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Neutrino Tomography of Earth

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We estimate geophysical properties of the Earth's interior (Earth's and core mass, moment of inertia, density profile) by looking at the absorption of neutrinos as they pass through our planet.

Cosmic-ray interactions with the atmosphere produce a "shower" of neutrinos with energies extending above the TeV scale. The Earth is not a fully transparent medium for neutrinos with energies above a few TeV, as the neutrino-nucleon cross-section is large enough to make the absorption probability non-negligible. Since absorption depends on energy and distance travelled, studying the distribution of the multi-TeV atmospheric neutrinos crossing the Earth offers an opportunity to infer its density profile by means of weak interactions, only. In our work, recently published in Nature Physics, 15, 37-40 (2019), we have performed the first "Neutrino Tomography of Earth" using actual data (one-year of through-going muon atmospheric neutrino data collected by the IceCube telescope at the South Pole). In a way that is completely independent of gravitational measurements, we are able to determine the mass of the Earth and its core, its moment of inertia, and to establish that the core is denser than the mantle. Our results demonstrate the feasibility of this approach to study Earth's internal structure, complementary to geophysics methods based on seismology. Neutrino tomography will become more competitive as soon as more statistics is available. We have performed a forecast on the expected results attainable using ten years of atmospheric neutrino data at IceCube, finding that the determination of the mantle density would improve by approximately a factor of five and ten for the lower and upper mantle, respectively, while the improvement for the core would be at least of a factor of two. This implies that a few percent (10%) precision in the outer (inner) mantle density may be reached.

This external input coming from neutrinos may help to improve seismological models.