, F. Fiore, F. La Franca, F. Nicastro, A. Fruscione, S. Molendi, P. Severgnini, R. Maiolino, 3.5 nights, March 2002

45. TNG + DOLORES, *Getting accurate distances to Local-Group Galaxies*, PI: **F.R. Ferraro**, CoI: **M. Bellazzini**, **L. Origlia**, L. Monaco, E. Pancino, E. Oliva, **C. Cacciari**, 3 nights, 2002

46. TNG + LRS, *RR Lyrae and BHB stars at the North Galactic Pole*, PI: **C. Cacciari**, CoI: **A. Bragaglia**, A. Buzzoni, T. Kinman, 4 nights, 2002, service mode

47. TNG + LRS, *Structure of the Galactic Halo towards the North Galactic Pole (NGP)*, PI: **C. Cacciari**, CoI: **A. Bragaglia**, A. Buzzoni, T. Kinman, 32 hrs, 2003, service mode

48. TNG + LRS/MOS, *Membership in old open clusters from multislit intermediate resolution spectroscopy*, PI: **A. Bragaglia**, CoI: **M. Tosi**, L. Di Fabrizio, G. Marconi, E. Held, 18hrs, 2003, service mode

49. TNG + NICS, *Near-Infrared PL and PLC relations of anomalous Cepheids in the dwarf spheroidal galaxy Ursa Minor*, PI: M. Marconi, CoI: F. Caputo, **G. Clementini**, M. Di Crescienzo, G. Fiorentino, I. Musella, V. Ripepi: 24.5 hrs, service mode

50. TNG + NICS, *Metal enrichment by recursive episodes of star formation: stellar abundances in massive starburst galaxies*, PI: **L. Origlia**, CoI: R. Maiolino, **A. Comastri**, P. Ranalli, A. Marconi, 3 nights, 2002

51. TNG + OIG, *A photometric search for interacting binaries in moderate-density GGCs*, PI: **F.R. Ferraro**, CoI: L. Monaco, E. Sabbi, E. Pancino, B. Paltrinieri, V. Testa, 1 night, 2002, service mode

52. TNG + OIG, *A photometric search for interacting binaries in moderate-density GGCs*, PI: **F.R. Ferraro**, CoI: E. Sabbi, L. Monaco, A. Possenti, R.T. Rood, 9hrs, 2003, service mode

53. TNG + SARG, *Metal abundances of old open clusters as tracers of Galactic chemical evolution*, PI: **Bragaglia A.**, CoI: **Tosi M.**, R. Gratton, E. Carretta; 3 nights, 2002–2003, service

Miscellaneous ground based telescopes

Keck II + NIRSPEC, *Abundances of Bulge and Galactic Center cluster stars*, PI: R.M. Rich, CoI: **L. Origlia**, 1.5 nights, July 2002

Keck II + NIRSPEC, *Abundances of Bulge and Galactic Center cluster stars*, PI: R.M. Rich, CoI: **L. Origlia**, 1 night, July 2003

54. CFHT, Cfh12K, *Multicolor wide field imaging of merging clusters*, PI: Benoist C., CoI: **Cappi A.**, Ferrari C., Maurogordato S. et al., 8hours, 2002

55. JKT + JAG, *RR Lyrae distances to the Sagittarius stream*, PI: F. Prada, CoI: D. Martinez-Delgado, Z. Ivezic, L. Di Fabrizio, K. Vivas, R. Zinn, **Clementini G.**, 7 nights, 2003

56. NOT + AFOSC, *RR Lyrae distances to the Sagittarius stream*, PI: D. Martinez-Delgado, CoI: F. Prada, Z. Ivezic, L. Di Fabrizio, K. Vivas, R. Zinn, **G. Clementini**, 5 nights, 2003

HST

57. HST-ACS, *Searching for primeval galaxies: the promising case of SBS 1414+437*, PI: A.Aloisi, CoI: **Tosi M.**, 18 orbits in 2003

XMM–Newton

58. *Spatially resolved spectroscopy of merging clusters in the Shapley Concentration*, PI: S. Ettori, CoI: **Bardelli S.**, **Zucca E.** et al., 45 ksec, 2001, 2002

