Vibrations and rotations of asteroids: planetary flyby as an opportunity for internal structure imaging with 6 degrees of freedom instruments. R.F. Garcia[1], N. Murdoch[1], V. Dehant[2], F. Bernauer[3], C. Schmelzbach[4], H. Igel[3], F. Guattari[5], D. Mimoun[1], G. Lecamp[5], S. Deraucourt[6], L. Ferraoili[4], S. Stahler[4], O. Karatekin[2], P. Lognonné[6], D. Giardini[4], A. Cadu[1], A. Wilhlem[1], PIONEERS Consortium, [1]ISAE-SUPAERO, 10 ave E. Belin, 31400 Toulouse, raphael.garcia@isae-supaero.fr, [2]Royal Observatory of Belgium, Brussels, [3]LMU, Munich, [4]ETHZ, Zurich [5]iXblue, Saint Germain en Laye, Brussels [6]PGP, University Paris Diderot, Paris.

Introduction: Previous studies of asteroids of size smaller than one kilometer are recalled. These worlds appears to be very quiet in terms of vibrations and rotation dynamics. Potential sources of seismic vibrations being limited to small size meteor impacts and thermal cracks; and difficulties to ensure a proper coupling between the instrument and the ground is making more complex seismic sounding. In addition, rotation dynamics is also limited to long term forcing through Yarkovsky and similar effects. We describe how a planetary flyby can increase the level of seismic and rotation dynamics forcing; thus generating larger signals that can potentially be measured by high performance accelerometers and fiber optics gyros deployed on the surface. An example of potential instrumentation under development is provided through the description of the compact 6 DoF (Degrees of Freeom) instrument developed in the framework of PIONEERS H2020 project.

Seismic vibrations of asteroids and planetary flyby: Various potential seismic sources exist for asteroids (thermal cracks, micro-meteorite impacts, tidal quakes, artificial sources). However natural sources are expected to generate either small or rare signals [1,2]. The existence of quakes on the Moon related to Earth's tide suggest that the tides due to a planetary flyby between Earth's and Moon will generate quakes in low cohesion asteroid materials. Challenges for numerical modeling of seismic sources and seismic wave propagation are presented.

Perturbations of asteroid rotations and planetary flyby: Tide effects on asteroids during planetary flyby are also generating perturbations of asteroid rotation parameters [3]. A close encounter with the Earth's may disturb the asteroid rotation by large values, thus providing a way to estimate the inertia matrix of the body.

6 Degrees of Freedom instrumentation : Instruments capable to probe the translations of rotations of asteroids on their surface are described. Usual seismic instrumentation probing high frequency seismic waves (geophones) is demonstrated to be a good candidate for sensing small vibration signals. However uncertainties on the coupling between the instrument and the surface during accelerations larger than local gravity make the science demonstration more difficult. A 6 DoF instrument combining high performance accelerometers and fiber optics gyroscopes is described. The science case for such an instrument is demonstrated for various types of applications, including Apophis planetary flyby. This instrument is currently developed in the framework of PIONEERS H2020 SPACE project of the European Commission (https://h2020-pioneers.eu/). Complementary between this type of instrumentation and geophones is discussed.

References:

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