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Astronomical Observatory of Bologna and Loiano

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Application for Oberving Time with the 152cm Telescope of Loiano

Send proposals to: **silvia.galleti@oabo.inaf.it** **PERIOD: February 2015 — July 2015**

1. Title (10 words maximum)

The Transient Sky with Gaia.

2. Observing mode

[X] Visitor

[ ] Service

3. Name and address of the Investigators

PI: Gisella Clementini, INAF - Osservatorio Atronomico, Bologna, Italia
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Co–investigators:

L. Wyrzykowski — Warsaw (PL)/Cambridge (UK); G. Altavilla — Bologna (Italy); F. Cusano — Bologna (Italy); M.I. Moretti — Bologna (Italy); T. Muraveva — Bologna (Italy); S. Hodgkin — Cambridge (UK); H. Campbell — Cambridge (UK); M. Fraser — Cambridge (UK); M. Pawlak — Warsaw (PL); K. Ulaczyk — Warsaw (PL); A. Hamanowicz – Warsaw (PL); N. Blagorodnova — Cambridge (UK); students from Warsaw and Cambridge Universities

People requesting guestrooms accomodation (number): 4

4. Instrument(s) and requested set-up and nights

BFOSC + EEV2

Filters: G,R,Z,I *Slits:* 1.5,2.0,2.5

Grisms: 4,5 *Nights:* 36

4.b Nights at 2 A.M.:

Yes [ ] Accettable [ ] No [X]

5. Moon

Dark [X]

Gray [X]

Any [ ]

6. Special Requirements

7. Observing period restrictions and preferences:

Six nights per month from February to July 2015

8. Proposal Category

[ ] Teaching [X] Short Term Project [ ] Long Term Project

Objects class:

8b. If Long Term Project

a) Number of nights already awarded to project: **29**

b) Number of nights needed to complete project:

9. Description of the status of the project(s) including publications based on the observations taken with this telescope (last 3 years)

Observations performed with the Loiano telescope in 2014B yielded the follow-up of about 30 targets reported by Gaia, which helped classify them into classes and provide follow-up photometric and spectroscopic data. In particular, the Loiano follow-up of Gaia14aae confirmed the source to be the third known eclipsing AM CVn (a candidate SN Ia progenitor). See http://davide2.bo.astro.it/?p=5996. A paper is in preparation.

10. Description of the proposed programme

The Gaia mission, launched in December 2013, is an excellent discovery instrument covering the whole sky an average of 70 times over 5 years at high spatial resolution with precise ($\sim 1\%$) photometry down to G=20 mag (white-light Gaia band). In the second half of 2014 Gaia released its first detections of transient objects, e.g. supernovae, novae, microlensing events, super-luminous supernovae, tidal-disruption events, cataclismic variables. Gaia Science Alerts (GSA) is designed also to detect peculiar and rare temporary objects, as well as unknowns, because Gaia is opening up new parameter space in time-domain observations.

We propose to continue using the Loiano telescope in a follow-up observing campaign of transient objects detected by GSA. The overall goals are: 1. to identify new examples of rare or unknown transient phenomena and trigger their detailed study, 2. to classify large samples of nearby Galactic transients (e.g. CVs, XRB, YSO in outburst, B[e] stars, microlensing events) and extragalactic transients (e.g. SNe, TDEs, SLSNe), 3. to confirm and verify the very first alerts from Gaia and to assess the completeness and contamination in the GSA stream, 4. to provide large samples of classification labels for training of the GSA stream automated algorithms. In the previous semester Loiano data contributed to confirm Gaia14aae to be a very rare transient, the third known eclipsing AM CVn, a candidate SN Ia progenitor. The requested observations will significantly contribute to the improvement of the Gaia Science Alerts performance throughout the rest of the mission.

Key science areas involve studies of the following objects.

Cataclysmic Variables: CVs are close binary star systems, in which a white dwarf accretes matter from a late-type companion via Roche-lobe overflow. CVs often display nova and dwarf nova eruptions of many magnitudes, and are considered as progenitors of type Ia supernovae, especially their subtype AM CVn-type stars, like Gaia14aae, and we expect Gaia will alert on about 200 new CVs just in its first year of operation.

X-ray binaries: Most stellar mass black hole binaries have been discovered via their transient outbursts, traditionally in X-rays. Studying their optical counterparts allows detailed dynamical studies to establish binary periods, the nature of the companion and remnant masses.

Young Stellar Objects: Those objects (e.g. EX Lup, FU Ori) exhibit drastic episodic outbursts (1-3 mag), however are very rare. Providing detailed light curves for those objects, especially on the rise, is needed to study the impact of such accretion bursts on the properties of the dust and gas in the disks.

