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Probing the Earth's Mantle Transition Zone and Large Low-Velocity Provinces with Neutrino Oscillation Tomography

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Neutrino oscillation tomography has the potential to complement classical geophysical and geochemical methods for probing the Earth's deep interior. This technique relies on identifying changes in neutrino oscillation patterns due to variations in the matter density and the proton-to-nucleon ratio distribution in the materials through which neutrinos pass. Consequently, open questions regarding the density distribution and chemical composition of the Earth's interior can be addressed with this novel method.

In this contribution, we present the sensitivity of neutrino oscillation tomography to the aforementioned properties of each Earth layer, considering a spherically symmetric Earth model. Our goal is to identify which depth ranges can be most effectively studied using this technique. To understand the constraints that neutrino oscillation tomography can provide on Earth structure, we first derive the sensitivity to the planet's composition and density, assuming an ideal neutrino detector. Next, we incorporate the response of next-generation neutrino telescopes. We show that while an ideal detector is most sensitive to the outer core, realistic detectors with lower resolution but large detection volumes are more sensitive to shallower depths.

Finally, making use of the recent implementation of a 3-dimensional Earth Model in the OscProb programming library, which handles the calculation of oscillation probabilities for a given neutrino trajectory, we investigate the possibility of characterizing heterogeneous structures. Here, we focus on the sensitivity to asymmetrical water distribution in the mantle transition zone (MTZ). Initial evidence suggests that the MTZ beneath Asia may contain significantly more water than that beneath Europe. To explore this, we assess the feasibility of combining measurements from neutrino detectors across these two continents to constrain the water content in these regions.

Collaboration(s)

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