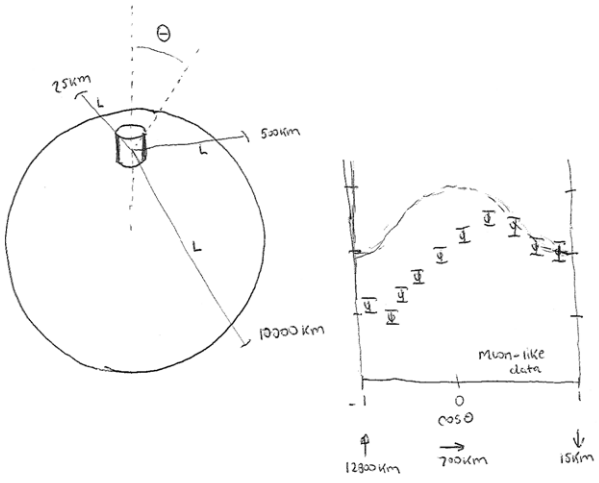
Atmospheric Neutrino Oscillations

Christopher W. Walter

Associate Professor, Department of Physics, Duke University
and Kavli IPMU Visiting Scientist

Neutrino mass was discovered by doing a quantum mechanics experiment using the entire earth. The neutrinos observed in experiments are states of flavor. However, these neutrinos are actually quantum mechanical mixtures of states, each with a well-defined mass. As they travel, the flavor states we measure oscillate back and forth between types. The equations that describe this oscillation are functions of mixing angles that describe how mixed the states are and mass splittings that describe the differences between their masses, along with distance and energy. By comparing the behavior of atmospheric neutrinos (see *IPMU News* No. 7, p. 28) traveling straight down with those coming thousands of kilometers from below, the mixing angle and mass splitting were measured. Atmospheric neutrinos traveling from below have about a 50% chance of changing to a type of neutrino we can't easily see. This is seen in the data from Super-Kamiokande where approximately half of the expected upward-going muon-like events are observed.



$$P_{\nu_\mu \to \nu_\tau} \cong \sin^2(2\theta_{23}) \sin^2\left(\frac{1.27\,\Delta m^2_{32} L}{E}\right)$$