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 2017 — July 2017**

1. Title (10 words maximum)

Physical characterization of space debris in GEO with spectrophotometric observations

2. Observing mode

[X] Visitor

[ ] Service

3. Name and address of the Investigators

PI: A. Di Cecco, INAF-Osservatorio Astronomico di Teramo (OATe), via M. Maggini snc, 64100 Teramo
dicecco@oa-teramo.inaf.it

Co–investigators:

F. De Luise – INAF-OATe; C. Marzo – ASI; M. M. Castronuovo – ASI; C. Portelli – ASI; G. Valentini – INAF-OATe

People requesting guestrooms accomodation (number): 2

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

BFOSC + EEV2

Filters: B,V,R,I *Slits:* 2.0

Grisms: 4,5 *Nights:* 4

4.b Nights at 2 A.M.:

Yes [ ] Accettable [X] No [ ]

5. Moon

Dark [ ]

Gray [X]

Any [ ]

6. Special Requirements

7. Observing period restrictions and preferences:

Thanks to the geometrical configuration between observer, Sun and GEO objects, we have the best illumination during the solstitium. Suggested dates are between 15/05/2016 and 31/07/2016

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:

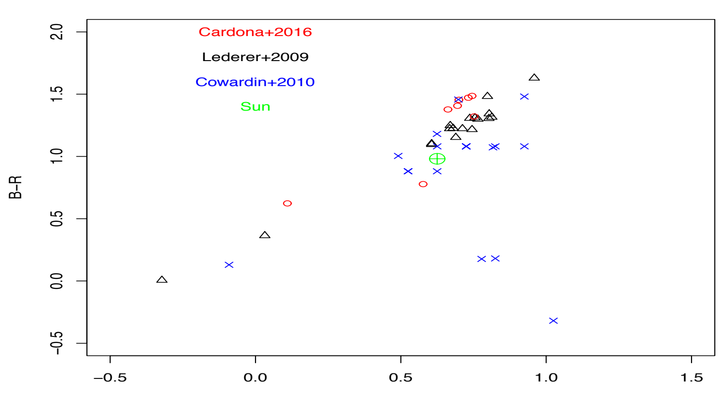
b) Number of nights needed to complete project:

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

10. Description of the proposed programme

A) **Scientific Rationale** The space activities such as the launch of astronomical telescopes, Earth observation satellites, communication satellites, anti-satellite tests and human spaceflights have produced a lot of quantity of space debris. These objects comprise non-functional satellites, rocket stages, mission-related small objects and fragments created during breakups and deterioration phenomena. The space debris population consists of thousands of large debris (>10 cm) up to more than 170 million of small debris (< 1 cm), populating the near-Earth space from 300 to 40,000 km. The increasing number of space debris in time and their high velocity (≈10 km/s) clearly represent a potential risk to impact and damage operational satellites. Extremely small is indeed the hazard of uncontrolled re-entry on the ground. In recent years the problem of space debris has been investigated by several observational campaigns with radar and optical telescopes. Observations allow to discover new debris as well as to provide information on orbital parameters and physical charaterization. In order to observe objects in the farthest regions of the Geostationary Earth Orbit (GEO, ≈36,000 km) optical telescopes are strictly required. In particular, small optical telescopes are used to provide spectroscopic and photometric observations in order to impose constraints to the surface materials of the space debris. By measuring the laboratory spectra of the most common spacecraft materials, Cowardin et al. (2010, AMOS Conference Proc. 47) showed as the B-V, B-R and B-R, R-I color-color planes are diagnostics to discern material surface properties of unknown objects. The laboratory values were used to compare the results of the multi-band photometric analysis of the data acquired by the SMARTs telescope of the CTIO for the fragments of the Titan IIIC Transtage (Cowardin et al. 2013, AMOS Conference Proc. 5). By using data acquired with the Loiano telescope, Cardona et al. 2016 (AdSpR. 58, 514) provided a multi-band photometry of GEO objects, such as operational and non-operational satellites, piece of debris and rocket bodies. Moreover, they imposed constraints on rotation and tumbling of space objects by providing light curves analysis. Spectroscopic investigations of space debris in GEO region were provided by Schildknecht et al. (2009, AMOS Conference Proc, E24; 2009 AdSpR 34, 901) and Lederer et al. (2012, AMOS Conference Proc. 22) with ESASDT data, and by Seitzer et al. (2013, International Astronautical Congress Proc. 3, 2000) with the Magellan telescopes at Las Campanas Observatory in Chile. Interesting spectroscopic results for operational satellites and space debris objects were also provided by Cardona et al. (2016, AdSpR 58, 514) by using BFOSC instrument mounted on Loiano telescope. However, literature presents a very small sample of observed GEO objects (<100) and often the observations are unique. The laboratory measurements are also too few to clearly identify the best filter set and not sufficient to cover all different space materials or spacecraft components. Moreover, the unknown observing angle phase increases the degree of freedom of the expected magnitude and it is still an open issue.

