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Probing velocity structure in Earth's inner core using coupled normal modes

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Low frequency normal modes have been used to investigate the inner core for over twenty years and models of inner core anisotropy have been made using this type of data. However these models, which describe radially varying cylindrical inner anisotropy core, do not agree well with the observations of inner core structure made using body waves that travel through the deepest parts of the Earth. More complex inner core structures, including the presence of an isotropic layer at the top of the inner core, lateral variations in inner core anisotropy and possibly a seismically distinct "innermost inner core" have been suggested, but verification of the large scale nature of these structures is limited by restricted raypaths through the inner core.

Many of the normal modes of the Earth are sensitive to large scale features present in the core. Previous normal mode studies of inner core anisotropy have used the self-coupling approximation, which assumes that normal modes are isolated from one another. However the presence of lateral structure in the inner core, as well as inner core anisotropy, cause normal mode oscillations sensitive to the inner core to resonate or cross-couple. Cross-coupling of normal modes permits the observation of both even and odd degree structure in the inner core.

Cross-coupling of pairs of modes where one mode is confined to the inner core and one mode is observable at the surface of the Earth allows us to ensure that the heterogeneous structure we observe is located in the inner core, as structure in the mantle or crust could not cause a inner core-confined mode to couple. Furthermore the use of normal mode data, which are sensitive to compressional wave, shear wave and density structures in the inner core, allow us to investigate variations in inner core shear velocity which cannot currently be observed using body wave data.

We use an extensive new data set, consisting of spectra collected for over ninety large magnitude events, to measure cross-coupled splitting functions of normal mode oscillations sensitive to the structure of Earth's inner core. In addition to the signature of cylindrical inner core anisotropy, we also observe more complicated features which give credence to the more complex picture of the inner core which has been developed using body wave data.

A better understanding of the lateral and radial variation of inner core structure is important if we are to understand the complex interactions between the magnetic and thermal forces present in the core and the textures we can observe using different seismic techniques.