CONSTRAINTS ON DENSITY AND SHEAR VELOCITY CONTRASTS AT THE INNER CORE BOUNDARY

Aimin Cao and Barbara Romanowicz • University of California, Berkeley

The density jump ($\Delta \rho_{ICB}$) at the Inner Core Boundary (ICB) is an important constraint on the dynamics and history of the Earth’s core. Two types of seismological data sensitive to $\Delta \rho_{ICB}$ have been studied since the 1970’s: free oscillation eigenfrequencies and amplitudes of core reflected phases (PKiKP/PcP). The reference PREM model (Dziewonski and Anderson, 1981), based largely on normal mode data, has a relatively low value of $\Delta \rho_{ICB} = 0.60 \text{ gcm}^{-3}$, whereas most studies based on PKiKP/PcP amplitude ratios find significantly larger values, sometimes in excess of 1.0 gcm$^{-3}$. It has been argued that, because PKiKP is rarely observed in the distance range considered (10-70°), the latter type of measurement provides only upper bounds on $\Delta \rho_{ICB}$ (e.g. Shearer and Masters, 1990). We have analyzed 10 years of high quality global broadband data accumulated since the work of Shearer and Masters (1990). We systematically analyzed over 4500 seismograms from intermediate/deep events (depth > 70 km) in the distance range 10-70°. The data were filtered in the band-pass 0.7-3 Hz. We performed a rigorous data selection and identified 5 pairs of very clear (Quality A), and 15 possible (Quality A-) PKiKP and PcP arrivals. In addition, 58 records showed no PKiKP but a clear PcP.

Together, we obtain a much less dispersed dataset than previously available, with the quality A data at the lower end of the ensemble of amplitude ratios versus distance. We combine our high quality measurements with 2 measurements from the literature that fall within our rigorous selection criteria and obtain estimates of $\Delta \rho_{ICB}$ in the range 0.6-0.9 gcm$^{-3}$ and $\Delta \beta_{ICB}$ in the range 2-3 kms$^{-1}$. Our estimate of $\Delta \rho_{ICB}$ is in agreement with a recent reevaluation of normal mode data (Masters and Gubbins, 2003), thus reconciling results from body wave and mode studies and providing a tighter constraint on $\Delta \rho_{ICB}$ for geodynamicists. Our study also provides evidence for a shear velocity gradient at the top of the inner core.

NSF Grant No. EAR-0308750

Measurements of PKiKP/PcP amplitude ratios. The red stars denote the Quality A data, and their error bars are derived from the fractional ratios of the average peak-to-peak amplitudes of background noise to the peak-to-peak amplitude of the identified phase arrivals; the red hexagon is Shearer and Masters’ (1990) second measurement with clear PKiKP; the inverted red triangle is a stacking measurement (Schweitzer, 1992) which has been remeasured by the author himself recently; the grey squares denote the Quality A- data; and the black dots are the Quality B data. The curves are the theoretical PKiKP/PcP amplitude ratio calculated with respect to PREM model. For the dashed green curve $\Delta \rho_{ICB} = 0.60 \text{ gcm}^{-3}$ and $\Delta \beta_{ICB} = 3.5 \text{ kms}^{-1}$ (original values in PREM model); for the dashed orange curve $\Delta \rho_{ICB} = 0.60 \text{ gcm}^{-3}$ and $\Delta \beta_{ICB} = 2.5 \text{ kms}^{-1}$; for the dashed red curve $\Delta \rho_{ICB} = 0.85 \text{ gcm}^{-3}$ and $\Delta \beta_{ICB} = 3.5 \text{ kms}^{-1}$; and for the solid blue curve $\Delta \rho_{ICB} = 0.85 \text{ gcm}^{-3}$ and $\Delta \beta_{ICB} = 2.5 \text{ kms}^{-1}$ (our best fitting values using PREM model). The open symbols are other data from previous studies, which were not used in our analysis (triangles: Souriau and Souriau, 1989; hexagon: Shearer and Masters, 1990; diamonds: Engdahl et al., 1970; Bolt and Qamar, 1970) (Cao and Romanowicz, GJI, 2004).