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Potential for seismic investigation of Europa using meteorite impacts

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Europa, one of the Galilean satellites of Jupiter, has an icy outer shell, beneath which there is probably liquid water in contact with a rocky core [1]. Europa, may thus provide an example of a sub-surface habitable environment so is an attractive object for future missions to explore. In fact, the Jupiter Icy Moon Explorer (JUICE) mission has been selected for the L1 launch slot of ESA's Cosmic Vision science programme with the aim of launching in 2022 to explore Jupiter and its potentially habitable icy moons.

In order to improve our understanding of the internal structure, a seismic investigation would provide powerful constraints. The Apollo seismic experiment detected numerous seismic events on the Moon, and has revolutionized our knowledge of the lunar interior. On Mars, unmanned establishment of the Viking seismometer was carried out despite the fact that it was not able to capture any detectable events due to the poor coupling to the ground. The deficiency will be addressed by NASA's 2016 InSight Mars lander.

In this study, we investigate the detectability of seismic waves on Europa's surface caused by meteorite impacts. Internal fracturing and cracking of the icy crust could be the largest source of seismic waves, but in general multiple well-dispersed seismometers are necessary to locate the seismic source. However, meteorite impact sites could potentially be located using other methods such as surface imaging. The internal structure could then be estimated using a single seismometer. Recently, the seismic detectability on Mars using a single seismic station has been studied [2]. Motivated by this work, we estimate the number of detectable meteorite impacts per year on Europa by the process mentioned below.

1) We derive a relation between the crater diameter and the impactor's kinetic energy based on observational data compiled from impact tests, controlled explosions, and simulations.
2) Impact frequency on Europa is estimated by the distribution of observed crater sizes.
3) The results of 1) and 2) are combined to give the number of meteorite impacts which can be detected per year.
4) Taking the precision of practical seismic instruments into consideration, we discuss if using a single seismic station could be a reliable way of probing Europa's interior.

Reference
[1] F. Cammarano et al., J. Geophys. Res., 111, E12009 (2006)
[2] N. A. Teanby and J. Wookey, PEPI, 186, 70 (2011)

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