59. *Tracing the hidden AGN activity in the EROs population*, PI: **Comastri A.**, CoI: M. Brusa, A. Cimatti, E. Daddi, **Mignoli M.**, **Pozzetti L.**, C. Vignali, **Zamorani G.**, A. Antonelli, 53.3 ksec, AO2

60. *The reddest quasars*, PI: **Comastri A.**, CoI: **Mignoli M.**, M. Brusa, C. Vignali, 23.3 ksec, AO2

61. *SSC emission from extragalactic compact radio hot spots with XMM*, PI: G. Brunetti, CoI: M. Bondi, **Comastri A.**, G. Setti, S. Varano, 50 ksec, AO2

62. *A deep wide area XMM survey in ELAIS-S1 to map the history of baryon transformations in quasars and galaxies*, PI: F. Fiore, CoI: **Comastri A.**, **Ciliegi P.**, C. Gruppioni, **Mignoli M.**, M. Brusa, F. La Franca, A. Franceschini et al., 400 ksec, AO2

63. *The nature of hard X-ray emission in starburst galaxies*, PI: P. Ranalli, CoI: **Comastri A.**, G. Setti, 43.3 ksec, AO2

Chandra

64. *Spatially resolved observation of a major merging event in the Shapley Supercluster*, PI: S.Ettori, CoI: **Bardelli S.**, **Zucca E.** et al., 80 ksec, March–April 2003

65. *Chandra and XMM-Newton to study the ionization cones of the Seyfert 2 galaxy NGC 5252*, PI: M. Dadina, CoI: M. Cappi, G. Malaguti, **Comastri A.**, G. Di Cocco, L. Bassani, G.G.C. Palumbo, 70 ksec, AO4

66. *Chasing quasar 2*, PI: F. Fiore, CoI: **Comastri A.**, M. Brusa, **Ciliegi P.**, **Mignoli M.**, R. Maiolino, P. Severgnini, F. La Franca, G. Matt, G.C. Perola, A. Baldi, S. Molendi, C. Vignali, 45 ksec, AO4

67. *Elusive Active Galactic Nuclei in starburst galaxies*, PI: R. Maiolino, CoI: **Comastri A.**, G. Matt, F. Fiore, T. Böker, A. Krabbe, R. Gilli, A. Marconi, F. La Franca, M. Salvati, 60 ksec, AO4

11 Position held in working groups and science policy committees

- **Bardelli S.:**

  - Board of Directors (since January 17, 2002): member

- **Bellazzini M.:**

  - Board of Directors (since January 17, 2002): member

- **Cacciari C.:**

  - TNG Time Allocation Committee: member (until May 2002)

  - SOC for the IAU Commission 27 (Variable Stars): member

  - PI of the ITAL–FLAMES Consortium (Bologna, Trieste, Cagliari and Palermo Observatories) for the FLAMES instrument

- **Ciotti L.:**

  - Visiting Astronomer of *Scuola Normale Superiore di Pisa* and Lecturer on "Dynamical models in astrophysics" (since 1997)

- **Comastri A.:**

  - ESA: XEUS (X-ray Evolving Universe Spectroscopy) Astrophysics Working Group: member

  - ESA: XMM–*Newton* User Group: member

  - 5th National AGN conference (Como, June 2002) Scientific Organizing Committee: member

  - 34th COSPAR Symposium: NEW X-RAY RESULTS FROM CLUSTERS OF GALAXIES AND BLACK HOLES (Houston, October 2002) Scientific Organizing Committe : member

  - Bologna University: teacher of the topic *Emissione di alta energia da oggetti collassati*, part of the *Space Physics* course, for the academic year 2001–2002

- **de Ruiter H.:**

  - Expert evaluator of the European Union Training and Research Networks

  - Local scientific coordinator of the European Union "Information Society Technologies (IST)", programme "Cosmolab" (3D visualisation techniques in Astronomy)

- **Ferraro F.R.:**

  - ST-ECF User Committee: member

  - ESO Observing Programmes Committee (OPC): panel D1: member

  - OAB team ITAL-FLAMES Consortium: member

  - Bologna University - teacher of *Stellar Evolution* class - Accademic year 2001-2002

- **Fusi Pecci F.:**

  - INAF Dip.1: Member of the Board

  - INAF Dip.3: Member of the TS Committee

  - Cagliari Astronomical Observatory: Member of the Board

  - ESO-OPC: panel P68: member at large

- **Mignoli M.:**

  - Organizer of the Observatory "*Thursday Seminars*"

