PROBING EUROPA'S INTERIOR WITH NATURAL SOUND SOURCES. N. C. Makris, S. Lee, M. Zanolin, *Department of Ocean Engineering, Massachusetts Institute of Technology, Cambridge MA 02139, USA, (makris@mit.edu)*, R. T. Pappalardo, *Laboratory for Atmospheric and Space Physics, University of Colorado, Boulder CO 80309-0392, USA*.

Our goal is to use both acoustic echo-sounding and tomographic techniques to determine Europa's interior structure. Echo-sounding reveals the depth and composition of terrestrial seafloor and sub-bottom layers by analysis of the arrival time and amplitude of acoustic reflections from these interfaces. Tomography reveals the temperature structure of terrestrial oceans by the way sound waves are perturbed along forward propagation paths. We plan to exploit natural cracking events on Europa's surfaces as sound sources of opportunity. Recent work shows that cycloidal cracks on the surface of Europa likely form on a daily basis [1] due to stresses induced by Europa's eccentric orbit which has a period of roughly 3.5 days. We estimate that the acoustic waves radiated from these cracks will be in the 0.1-100 Hz range with typical wavelengths exceeding 1 km. In contrast to ice-penetrating radar, such long wavelength disturbances suffer minimal attenuation in impure ice and water, and are relatively insensitive to anomalies such as ice fractures. Meteor impacts typically occur at a monthly rate and also have potential use as sound sources.

According to current plans, the first Europa landing mission will likely carry only a single geophone. Many valuable measurements can be made with a single geophone. For example, a first task should be to determine the level of acoustic activity on Europa by time series and spectral analysis. Correlations should be made of ambient noise level versus tidal stress to determine whether noise levels respond directly to orbital eccentricities. Such an analysis was conducted for the Earth's Arctic Ocean and showed a near perfect correlation between underwater noise level and environmental stresses and moments applied to the ice sheet from wind, current and drift [2].

Robust estimates can be made of Europa's ice layering structure and potential ocean depth with a single acoustic sensor if the signal-to-noise ratio is sufficiently high. On Europa, an isolated cracking event will lead to numerous echoes emanating from multiple reflections of compressional, shear and combined compressional-shear waves from the various layers of Europa's ice-water interior. Using 3-D seismo-acoustic propagation models developed for the Arctic Ocean on Earth, we find that the spacing of arrivals in time can be used to robustly estimate source range as well as ice and ocean layering parameters. To investigate signal-to-noise ratio issues, we have developed a Europan waveguide noise model that is based on classical ocean acoustic noise models [3]. Our present simulations indicate that possible "Big Bang" cracking events due to the inhomogeneities in the ice shell will emanate significant amount of seismo-acoustic waves that can stand robustly above Europan ambient noise. We also show that impacts of even small meteors fall into the Big Bang category that may be frequent enough to be used as sources of opportunity.

References

[1] Hoppa G. V., R. Tufts, R. Greenberg and P. E. Geissler 1999, *Science*, **285**, 1899-1902.

[2] Makris, N. C. and I. Dyer 1986, *J. Acoust. Soc. Am.*, **79**, 1434-1440.

[3] Kuperman, W. A. and F. Ingenito 1980, *J. Acoust. Soc. Am.*, **67**, 1988-1996.