Nuclear Seminar

Fishing in a sea of Xe—Barium-ion tagging for ^{136}Xe double-beta decay studies with EXO

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The nature of the neutrino, i.e., whether it is a Dirac or Majorana particle, still remains a mystery. An experimental approach to answering this question is through decay experiments searching for the lepton-number violating neutrino-less double decay (0nbb). A positive observation of this decay would determine the character of the neutrino to be a Majorana particle. Furthermore, one could extract the effective Majorana neutrino mass from the half-life of the decay. Several collaborations worldwide are investigating bb decays in different isotopes. EXO-200 is a bb-decay experiment searching for a 0nbb signal in the bb decay of ^{136}Xe to its daughter isotope ^{136}Ba. This detector contains ~175 kg liquid Xe enriched to ~80.6% and is currently operational at the WIPP site in New Mexico, USA. The best limit on the 0nbb decay half-life of ^{136}Xe ($t_{1/2}$=1.6x10^{25} years) has recently been published (PRL, 109(2012)032505).

In order to further push the limit of sensitivity it is necessary to suppress the background (currently dominated by gamma rays) and increase the mass of the parent isotope. EXO has started the development of a multi-ton scale time-projection chamber (TPC). One option under development is the search for 0nbb in ^{136}Xe using a TPC filled with high pressure gaseous xenon as source and detection material. This layout allows the unique opportunity to extract into vacuum and tag Ba-daughter ions. This tagging possibility, combined with enough energy resolution to separate 0nbb and 2nbb decays, allows one to dramatically reduce the background of the measurement to virtually zero.

A test setup is being developed at Stanford to demonstrate the feasibility of Ba-ion extraction from 10 bar Xe into an UHV environment. A supersonic nozzle combined with an extraction RF-funnel (see e.g. NIMA, 496(2003)286) can be used to accomplish this task. Gas dynamic and Monte Carlo simulations indicate Ba-ion transport efficiencies higher than 90%. A prototype of such a nozzle-funnel system is currently being developed. A 10 bar Xe chamber and a Xe recovery system as well as the RF-funnel and a downstream sextupole ion guide are operational at Stanford. First ions have been extracted from Xe gas and the development of a m/q identification is ongoing. The status of Ba-ion extraction from a high pressure Xe gas environment, along with the latest results from EXO-200 will be presented.

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