- **Origlia L.:**

  - TNG TAC member

- **Pozzetti L.:**

  - ESO : Observing Programmes Committee (OPC): panel A (cosmology): member

- **Sancisi R.:**

  - Scientific Technical Committee, ESO, Garching: member

  - Time Allocation Committee, TNG: member

  - Board of Directors: member

- **Tinti F.:**

  - Board of Directors: member

- **Tosi M.:**

  - Deputy Director of the Bologna Observatory

  - *Local Late Galactic Evolution* Group, International Space Science Institute (ESA), Berna (since 1998): member

  - Proposal for the NASA space mission *Interstellar Pathfinder* (since July 1998): associate scientist (since July 1998)

  - INAF Working Group for the Macro–Area *Stars and Interstellar Medium* : coordinator

  - INAF Working Group for the Equal Opportunities: member

  - PhD in Astronomy at the University of Bologna, Collegio dei Docenti: external member

- **Zamorani G.**

  - ESO : VIRMOS Science Team : member

  - ESO: Survey Working Group : member

  - XMM: Time Allocation Committee: Survey panel : chairman

  - SAX: Science Steering Committee (1999 - 2002) : member

  - INAF: Comitato di Consulenza Scientifica: chairman

- **Zitelli V.**

  - Board of Directors: member

  - Responsabile stazione osservativa di Loiano

  - Member of the TNG working group site test

  - Teacher of "Teoria e Tecniche di Elaborazione delle immagini astronomiche", AA 2001/2002

  - INAF working group "Piccoli Telescopi Nazionali"

12 Organization of Workshops

Bologna Workshop on Galactic Winds, organized by **D'Ercole A.**, **Tosi M.**, Brighenti F.

In January 17-18 2002 a workshop on Galactic Winds was held in Bologna at the Astronomical Observatory. This workshop was organized by F. Brighenti (Dep. of Astronomy, Bologna University), and A. D'Ercole and M. Tosi (Astronomical Observatory of Bologna). Only a restricted number of persons (see the list below) were invited, the most active on the specific field of starbursts and galactic winds. They came from different countries such as USA, Germany, England, UK, Japan, Italy. The workshop was intended to confrontate the opinion of different leading experts on several questions still open such as the ability of a starburst to really sustain a galactic wind, the efficiency of SNs in thermalizing the ISM and the circulation and ultimate fate of the metal ejecta of SNs.
After two days of interesting presentations and lively discussions on both observational data and numerical models, the participants divided into two groups and suggested the three highest-priority issues to be addressed both for new observations and for new models, to better understand starburst gas outflows and their final fate.
The groups were divided into self–defined "observers" or "theorists".

Observations:

1) observations of the actual environment of starbursts, to confirm evidence and parameterization of outflows; and to determine the ambient conditions. What is the hot, warm, and cold gas distribution in the immediate environment of starbursts? What is the metallicity?

2) get better kinematic observations and parameterization of the gas outflows.

3) get better statistics on the star formation properties of galaxies: what is the role of starbursts as a population among galaxies? what are the range and properties of star formation in galaxies?

Theory:

1) make simulations that include continuous star formation both in space and time, rather than only with instantaneous central burst.

2) study microphysics: mixing, thermal conduction, instabilities, element abundances

3) improve initial conditions: resolution, multiple explosions, realistic density distributions, etc.

List of partecipants: Dominik Bomans, Fabrizio Brighenti, Annibale D'Ercole, Andrea Ferrara, Tim Heckman, Mordecai-Mark Mac Low, Crystal Martin, Francesca Matteucci, Gerhardt Meurer, Masao Mori, Casiana Munoz Tunon, Sally Oey, Sergey Silich, Evan Skillman, Ian Stevens, Dave Strickland, Guillermo Tenorio-Tagle, Roberto Terlevich, Monica Tosi.

