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Seismic Investigations of Europa and Other Ocean Worlds

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Seismic investigations offer the most comprehensive view into the deep interiors of planetary bodies. Developing missions (InSight, Europa Lander, Lunar Geophysical Network) identify seismology as a critical measurement to constrain interior structure and thermal state. In oceanic icy worlds, pinpointing the radial depths of compositional interfaces using seismology in a broad frequency range can address uncertainty in interior structures inferred from gravity and magnetometry studies, such as those planned for NASA's Europa and ESA's JUICE missions. Seismology also offers information about fluid motions within or beneath ice, which complement magnetic studies; and can record the dynamics of ice layers, which would reveal mechanisms and spatiotemporal occurrence of crack formation and propagation. Investigating these with future missions will require detailed modeling of seismic sources and signatures in order to develop the most suitable instrumentation.

We evaluate seismic sources and their propagation in Europa, with extension to other oceanic icy worlds, building on prior studies (Kovach and Chyba 2001, Lee et al. 2003, Cammarano et al. 2006, Panning et al. 2006, Leighton et al. 2008). We also consider additional sources: gravitationally forced librations, which will create volume-filling turbulent flow (le Bars et al. 2015), a possible seismic source similar to that seen from turbulent flow in terrestrial rivers (Tsai et al., 2012; Gimbert et al., 2014; Chao et al., 2015); downflow of dense brines from chaos regions on Europa into its underlying ocean (Sotin et al. 2002), possibly resembling riverine flows and flows through glacial channels (Tsai and Rice 2012); ocean acoustic signals that couple with the overlying ice to produce seismic waves, by analogy with Earth's ocean-generated seismic hum (Kedar 2011, Ardhuin 2015).

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