Determination of physical models of the smalest near-Earth asteroids from one flyby

Asteroids are small, rocky bodies, which revolve around the Sun between the orbits of Mars and Jupiter in the Main Belt. There is a small group of objects, however, which can pass the Earth at close distances. They are called near-Earth asteroids (NEAs). Relative proximity of NEAs make them a natural choice for detailed studies during which even small telescopes can be used. Results of such observations can be used to determine basic physical properties of NEAs such as their diameters, rotation periods, spin axes, and types of minerals covering their surfaces.

Among NEAs, there is a group of objects called very small asteroids (VSAs), whose diameters are smaller than about 200 metres. Bigger asteroids are aggregations of individual boulders, held together by gravity. When their rotation periods are decreased, by different mechanisms, below the 2 hours threshold, the centrifugal force causes their fission into VSAs. VSAs, which are monolithic bodies held together by the material strength, can rotate faster than their parent bodies, and many of them show rotation periods smaller than 2 hours. Such objects are called super-fast rotators. Their rapid rotation is caused by the influence of the solar radiation in the so-called YORP effect, which can continuously spin-up VSAs until another threshold period is reached. When the rotation period of a VSA is as short as several minutes (or in some cases shorter than a minute), the centrifugal force is big enough to disrupt even a monolithic rock. This process of fission can be used to study the material strength and fractures inside the rotating body.

Observations of VSAs in the near-Earth space are challenging. They are very small and can be observed only during close fly-byes, which usually happen once in a decade or even less frequently. Because of thta, for successful characterization, observations should be planned during a relatively short window of opportunity, during which all necessary data must be collected. While derivation of some physical parameters can be done during 1-2 nights, others (like a spin axis) require that the length of the arc swept by the asteroid in the sky (while being bright enough for observations) is longer than about 120°. The latter means the observations should be done in a coordinated way with a network of telescopes located around the world.

Studies of VSAs are important for several reasons. Firstly, VSAs are part not only of the Main Belt in our Planetary System, but also asteroid belts around other stars. To understand how those remote planetary systems evolve requires good knowledge about the internal structure of VSAs and the way the YORP effect acts on them. Secondly, the knowledge about the material strength of the VSAs in the population of NEAs can help us to predict consequences of their collisions with our planet. Thirdly, VSAs are potential sources of raw materials for industry and plans for their mining must be based on knowledge about their surfaces and interiors.

In the present project, we plan to do photometric observations of near-Earth VSAs using a network of collaborating telescopes around the world. Their diameters range from 0.3-m to 1.2-m. For special cases a larger 4.3-m telescope will be put into work. Results will be used to determine physical parameters of VSAs such as: diameters, rotation periods, spin axes, colour indices, taxonomy types, and the H-G parameters of their phase functions. We will also test the hypothesis that the YORP effect, acting on small bodies without the insulating layer of regolith on their surfaces, draw their spin axes to a position perpendicular to their orbital planes.