13 Seminars and visiting astronomers

1. January 17–18 2002, *Bologna Workshop on Galactic Winds*, (organized by **D'Ercole A.**, **Tosi M.**, Brighenti F.)

2. January 22, 2002, **Elena Terlevich** (Institute of Astronomy, University of Cambridge, UK), *Star Formation Rate estimators, a statistical approach*

3. January 31, 2002, **Konrad Kuijken** (Department of Astronomy, Kapteyn Institute, NL) *Kinematics of Bulges, Large and Small*

4. February 14, 2002, **Silvano Desidera** (Osservatorio Astronomico di Padova), *Ricerca di Pianeti Extrasolari con il SARG*

5. February 21, 2002, **Elisa Costantini** (Max-Planck-Institut für extraterrestrische Physik, Garghing, DE), *X-ray haloes as diagnostics of interstellar grains*

6. February 28, 2002, **Paolo Tozzi** (Osservatorio Astronomico di Trieste), *The 1Msec Exposure of the Chandra Deep Field South*

7. March 14, 2002, **Francesca Panessa** (Istituto TeSRE-C.N.R. & Dipartimento di Astronomia, Bologna), *Study of a complete sample of Seyfert galaxies*; **Marcello Giroletti** (Istituto I.R.A.-C.N.R. & Dipartimento di Astronomia, Bologna), *Nearby blazars: what did they tell us, what will they tell us?*

8. March 21, 2002, **Enrico V. Held** (Osservatorio Astronomico di Padova), *Gas, stars, and the evolution of dwarf galaxies: the case of Phoenix*

9. April 18, 2002, **Luca Amendola** (Osservatorio Astronomico di Monteporzio, Roma), *Scienza e mito dell'energia oscura*

10. May 2, 2002, **R.H. Sanders** (Kapteyn Astronomical Institute, Groningen, NL), *Evidence for modified newtonian dynamics at low accelerations*

11. May 14, 2002, **Renzo Sancisi** (INAF – Osservatorio Astronomico di Bologna),

12. May 21, 2002, **Eric Emsellem** (Observatoire de Lyon, France), *I - Density waves in the inner regions of galaxies II- The Sauron survey*

13. May 30, 2002, **Piero Galeotti** (Istituto Nazionale di Fisica Nucleare, Torino), *Neutrini da supernovae*

14. June 6, 2002, **Giovanni Fiorentini** (Istituto Nazionale di Fisica Nucleare, Ferrara), *Alpha: A constant that is not a constant?*

15. June 11, 2002, **Piero Madau** (University of California - Lick Observatory, USA), *The Assembly and Merging History of Supermassive Black Holes in Hierarchical Models of Galaxy Formation*

16. June 13, 2002, **Ulrich Hopp** (Institut für Astronomie und Astrophysik der Ludwig-Maximilians-Universität, München, DE), *No local young galaxies?*

17. June 20, 2002, **Julien Devriendt** (Observatoire de Lyon, France), *The GALICS project: a self-consistent multi-wavelength modelling of hierarchical galaxy formation*

18. September 19, 2002, **Marta Volonteri** (Università dell'Insubria, Como), *The assembly of massive black holes in a hierarchical universe*

19. September 26, 2002, **Marcella Marconi** (INAF - Osservatorio Astronomico di Capodimonte - Napoli), *Modelli pulsazionali di RR Lyrae e Cefeidi anomale*

20. October 10, 2002, **Valerio Vittorini** (Dipartimento di Fisica, Università di Roma Tor Vergata), *Connessione tra AGN e ambiente ospite*

21. October 17, 2002, **Luca Ciotti** (INAF – Osservatorio Astronomico di Bologna), *Fundamental Planes*

22. October 24, 2002, **Flavio Fusi Pecci** (INAF – Osservatorio Astronomico di Bologna), *Deep HST observations of 19 fields in M31 and M32: metallicity distributions, streams, interactions*

23. October 31, 2002, **Maria Luisa Marchesini** (Department of Physics & Astronomy - University of Leeds, UK), *Ultra High Energy Cosmic Rays (UHERC)*

24. November 12, 2002, **Maria Victoria Alonso** (Observatoire Midi-Pyrenees, Toulouse, France, & Observatorio Astronomico de Cordoba, Argentina), *Peculiar motions in the nearby Universe*

25. November 21, 2002, **Guido Risaliti** (INAF - Osservatorio Astronomico di Arcetri), *The complex structure of the circumnuclear medium in AGN*

26. November 27, 2002, **Carlo Cavazzoni** (CINECA - Bologna), *Problemi per la installazione e manutenzione di un sistema parallelo di PC per il calcolo, Linux Cluster*

27. December 5, 2002, **Radoslav Zamanov** (INAF – Osservatorio Astronomico di Padova), *Quasar spectra in the context of Eigenvector-1 correlations*