Microlensing Events: With Gaia's cadence we are most sensitive to long-duration events from more massive lenses (30 days for $\sim 1 M_{\odot}$ lens). Gaia will be the only survey capable of finding rare microlensing events occurring outside of the Bulge and the Galactic Plane. Superb Gaia astrometric information combined with the ground-based photometric follow-up offers an exciting possibility of discovering extremely dark and massive lenses such as neutron stars or black holes (see e.g., Wyrzykowski&Hodgkin 2012).

B[e] stars: These are normal B-type stars, which, for yet not fully understood reasons, show episodic mass loss, resulting in ejection of circumstellar material which forms a disk. A well covered light curve can provide important clues, e.g. if the star is pulsating and how the pulsation amplitude changes during the outburst.

Supernovae: SNe Ia are well-proven cosmological probes, providing evidence for an accelerating Universe. Core-collapse SNe (CC SNe) are a major source of metals in the Universe. All types of supernovae are known to have influence also on galaxy structure and star formation. Gaia is expected to detect about 3 supernovae brighter than 18 mag per day (see e.g. Altavilla et al. 2012), primarily type Ia to $z < 0.1$. This large homogenous sample will improve our understanding of SNe explosions and enable unbiased investigations of numerous scientific applications of supernovae, including host type and mass function, the rates and the explosion environments. Gaia's relatively sparsely sampled observations need to be supplemented from the ground to provide well-sampled lightcurves for each individual supernova. Gaia will also be capable of detecting super-luminous supernovae out to z$\sim$0.4, allowing for volumetric rate estimates and providing important clues on their progenitors.

Tidal Disruption Events: Flares from stars being disrupted by a central super-massive black hole are the only tool to study dormant, non-interacting black holes at intermediate redshift. Gaia should discover about 10 TDEs per year (Blagorodnova et al. in prep) down to 19 mag, with relatively low false-alert rate thanks for on-board low-resolution spectrographs and superb angular resolution.

11. Justification of the requested number of nights

Gaia started sending out its first alerts in late August 2014. We expect that until July 2015 there will be about 200 Galactic and extragalactic transients down to 18 mag detected in the northern hemisphere by Gaia Science Alerts, for which Loiano telescope could provide imaging confirmation, multi-band photometric follow-up and spectroscopic classification. There will be three modes of observations: confirmation, classification and follow-up.

In the **confirmation mode** we will execute a single exposure, typically in the g-band, for selected newly alerted transients, allowing for obtaining the contextual image (Gaia will not provide images, only catalogues) and confirming the presence of a new object. This will be significant especially for the very early detections by Gaia, during the Verification Phase of the Gaia Alerts Stream operation.

The **classification mode** will utilise Loiano's spectrograph in order to classify some of the brightest unknown transients reported by Gaia. We predict that there will be a handful of suitable targets for spectroscopic classification, brighter than 16 mag, mostly cataclysmic variables and rare supernovae. However, the spectral classification will be particularly important during the first months of operation of the Gaia Alerts Stream and will help train the automated classifiers on both false-positives and true-positives. Grism 4 provides a wide wavlength coverage and sufficient resolution to classify nearly all the classes of transient which Gaia will detect. We have also requested Grism 5 for the reddest transients, to extend our wavelength coverage up to 1μm.

The **follow-up mode** will be providing subsequent sets of multi-band observations of selected transients, e.g. interesting supernovae, novae, microlensing events or tidal-disruption events. Such observations will allow constructing full multi-band light curves, which will then be used in the detailed studies of each of the events.

We expect to collect 6 sets of multiple band observations in the follow-up mode each night (for 18th mag targets), and another 6 single shots in the confirmation mode. In total we hope to provide detailed light curves for at least 25 targets and provide confirmation information for about 200 alerts. The durations of transients expected to be found by Gaia, vary from couple of days to months. In order to build a meaningful light curve we request 6 subsequent nights each month.

The observations carried at Loiano telescope will be accompanied by other telescopes from around the globe. The time was allocated on major telescopes like WHT, INT, LT and Asiago in the North, as well as NTT in the South (PIs: Hodgkin, Fraser, Campbell). Those, however, will be primarily carrying out spectroscopic observations of fainter targets (brighter than 18-19 mag). For the photometric observations we have arranged a network of mostly European telescopes under the OPTICON EC's grant (www.astro-opticon.org), under the Time-Domain Astronomy work-package (WP11), which is led by L.Wyrzykowski. The network utilised common protocols of data transfer and calibration in order to provide homogenous data sets.

The significant amount of time allocated to our programme could make Loiano play a leading role in the multi-band photometric follow-up of supernovae and other transients.

12. List of targets

Name	α	δ	Equinox	Mag.	diam.	Additional Information
						Targets will come from the Gaia Alerts Stream (ToO).