Neutrino and neutron spectroscopy using trapped ions

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The neutrinos and neutrons emitted in nuclear beta decay can be precisely studied using radioactive ions held in a radiofrequency-quadrupole ion trap. When a radioactive ion decays in the trap, the recoil-daughter nucleus and emitted particles emerge from the ~1-mm^3 trap volume without scattering and propagate unobstructed through vacuum. This allows the momentum and energy of particles that would otherwise be difficult (or even impossible) to detect to be reconstructed from the momentum imparted to the recoiling nucleus. Measurements of beta-neutrino angular correlations can be made by taking advantage of the favorable properties of the ^{8}Li and ^{8}B beta decays and the benefits afforded by using trapped ions to allow an accurate determination of the direction and energy of each emitted neutrino. Beta-delayed neutron spectroscopy can be performed by circumventing the many difficulties associated with direct neutron detection and instead reconstructing the neutron emission probabilities and energy spectra from the time of flight of the recoiling nuclei. These novel techniques will have an important impact on improving our understanding of fundamental electroweak theory and the origin of the elements and will benefit applications of nuclear science such as nuclear energy and stockpile stewardship.