28. December 12, 2002, **Reinaldo De Carvalho** (INAF – Osservatorio Astronomico di Brera & Observatorio Nacional - CNPq / DAF - Rio de janeiro, Brazil), *The Northern Sky Optical Cluster Survey: Towards the Mass Function*

29. December 19, 2002, **Andreas Eckart** (Physikalisches Institut, Universität zu Köln, Germany), *Stellar Orbits and a Cusp at the Center of the Milky Way*

14 "Laurea" thesis

March 15, 2002

1. **Avolio Serena**, *Proprietà statistiche di ammassi di galassie selezionati in banda X* (Marano B., **Zucca E.**, **Bardelli S.**)

2. **Cancelliere Francesco**, *Spettroscopia e variabilita' in banda X di galassie di Seyfert* (Marano B., **Comastri A.**)

3. **Valenti Elena**, *Ricerca delle variabili RR Lyrae negli ammassi globulari NGC6304 e Arp2* (Battistini P., **Bellazzini M.**, **Cacciari C.**)

July 19, 2002

4. **Battista Claudia**, *Modelli di Universo con equazioni di stato non standard* (Bonoli F., **Ciotti L.**, **Cappi A.**)

5. **Lagani Paolo**, *L'ammasso globulare post-core collapse NGC 6752* (Battistini P., **Ferraro F.R.**)

6. **Montarolo Vittorio**, *Osservazioni Chandra di Cygnus A* (Marano B., **Comastri A.**)

7. **Sollima Antonio**, *Fotometria infrarossa dell'ammasso globulare omega Centauri* (Battistini P., **Ferraro F.R.**)

October 11, 2002

Gennari Nicolò, *Fotometria in banda V e I delle galassie sferoidali nane Leo I e Leo II* (Battistini P., **Bellazzini M.**)

December 20, 2002

8. **Marini Francesca** *Interazione tra ammassi di galassie nel superammasso di Corona Borealis* (Dallacasa D., **Bardelli S.**, **Zucca E.**)

15 PhD theses

1. **Luca Angeretti**, *Star formation histories of nearby galaxies*, I year (advisors: **Tosi M.**, Marano B.)

2. **Lara Baldacci**, *Variable stars and stellar populations in Local Group dwarf galaxies*, II year (advisors: **Clementini G.**, Gregorini L.)

3. **Marcella Brusa**, *Physics and evolution of the sources of the X–ray and infrared backgrounds*, III year (advisors: Marano B., **Comastri A.**)

4. **Elena Pancino**, *Multiple stellar populations in omega Centauri*, III year (advisors: **Ferraro F.R.**, Bartolini C.)

5. **Lorenzo Monaco**, *Stellar populations in the Galactic Halo*, II year (advisors: **Ferraro F.R.**, Battistini P.)

6. **Elena Sabbi**, *HST observations of globular clusters*, I year (advisors: **Ferraro F.R.**, Bartolini C.)

7. **Carlo Nipoti**, *The scaling relations of elliptical galaxies: constraints from stellar dynamics*, (advisors: Setti G., **Ciotti L.**, **Londrillo P.**)

8. **Piero Ranalli**, *High energy emission properties of starburst galaxies*, III year (advisors: Setti G., **Comastri A.**)

16 Post-Doctoral, Post-Laurea fellowships and Contracts

1. **Luca Angeretti**, Post Laurea contract
2. **Emanuela Calabrese**, Post Laurea contract
3. **Filippo Fraternali**, Post Doctoral fellow
4. **Simona Giacintucci**, Post Laurea contract
5. **Silvia Galleti**, Post Laurea contract
6. **Barbara Lanzoni**, Post Doctoral fellow
7. **Marcella Maio**, Post Laurea contract
8. **Andrea Marcolini**, Post Laurea contract
9. **Andrea Possenti**, Post Doctoral fellow
10. **Francesca Pozzi**, Post Doctoral fellow
11. **Emanuel Rossetti**, Post Laurea contract
12. **Elena Valenti**, Post Laurea contract

17 Budget information

Il bilancio preventivo per l'anno 2002 è stato approvato dal Consiglio di Osservatorio (CdO) il 18 Dicembre 2001, secondo criteri di competenza. Quello consuntivo il 13 Marzo 2003, adottando il nuovo criterio di cassa come previsto dal Regolamento INAF. Ciò genera alcune apparenti disuniformità dovute alla diversa procedura.

