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Vibrations and rotations of asteroids: internal structure imaging with 6 degrees of freedom instruments

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ABSTRACT

The determination of the internal structure of asteroids is important to evaluate their evolution during Earth's atmosphere entry, and to define the proper mitigation strategies. Seismic and geodetic methods have proven their efficiency at performing such internal structure imaging on Earth and on other planetary bodies.

Various potential seismic sources exist for asteroids (thermal cracks, micro-meteorite impacts, tidal quakes, artificial sources) that would allow to excite seismic waves and to consequently image its internal structure. In addition, the rotational dynamics can help us to understand the physical properties and mass distribution (relative moments of inertia) of an individual asteroid, as well as the physical processes that govern asteroid rotation. For example, the amplitude of forced

librations of a binary system and the decay of excited rotation sates such as the free librations inform us directly about the internal structure. An analysis of the amplitude of these signals as a function of frequency and their relevance to internal structure imaging is presented. It appears that these vibration and rotation forcing are covering large range of amplitudes and frequencies, making it almost impossible to measure the signals using a single instrument.

An example of potential instrumentation under development is provided through the description of the compact 6 DoF (Degrees of Freedom) instrument developed in the framework of PIONEERS H2020 project. This instrument is combining MEMS accelerometers and fiber optics gyroscopes. The science case for such an instrument is analyzed for various types of applications.

It is shown that the signals expected for passive seismology experiments are much below our noise floor. These signals must be investigated by another type of payload (see presentation by N. Murdoch in this session).

However, in addition to making precise measurements of the asteroid rotational dynamics, including forced librations of binary systems, the 6 DoF instrument can probe the mechanical properties of the asteroid by measuring the interactions between a lander and the asteroid surface (landing and rebounds). The 6 DoF instrument may also be used for active seismic experiments and can improve orbiter navigation around the asteroid before lander deployment to the surface. The first performance results obtained from the engineering models are also presented.

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Oral preferred
If possible, please schedule this presentation just before the presentation of Murdoch et al. proposed in the same session.