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Small Bodies Near and Far (SBNAF): Challenges in the Physical and Thermal Characterization of NEOs, MBAs and TNOs

T. G. Müller (1), A. Marciniak (2), C. Kiss (3), R. Duffard (4), V. Alí-Lagoa (1), P. Bartczak (2), M. Butkiewicz-Bąk (2), G. Dudziński (2), E. Fernández-Valenzuela (4), G. Marton (3), N. Morales (4), J. L. Ortiz (4), D. Oszkiewicz (2), T. Santana-Ros (2), P. Santos-Sanz (4), R. Szakáts (3), A. Takácsné Farkas (3), E. Varga-Verebélyi (3)
(1) Max Planck Institute for Extraterrestrial Physics, Garching, Germany; (2) Astronomical Observatory of A. Mickiewicz University, Faculty of Physics, Poznań, Poland; (3) Konkoly Observatory, Research Centre for Astronomy and Earth Sciences, Budapest, Hungary; (4) Instituto de Astrofísica de Andalucía - CSIC, Granada, Spain.

Abstract

We present results from the first two years of our EU Horizon2020-funded benchmark study (2016-2019) that addresses critical points in reconstructing physical and thermal properties of near-Earth, main-belt, and trans-Neptunian objects. The combination of the visual and thermal data from the ground and from astrophysics space missions (like Herschel, Spitzer, Kepler-K2 and AKARI) is key to improving the scientific understanding of these objects. The development of new tools will be crucial for the interpretation of much larger data sets, but also for the operations and scientific exploitation of interplanetary missions. We combine different methods and techniques to get full information on selected bodies: lightcurve inversion, stellar occultations, thermophysical modeling, radiometric methods, radar ranging and adaptive optics imaging. The applications to objects with ground-truth information from interplanetary missions Hayabusa, NEAR-Shoemaker, Rosetta, and DAWN allow us to advance the techniques beyond the current state-of-the-art and to assess the limitations of each method.

1. Targets

For our benchmark study on minor bodies we selected important targets which were already visited by spacecraft (or are currently visited), which have a wealth of data from different observing techniques available (or are candidates for being observed with new techniques), which are or will be useful in the calibration context, or which will allow us to address and solve specific scientific questions [1].

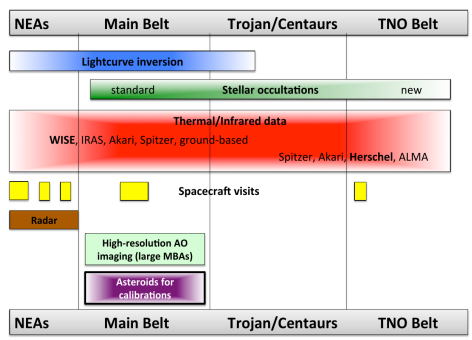

Figure 1: Overview of the SBNAF sample and the available observations.

2. Techniques

The characterization of small bodies is based on lightcurve inversion, radiometry, occultation, radar, and direct imaging techniques. We extract the crucial information from all available observations for a given target. The combination of different data sets leads to the development of new tools and methods which are validated against ground-truth information and to test capabilities and limitations. Figure 1 shows the different available techniques for our sample targets.

3. Tools, Services, and Products

ISAM (`http://isam.astro.amu.edu.pl/`) contains a collection of own and literature shape models for more than 900 asteroids. It allows to (i) display an asteroid orientation as seen from Earth at any date; (ii) to generate lightcurves; (iii) to animate the rotation; (iv) to produce 3D views; (v) to investigate viewing and illumination geometries; and (vi) to download spin-shape solutions and generated products. The **Gaia-GOSA page** (`http://www.gaiagosa.eu`) is an interactive tool which supports observers in planning photometric observations of asteroids. The asteroid prediction tool is based on the Gaia orbit and scanning law (ESA) and SSO ephemerides (MPC). The planned **Asteroid IR database** will contain thermal IR/submm/mm observations of small bodies (NEAs, MBAs, Trojans, Centaurs, TNOs), including measurements from ground (MIR, submm, mm instruments), airborne (SOFIA), and space projects (IRAS, MSX, AKARI, ISO, Spitzer, WISE, Herschel, Planck).

The SBNAF project makes **occultation predictions** for MBA events in 2017/18/19, as well as long- and short-term planning/calculations for TNO events. We also produce **high-quality images and fluxes** for NEAs, MBAs, and Centaurs/TNOs derived from Herschel photometric measurements. The new products are publically available from the Herschel Science Archive. We also support **asteroid-related calibration activities** for Herschel, ALMA, APEX, SOFIA, ISO, AKARI, IRAM, etc. calibration work.

4. Scientific results

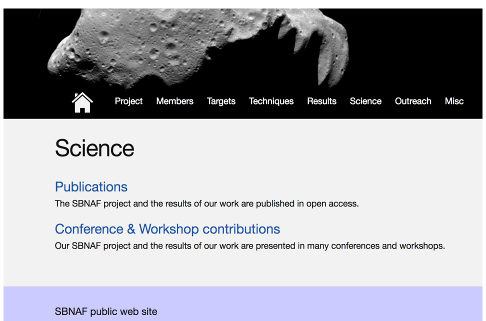

Figure 2: SBNAF web page where all SBNAF-related publications are documented and the open access links are provided.

Our SBNAF scientific results are documented in a large number of conference contributions and publications (see Figure 2). We are currently counting about 50 refereed publications (published, accepted, or submitted), with SBNAF contribution or led by SBNAF team members. The highlight publication is a Nature publication on "The size, shape, density and ring of the dwarf planet Haumea from a stellar occultation", by Ortiz et al. [2], which is based on a combined effort between the SBNAF and Lucky Star[1] teams, with inputs from many professional and amateur astronomers. The scientific SBNAF output is documented on our public web page at `http://www.mpe.mpg.de/~tmueller/sbnaf`. We will present selected results and highlights from our first two years of the SBNAF project.

Acknowledgements

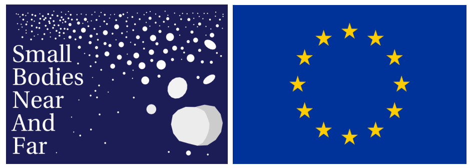

Figure 3: Left: The SBNAF project logo: `http://www.mpe.mpg.de/~tmueller/sbnaf/`. Right: The research leading to these results has received funding from the European Union's Horizon 2020 Research and Innovation Programme, under Grant Agreement no 687378.

References

[1] Müller, T. G., Marciniak, A., Kiss, C. et al. 2018: Small Bodies Near and Far (SBNAF): a benchmark study on physical and thermal properties of small bodies in the Solar System, accepted for publication by Advances in Space Research; `https://arxiv.org/abs/1710.09161`.

[2] Ortiz, J. L., Santos Sanz, P. Morales, N. et al. 2017: The size, shape, density and ring of the dwarf planet Haumea from a stellar occultation, Nature 550, 219-223.

[1] `http://lesia.obspm.fr/lucky-star/`