Geoneutrino Flux From Earth’s Mantle And Its Detectability

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1. Earth Structure And Present-Day Energy Budget

- Earth loses heat at a rate of 46 ± 3 TW [1], which includes heating by long-lived radioactivity (238U, 232Th, 40K) and primordial heat remnant after accretion and core–mantle differentiation.

2. Geoneutrinos

- Radioactivity in the highly enriched crust accounts for 8:1 TW [2].
- We use three shallow mantle compositional estimates, “low”, “medium” and “high” in terms of U+Th abundances [3].
- Concentrations of U & Th calculated from available estimates for average mantle abundances implied by different estimates of silicate Earth bulk composition account for 1 to 2 TW of radiogenic heating [3].

3. Seismic Image of the Mantle

- Shear-wave seismic speed anomaly relative to a spherically symmetric seismic speed model (seismic model 20RT05 [4], figure from [5])

4. Geoneutrino Flux Predictions (238U + 232Th)

- Assumption: seismically imaged deep-mantle structures (section 3) can be compositionally distinct from ambient mantle.
- Concentrations of U & Th calculated from available estimates for average mantle and shallow mantle (section 1).

5. Detectability of Mantle Flux

- We present results for “geochemical mantle” and “medium U+Th” shallow mantle.
- Detection 1/σ error regions for hypothetical measurements, exposure value in TNU.

Fundamental unanswered questions:

- How much radioactivity is there in Earth's mantle?
- OR more broadly: What is Earth made of?
- How is mantle radioactivity spatially distributed?
- Is the mantle compositionally uniform? layered? 3-D compositional structures?
- Crucial for understanding the power available for mantle convection & plate tectonics, Earth’s thermal history, planetary accretion.

References


Summary

- Model of geoneutrino emission from Earth’s mantle, constrained by geophysics and geochemistry.
- Plausible compositional estimates result in mantle flux patterns ranging from low-amplitude spatially uniform to high-amplitude laterally variable.
- Predicted lateral variation in mantle flux is resolvable for “geophysical” mantle and the high-abundance end of “geochemical” mantle by a two-site measurement in the Pacific.

Detection at site #1 in TNU

Detection at site #2 in TNU

Two detection sites in Pacific basin proposed to benefit from:

- high mantle-to-crust signal ratio
- large lateral variation of predicted flux