### IAU Highlights

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Highlights of Astronomy as presented at the XXVII General Assembly, 2009

Edited by

## lan F. Corbett

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### INTERNATIONAL ASTRONOMICAL UNION

## HIGHLIGHTS OF ASTRONOMY VOLUME 15

# AS PRESENTED AT THE TWENTY SEVENTH GENERAL ASSEMBLY RIO DE JANEIRO 3–14 August 2009



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#### COVER ILLUSTRATION

The Frontispiece of *Sidereus Nuncius* ("Starry Messenger") by Galileo Galilei. Published in March 1610, it was the first scientific report on observations made through a telescope, giving the results of Galileo's early observations of the Moon, the stars, and the moons of Jupiter. This is seen as the start of modern astronomy. The International Year of Astronomy 2009 commemorates Galileo's contributions to astronomy and science.

## Galaxy formation from dry and hydro simulations

#### Luca Ciotti

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**Abstract.** The effects of dry and wet merging on the Scaling Laws (SLs) of elliptical galaxies (Es) are discussed. It is found that the SLs, possibly established at high redshift by the fast collapse of gas-rich and clumpy stellar distributions in preexisting dark matter halos following the cosmological SLs, are compatible with a (small) number of galaxy mergers at lower redshift.

Keywords. Galaxies: elliptical and lenticular, cD – Galaxies: formation – Galaxies: evolution

The main results obtained in a series of papers (Ciotti & van Albada 2001; Nipoti, Londrillo & Ciotti 2003; Lanzoni et al. 2004; Ciotti, Lanzoni & Volonteri 2007; see also Ciotti 2009), are presented. It is found that 1) Parabolic dry merging in a population of low mass spheroids leads to massive Es that fail the Faber-Jackson (FJ) and Kormendy relations, being characterized by low velocity dispersion and very large effective radii. Parabolic wet merging in the same population of progenitors leads to Es in better agreement with the observed SLs, as long as enough gas for dissipation is available. 2) The edge-on structure of the Fundamental Plane (FP) is surprisingly preserved. Therefore, the FJ and Kormendy relations, despite their larger scatter, are stronger tests for merging than the edge-on FP. 3) Parabolic dry or wet merging of Es following the observed SLs over the full mass range preserve the Kormendy, FJ, and edge-on FP relations. Thus, massive Es cannot be formed by parabolic merging of low mass spheroidal galaxies, even in presence of substantial gas dissipation, but their SLs, once established by galaxy formation, are robust against merging. 4) Dark matter halos obtained from cosmological simulations define a FJ, a Kormendy, and a FP-like relation, as expected from the spherical collapse model for virialized systems. 5) Numerical simulations of cold dissipationless collapse in pre-existing dark matter halos can reproduce Sersic profiles remarkably similar to those observed, over a large radial range. Note that cold dissipationless collapse is a process which is expected to dominate the late stages of an initially dissipative process. Thus the SLs of Es, possibly established at high redshift by the fast collapse of gas rich and clumpy stellar distributions in pre-existing dark matter halos (following the cosmological SLs), can persist even in the presence of a moderate number of dry or wet mergings. Then monolithic-like collapse at early times and subsequent merging could just represent the different phases of galaxy formation (collapse) and evolution (merging, in addition to the aging of the stellar population and related phenomena).

#### References

Ciotti, L. 2009, La Rivista del Nuovo Cimento 32, n.1, 1 Ciotti, L. & van Albada, T. S. 2001, ApJ 552, L13 Ciotti, L., Lanzoni, B., & Volonteri, M. 2007, ApJ 658, 65 Lanzoni, B., Ciotti, L., Cappi, A., & Tormen, G. 2004, ApJ 600, 640 Nipoti, C., Londrillo, P., & Ciotti, L. 2003, MNRAS 342, 501

### AGN feedback in numerical simulations

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**Abstract.** The passively evolving stellar population in elliptical galaxies (Es) provides a continuous source of fuel for accretion on the central supermassive black hole (SMBH), which is 1) extended over the entire galaxy life (but declining with cosmic time), 2) linearly proportional to the stellar mass of the host spheroid, 3) summing up to a total gas mass that is > 100 times larger than the currently observed SMBH masses, 4) available independently of merging events. The main results of numerical simulations of Es with central SMBH, in which a physically based implementation of radiative and mechanical feedback effects is considered, are presented.

Keywords. X-rays: ISM - Galaxies: cooling flows - Galaxies: active

In a series of papers (Ciotti & Ostriker 2007; Ciotti, Ostriker & Proga 2009; Pellegrini, Ciotti & Ostriker 2009; Shin, Ciotti & Ostriker 2009; Jiang et al. 2009; see also Ciotti 2009) we study, with a high-resolution 1-D hydrodynamical code, the evolution of the ISM in Es under the action of SNIa heating, thermalization of the stellar mass losses, and feedback from the central SMBH. The cooling and heating functions include photoionization and Compton effects, radiation pressure is evaluated by solving the transport equation, mechanical feedback is produced by a physically based luminosity-dependent nuclear wind and jet, and star formation is also allowed. The recycled gas from the aging stars of the galaxy cools and collapses towards the center, a star-burst occurs and the central SMBH is fed. The energy output from the central SMBH pushes matter out, the accretion rate drops precipitously and the expanding matter drives shocks into the ISM. Then the resulting hot bubble ultimately cools and the consequent infall leads to renewed accretion; the cycle repeats, with the galaxy being seen alternately as an AGN/starburst for a small fraction of the time and as a "normal" elliptical hosting an incipient cooling catastrophe for much longer intervals. No steady flow appears to be possible for Eddington ratios above  $\simeq 0.01$ : whenever the luminosity is significantly above this limit both the accretion and the output luminosity are in burst mode. Strong intermittencies are expected at early times, while at low redshift the models are characterized by smooth, very sub-Eddington mass accretion rates punctuated by rare outbursts. One of the general consequences of our exploration is the fact that the recycled gas from dying stars can induce substantial QSO activity, even in the absence of external phenomena such as galaxy merging, while accretion feedback can be strong enough to solve the "cooling-flow" problem and to maintain the mass of the SMBH on the observed range of values.

#### References

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### IAU Highlights 15

# Highlights of Astronomy

Recording the proceedings of the IAU XXVII General Assembly, this volume of *Highlights of Astronomy* provides an up-to-date review of modern astrophysics, as discussed by 2400 participants. Covering planets, stars, galaxies, dark matter and modern cosmology, it gives a broad overview, allowing specialists and non-specialists alike to bring themselves up to date with the latest developments. This text brings together the work of observers and theoreticians from widely different fields who work towards a common goal: understanding the physics of the Universe. Together with the *Proceedings* of the IAU Symposia 262–267, this volume examines all of the astrophysics presented at the General Assembly, and provides a valuable testament to the vigour and momentum of astrophysical discovery in 2009, the International Year of Astronomy.

#### Proceedings of the International Astronomical Union Editor in Chief: Dr Thierry Montmerle

This series contains the proceedings of major scientific meetings held by the International Astronomical Union. Each volume contains a series of articles on a topic of current interest in astronomy, giving a timely overview of research in the field. With contributions by leading scientists, these books are at a level suitable for research astronomers and graduate students.

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