Deepening asteroid dynamics in the new era of observations: the project MONASTER (MONitoring ASTERoids)*

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Abstract. We present the Italian project MONASTER (MONitoring ASTERoids). Established thanks to Italian Space Agency (ASI) funding, it aims to consolidate the knowledge acquired by the Celestial Mechanics Group (CMG) of the University of Pisa in last 30 years of activities and to develop innovative mathematical models and algorithms to face the new era of observations and discoveries. An example of reasearch works dealing with the detection of the Yarkovsky effect will be showed and discussed.

Keywords: Asteroids · Orbit Determination · Impact Monitoring · Yarkovsky effect

1 The project

Studying the long term orbital evolution of a small body is a quite difficult task because of multiple planetary encounters and non-gravitational forces. However, the precise computation and propagation of an asteroid orbit is essential, not only for scientific purpose, but also for planetary protection. The Celestial Mechanics Group (CMG) of the Department of Mathematics of the University of Pisa has an internationally recognized experience in the field of asteroids dynamics, orbit determination (OD) and impact monitoring (IM) of Near Earth Objects (NEOs). Precisely, IM algorithms were born in Pisa in the late '90s thanks to the work of Prof. Andrea Milani Comparetti and his collaborators. At the same time, the AstDyS and NEODyS web services were developed, playing an important role for the astronomic community ever since, together with the OrbFit software (developed by the CMG and various collaborators since the '80s). In the last five years, the NEODyS services and part of those of AstDyS have migrated, thanks to the contribution of the Pisa University spin-off SpaceDyS, to ESA's NEO Coordination Center (NEOCC), which delivers them through its website. With the completion of the migration of services to ESA, however, the need of carry on the tradition of an innovative research on asteroid dynamics was felt.

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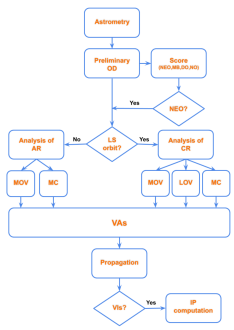
The MONASTER (MONitoring ASTeroids) project represents the first step in that direction: we aim to create a synergy between the Italian Space Agency (ASI) and the CMG to deepen the knowledge on asteroid dynamics (both NEOs and MBAs) and train a generation of scientists capable of facing the new era of telescopes (Fly-Eye, New LSST, space telescopes) and data, conceiving innovative mathematical methods and algorithms. The scientific results of the project would like to move in the direction of improving the pipeline described in the next figure: recognition of the type of object starting from the astrometric data present in the NEOCP or in other observational databases, application of the best strategy for managing uncertainty and, in the case of NEOs, choosing the most appropriate algorithm for the risk assessment.



The MONASTER project will start in Autumn 2022 and will last three years. The talk will describe the structure of the project and the objectives.

2 Detection of Yarkovsky effect

A recent reasearch work (joint with Lisa Bedini) that fits perfectly in the spirit of the MONASTER project is presented.

The Yarkovsky drift represents the semi-major axis variation of a celestial body due to the Yarkovsky effect. This thermodynamic effect acts on bodies with a diameter between $\approx 0.1\,\mathrm{m}$ and $\approx 30\,\mathrm{km}$: therefore the orbits of a lot of minor bodies are affected and knowing the value of the Yarkovsky drift is crucial to accurately predict their positions, especially when there is the possibility to impact the Earth, as in the case of NEOs. The Yarkovsky drift is difficult to compute because of the lack of physical information of the majority of NEOs, thus a possibility is the estimation through an OD procedure. The talk will show the detection of the Yarkovsky drift for 210 NEAs, of which 108 are not presented in literature. Furthermore, how to use such results to estimate the ratio of the retrograde over prograde rotators and to validate the dependence of the Yarkovsky drift from the diameter, $da/dt \approx D^{-1}$ will be discussed.

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