B) Scientific Aim We plan to observe operational satellites and space debris in GEO region by using both photometric and spectroscopic modes of BFOSC. The aim of this project is to investigate the surface materials of the observed objects by collecting data in B,V,R,I filters and in grisms # 4 and #5. We will provide accurate aperture photometry of the photometric data in order to obtain appropriate color-magnitude-diagrams and color-color planes. We will compare the results with both literature and our new laboratory measurements obtained for several spacecraft materials. As istance, the following figure shows the comparison between the GEO objects observed by Cardona and Lederer with the laboratory measurements of different materials taken by Cowardin. We will also analyse the spectroscopic data and we will compare the results with literature laboratory spectra, by providing robust constrains to the objects material components and hence infer their nature. The results of this investigations is twofold: i) investigate the best suitable filter set for discriminate different materials in both photometric and spectroscopic analysis; ii) statistically increase the number of the observed objects in the GEO region where too few objects are publically available. To these purposes we will take the advantage of our large experience in multi-band photometry (Di Cecco et al. 2015, AJ, 150 51) and in both photometry and spectroscopy analysis of NEOs (De Luise et al. 2010, Icar 209,586D, De Luise et al. 2007, Icar 191,628D).



11. Justification of the requested number of nights

We propose to carry out photometric and spectroscopic observations of GEO objects for a total of four nights. We propose to observe operational satellites and space debris with B, V, R and I bands for photometric analysis. For spectroscopy, the low resolutions grisms #4 and #5 will be used, combined with a 2" slit. For each target, it is planned to switch among photometric and spectroscopic runs, to follow-up its behaviour at different illumination angles. The brightness of the selected targets will guarantee a good S/N in both photometry and spectroscopy. Each target should be observed more than once during the requested nights. During each night, standard fields will be observed for photometric calibrations purposes. Solar analogues stars will be observed as well, to remove the solar contribution from spectroscopic data.

In case the sky conditions will not be good enough for our selected targets, we will observe very bright GEO objects. These observations will increase our database of visible magnitudes and spectra, providing more information on this kind of population.

12. List of targets

Name	α	δ	Equinox	Mag.	diam.	Additional Information
Meteosat 8	21:35:44.72	-07:24:25.1	J2000	12.3		1st June 2017
Meteosat 9	19:28:01.41	-03:49:15.4	J2000	11.7		"
Meteosat 10	13:16:23.97	-01:47:37.6	J2000	12.1		"
Express AM 7	20:07:35.96	-01:53:50.8	J2000	12.5		"
Astra 2F	21:10:59.02	-02:14:31.8	J2000	12.5		"
Astra 2G	21:44:39.97	-02:13:36.6	J2000	12.6		"
Astra 5B	21:34:27.43	-01:59:18.8	J2000	12.8		"
Astra 1KR	20:22:12.78	-01:59:50.0	J2000	12.5		"
Inmarsat 3 F2	15:50:13.34	-01:18:28.5	J2000	12.3		"
Athena Fidus	05:10:05.88	-00:50:48.3	J2000	12.1		"