ID contributo: **512**   Tipo: **Poster**

Neutrino tomography of the Earth's lower mantle: first study with a full 3D model

venerdì 21 giugno 2024 17:30 (2 ore)

Much has been learned about the deep Earth based on seismic measurements, combined with geophysical constraints and theories of Earth formation. However, such methods alone cannot directly resolve the full structure of the inner Earth, e.g. in terms of matter density, composition and temperature distributions. One open question in this realm concerns the nature and composition of two large-scale heterogeneities revealed by 3D seismology and known as large low-shear-velocity provinces (or LLVPs), that sit at the base of the mantle beneath the Pacific and Africa.

A renewed perspective on these questions may come from atmospheric neutrino oscillation tomography. For neutrinos crossing the Earth, distortions in the flavour oscillation patterns due to matter effects are expected in the energy range ~1-10 GeV, where the atmospheric neutrino flux is most abundant. Measuring the flavour, energy and angular distributions of such neutrinos provides sensitivity to a new observable of geophysical interest: the electron number density in the layers of matter traversed.

The upcoming generation of experiments detecting atmospheric neutrinos at the GeV scale, including DUNE, Hyper-Kamiokande and KM3NeT/ORCA, may therefore open new perspectives for neutrino oscillation tomography of the Earth. In order to explore their potential for probing asymmetric models of the Earth's mantle, we have developed a flexible simulation framework based on parameterized detector response functions and including for the first time a full 3D Earth model. Applying this framework, we investigate (i) the possibility of neutrino tomography to differentiate LLVP models consistent with current seismic data, and (ii) the combined sensitivity achievable with different detector configurations around the Earth.

Poster prize

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Classifica Sessioni: Poster session and reception 2

Classificazione della track: Geo neutrinos