APR07-2007-000542

Abstract for an Invited Paper
for the APR07 Meeting of
the American Physical Society

Henry Primakoff Lecture: Neutrinoless Double-Beta Decay

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With the realization that neutrinos are massive, there are intriguing questions about their very nature. Might neutrinos and antineutrinos be actually the same particles, so called Majorana particles? Many theoretical models favor the existence of Majorana neutrinos, which would break one of nature's most fundamental symmetries – lepton number conservation. Neutrinoless double-beta decay provides the only practical experimental technique to probe the Majorana nature of neutrinos. Observation of this decay mode would not only demonstrate that neutrinos are Majorana particles and violate lepton number, but would determine the absolute mass of neutrinos as well, since the rate of the observed decay is directly proportional to the square of the effective Majorana neutrino mass. A number of next-generation experiments are currently being constructed or developed that initially aim to achieve sensitivities to the neutrino mass in the "quasi-degenerate" region (> 100 meV). This talk will review the physics of neutrinoless double-beta decay, explain the need to study neutrinoless double-beta decay in different isotopes using diverse experimental techniques, and discuss the status of current experimental efforts.