INNER CORE ANISOTROPY FROM PKP TRAVEL TIMES AT NEAR ANTIPODAL DISTANCES

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The central region of the inner core is difficult to study because of poor sampling of seismic data. Previous studies from PKP(AB-DF) differential travel times at large distances suggest that the central part of the inner core is very anisotropic (Vinnik et al., 1994; Song, 1996). These differential times, however, can be affected greatly by strong heterogeneity in the lowermost mantle (e.g., Breger et al., 2000).

We’ve recently examined a unique data set of PKP travel times from global digital and analog stations at near antipodal distances (Sun and Song, 2002). Most of the digital data are obtained from the IRIS DMC. The advantages of using antipodal PKP waves include:

1. The effect of inner core anisotropy on DF travel time is greatest as the DF ray travels the longest path in the inner core.
2. The effect of lowermost mantle heterogeneity on AB-DF time is greatest because of the largest separation of the two rays.
3. Antipodal waves have the peculiarity that a small variation of source or receiver locations can produce a wide azimuthal coverage of ray paths in the globe, thus, even a limited number of stations that are at near antipodal distances to active source regions may result in a good ray coverage.

We obtained 638 AB-DF differential travel-time measurements and 470 DF, 466 AB absolute travel-time measurements at distances larger than 168 degrees (Fig. 1). The observed AB-DF residuals for the polar paths are consistently larger than those of the equatorial paths by over 3-4 standard deviations (Fig. 1A). Assuming a uniform cylindrical anisotropy model, the average inner core anisotropy amplitude is about 2.5%. We conclude that most of the AB-DF anomalies for the polar paths are likely from the inner core anisotropy and not from mantle heterogeneity.

Although often sparse and not uniform, the ray coverage of the AB rays at the CMB is quite good, with data at all latitudes and longitudes, thus they are affected by both slow and fast mantle anomalies (Fig. 2). The regions sampled by the AB rays of the polar paths are well sampled by the AB rays of the equatorial paths.

Cross points of all DF and AB rays in this study at CME

Observed PKP travel time residuals used in this study

Travel time residuals relative to PREM versus the angle of the DF leg in the inner core from the spin axis. (A) Residuals of AB-DF differential times. Assuming a model of uniform anisotropy in the inner core with symmetry around the spin axis, we obtained a least squared model with 2.5% anisotropy amplitude (solid line). The dotted line is the anisotropy model from Song and Helmberger (Song and Helmberger, 1993) with 3% anisotropy averaged over the top 500 km of the inner core. (B) Residuals of DF absolute times. The dashed line is the average of the DF residuals of the equatorial paths with ray angle from spin axis larger than 60 degrees. Note the DF rays for the polar paths are anomalously fast relative to equatorial paths. (C) The same as (B), but for the AB residuals. Note the AB residuals for the polar paths do not appear anomalous.
(2) The DF residuals are negatively correlated with the AB-DF residuals while the AB residuals have a much weaker correlation with the AB-DF residuals (Fig. 1B, C).

(3) We compare several mantle models with the data. Our results suggest that the mantle structure can explain part of the residuals of the equatorial paths, but cannot explain the polar path anomalies.