Nel corso dell'anno sono state apportate variazioni di bilancio in occasione di quattro sedute del CdO, essenzialmente per prendere in carico nuove entrate (ASI, MIUR, etc.) o per apportare adeguamenti tecnici in alcuni capitoli di spesa.

Le Tabelle 1 e 2 riportano in modo estremamente schematico il quadro delle entrate e delle spese (in migliaia di euro).

Table 1: **ENTRATE (in K-euro)**

descrizione	Previsioni defintive	Riscosse
Avanzo di cassa	5.482	——
Trasferimenti INAF	3.846	3.832
Trasferimenti INAF vincolati	470	470
Partite di giro	1.562	792
Totale	11.330	5.094

Il conto consuntivo si compone del rendiconto finanziario, della situazione amministrativa e dell'elenco dei crediti e dei debiti al 31 dicembre 2002. Dalla situazione amministrativa si evince l'avanzo di cassa definitivo al 31 dicembre 2002, pari a euro 5.806.058,51 (uguale a quello presunto riportato nel bilancio di previsione 2003), oltre all'avanzo di amministrazione pari a euro 5.682.348,20.

L'elenco dei crediti e dei debiti (qui non riportato per brevità, ma disponibilie) rappresenta l'ammontare delle operazioni in sospeso alla chiusura dell'esercizio, la cui manifestazione finanziaria avverrà nel corso del 2003.

Table 2: **SPESE (in K-euro)**

descrizione	Previsioni defintive	Pagate
Spese per organi	33	27
Oneri per Personale	3231	2917
Acquisto di beni e servizi	277	185
Correnti per la ricerca	456	243
Correnti per la ricerca vincolate	680	301
Oneri finanziari e tributari	3	2
Spese diverse	99	0
Acquisti e manutenzioni straord.	128	31
Investimento per la ricerca	138	106
Investimento per la ricerca vincolate	212	102
Edilizia (impegno vincolato)	4491	19
Partite di giro	1562	805
Totale	11.330	4.738

L'avanzo è stato definito come vincolato in quanto ripartito tra capitoli la cui copertura deve essere garantita sia per rispetto dei contratti e degli impegni vigenti, sia in osservanza a norme di legge.

Come si evince rapidamente anche dalle Tabelle sopra riportate, gran parte dell'avanzo è dovuto a 4.472 K-euro lì confluiti a causa dell'impegno assunto per la compartecipazione alla costruzione della nuova sede congiunta OAB -Dipartimento di Astronomia, al Navile.

Il resto dell'avanzo è dovuto sostanzialmente a tre voci principali:

- riduzione del personale di ricerca e tecnico-amministrativo a causa di trasferimento ad altro ente (promozioni a professore universitario, trasferimenti diretti verso altra sede, etc.), pensionamenti o dimissioni;
- fondi di ricerca aventi durata pluriennale e destinazione vincolata, e accantonamenti per acquisti, interventi, manutenzioni etc. su base pluriennale (cioè non attuabili con le risorse disponibli in un unico esercizio finanziario);

- fondo di riserva o fondi vincolati per norme di legge.

Da un punto di vista meramente economico, l'esercizio finanziario 2002 si è chiuso pertanto in modo sostanzialmente positivo. Tuttavia va posta l'attenzione sul fatto che, a parte l'avanzo relativo al progetto edilizio della nuova sede (i cui tempi sono fortemente condizionati dal contesto universitario), è stata la contrazione del personale ad originare una parte significativa dell'avanzo. Ciò ha un impatto negativo sulla quantità e qualità della ricerca cui si sta già cercando di ovviare, nonostante il perdurante blocco delle assunzioni.

Tenendo anche conto dei tagli già apportati ai finanziamenti (e di quelli ulteriori che potrebbero prospettarsi), è evidente che a fronte del rapido incremento delle spese fisse (dovuto agli incrementi stipendiali e di tutti i costi legati all'inflazione) e di quelle di fatto obbligate dal normale funzionamento e gestione, il progressivo assottigliarsi dell'avanzo renderà rapidamente molto difficile non solo il miglioramento, ma addirittura il mantenimento della attività di ricerca agli attuali livelli.