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Seismic constraints on inner core structure from normal mode data, and comparison with mineral physics

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The solidity of the Earth's inner core was inferred in 1971 from normal mode observations. However, since then there has been little further proof that the inner core is solid and observations of PKJKP body wave arrivals are strongly dependend on the assumed inner core shear wave velocity. Ab initio mineral physical calculations suggest seismic velocities for various candidate structures which conflict with seismological results.

Here, we try to constrain the velocity structure of the inner core and show which, if any, models from mineral physics are compatible with the normal mode data excited by the 1994 Bolivian and 2004 Sumatran earthquakes. We aim to reinforce the argument for a solid core, and determine the most likely average velocity from this data.

Synthetic spectra, calculated for models with varying compressional and shear wave velocity, are compared with seismic spectra. We find that the best fit is obtained for inner core velocities very close to the PREM reference model: $v_s = 3.6 \pm 0.15$ km/s, $v_p = 11.15 \pm 0.15$ km/s. Velocities for candidate iron structures at inner core conditions from ab initio calculations are shown to disagree with the data. In most cases the fit is worse than for a liquid inner core model, suggesting that many effects remain unaccounted for. The discrepancy can be explained by the existence of fluid inclusions in the inner core, or the effect of viscoelastic weakening as the inner core is close to its melting temperature.

A layered inner core structure is also investigated and we find evidence for a discontinuity in velocity at a radius of 1020 ± 40 km. Using fully coupled normal mode synthetics, we find support for an isotropic outer layer surrounding an anisotropic region

of the inner core, possibly due to a change in mineral structure across this boundary.