

### ASTR 680 Practice questions for lecture 3: Neutrinos and friends

1. A neutron in free space decays to produce a proton, an electron, and an electron antineutrino (of energy  $\sim 1$  MeV in the original neutron rest frame). If the neutron moves rapidly enough toward us, the emitted neutrino will be blueshifted by approximately the Lorentz factor  $\gamma$  of the neutron. Could the  $\sim 1$  PeV neutrinos seen with IceCube be produced by neutrons with  $\gamma \approx 10^9$ ? After all,  $\gamma \sim \text{few} \times 10^{10}$  is invoked for protons that produce ultra-high-energy cosmic rays.
2. Suppose you place a flat disk in an isotropic radiation field, where the disk is initially at rest in the frame that sees isotropy. Can the disk experience a net acceleration?