Probing the particle-antiparticle nature of neutrino

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The existence of neutrino was first proposed by Pauli [1] in 1930 to conserve fundamental quantities like momentum and energy in the nuclear beta decay process. Neutrino oscillation data have now established that neutrinos have non-zero mass [2]. Although, the two mass-squared differences are measured, the absolute mass of the lightest neutrino and mass ordering are not known. The fundamental question regarding the nature of neutrinos – whether neutrino and antineutrino are distinct or identical (referred to as Dirac or Majorana Fermions), is yet to be answered. The mass and nature of neutrino also plays an important role in astrophysics and cosmology. In addition, CP violation in the leptonic sector is an open question in neutrino physics.

Maria Goeppart-Mayer predicted Double beta decay ($2\nu\beta\beta$ or DBD), a second order weak interaction, where a (A, Z) nucleus transforms to its isobar (A, Z + 2) with the emission of two electrons and two antineutrinos [3]. The DBD is possible in few cases, where single beta decay of a nucleus is forbidden either due to energy or spin. G. Racah [4] suggested that if neutrino is its own antiparticle, there is a possibility of virtual annihilation of the two neutrinos in DBD leading to a neutrinoless double beta decay process ($0\nu\beta\beta$ or NDBD). Experimental signature of observation of $0\nu\beta\beta$ process is a peak at the $Q_{\beta\beta}$ value in the sum energy spectrum of the two emitted electrons. At present, $0\nu\beta\beta$ is perhaps the only experiment that can reveal the true nature of the neutrino.

Given its significance, there is a widespread interest in the quest for $0\nu\beta\beta$ employing different techniques [5]. There are about 35 possible candidates for DBD. Both DBD and NDBD are rare processes with $T_{1/2} > 10^{18}$ yrs. In order to achieve the desired experimental sensitivity, background reduction is very crucial and often experiments are located in an underground laboratory to reduce cosmic muon induced background. While the half-life of $2\nu\beta\beta$ decay has been already measured for 11 nuclei, no clear signature of NDBD is seen so far. The present best limit is obtained for ^{136}Xe as $T_{1/2}>1.07\text{x}10^{26}$ y [6].

A crucial criterion for detector design is high energy resolution for a precision measurement of the sum energy of two electrons emitted in $0\nu\beta\beta$ decay. The cryogenic bolometers with excellent energy resolution and high sensitivity, are well suited for rare event studies like NDBD or dark matter search. With the upcoming INO laboratory in India, R&D for The India based TIN detector (*TIN.TIN*), comprising Sn cryogenic bolometer, has been initiated [7] for the study of $0\nu\beta\beta$ in ^{124}Sn ($Q_{\beta\beta}$=2.28 MeV, 5.8% abundance). *TIN.TIN* is multidisciplinary in nature and the ultra-low event rate involves many challenges like mK thermometry, enrichment of ^{124}Sn, background reduction and readout electronics for low temperature measurements with good resolution.

This talk will present status of $0\nu\beta\beta$ experiments, with emphasis on the indigenous effort to search for $0\nu\beta\beta$ in ^{124}Sn.

References

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