# Universal effect

Neutrinos have always been my favourite elementary particles. In spite of, or perhaps because of, their elusive nature, they were key to unravelling the nature of both the strong and weak interactions. Astrophysical neutrinos provided — through the observation of oscillations between different neutrino species, which require neutrinos to have mass — the first definitive evidence for new physics beyond the standard model of elementary particles.

But oscillations are not an unambiguous pointer to the source or energy scale of the new physics. Moreover, they do not pin down the mass of the neutrinos, but only the scale of the mass differences between neutrino types. As a result, we do not even know whether the electron neutrino is heavier than the muon neutrino, or vice versa.

All this may change in the near future. New terrestrial experiments and, in particular, new astrophysical observations, might be directly sensitive to neutrino masses: I find it remarkable that an observation of minute gravitational effects associated with the clustering of galaxies in the Universe might be sensitive to neutrino masses, ten million times smaller than the mass of the electron.

For example, the South Pole Telescope will measure small temperature and polarization anisotropies in the cosmic microwave background radiation, caused by the radiation's traversal of clumps of matter,

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such as galaxies and clusters, over the past 14 billion years. Untangling these effects can, in principle, enable precise three-dimensional 'tomography' of the distribution of matter on a wide range of cosmological scales. If neutrinos have masses in the range suggested by oscillation experiments, then cosmological neutrinos left over from the Big Bang should leave an imprint on the clustering of matter on these scales that may be detectable by the end of this decade.

It would be another triumph for the power of cosmological observations, and for neutrinos as an empirical guidepost, constraining the otherwise vivid imaginations of particle theorists.

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