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Seismic detectability of meteorite impacts on Europa

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Europa, the second of Jupiter's Galilean satellites, has an icy outer shell, beneath which there is probably liquid water in contact with a rocky core. Europa, may thus provide an example of a sub-surface habitable environment so is an attractive object for future lander missions. 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.

One of the best ways to probe icy moon interiors in any future mission will be with a seismic investigation. Previously, the Apollo seismic experiment, installed by astronauts, enhanced our knowledge of the lunar interior. For a recent mission, NASA's 2016 InSight Mars lander aims to obtain seismic data and will deploy a seismometer directly onto Mars' surface. Motivated by these works, in this study we show how many meteorite impacts will be detected using a single seismic station on Europa, which will be useful for planning the next generation of outer solar system missions. To this end, we derive: (1) the current small impact flux on Europa from Jupiter impact rate models; (2) a crater diameter versus impactor energy scaling relation for ice by merging previous experiments and simulations; (3) scaling relations for seismic signals as a function of distance from an impact site for a given crater size based on analogue explosive data obtained on Earth's icy surfaces. Finally, resultant amplitudes are compared to the noise level of a likely seismic instrument (based on the NASA InSight mission seismometers) and the number of detectable impacts are estimated.

As a result, 0.5–3.0 local/regional small impacts (i.e., direct P-waves through the ice crust) are expected to be detected per year, while global-scale impact events (i.e., PKP-waves refracted through the mantle) are rare and unlikely to be detected by a short duration mission. We note that our results are only appropriate for order of magnitude calculations because of considerable uncertainties in the small impactor source population, internal structure, and ambient noise level. However, our results suggest that probing the deep interior using impacts will be challenging and require an extended mission duration and low noise levels to give a reasonable chance of detection. Therefore, for future seismic exploration, faulting due to stresses in the rigid outer ice shell is likely to be much more viable mechanism for probing the interior.