Nuclear Structure for Neutrinoless Double-β Decay

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If the process of neutrinoless double-β decay (0ν2β) were to be observed, neutrinos would be established as their own antiparticles (Majorana particles) and progress could be made toward determining an absolute scale for the neutrino-mass eigenstates. That neutrinos have mass is established by the observation of neutrino-flavor oscillations. However, such work only establishes differences between the squares of the mass eigenstates. A determination of the lifetime of the 0ν2β decay process would allow access to the absolute mass scale, provided the mechanism responsible for the decay is driven by light Majorana-neutrino exchange. The rate of the 0ν2β decay is sensitive to nuclear structure inputs, with the decay rate being proportional to the phase space for the two b-particles, the square of the nuclear transition matrix element and the effective Majorana mass of the electron neutrino. The latter is the sum of the mass eigenstates weighted with the square of the mixing matrix elements: $\langle m_{\beta\beta} \rangle = |\sum_k m_k U_{ek}^2|$. Therefore from a finite 0ν2β decay rate one gets access to the absolute neutrino mass scale, provided one can reliably calculate the nuclear transition matrix element. As benchmarks to such calculations experimental quantities are necessary.

We have investigated pairing properties for the ^{100}Mo-^{100}Ru system by studying (p,t) reactions on ^{100,102}Ru and ^{98,100}Mo targets [1]. Cross sections were measured at lab angles 6° and 15° to be sensitive to L=0 transitions leading to 0^+ states. Whereas the L=0 transfer to and from ^{100}Ru leads almost exclusively to the ground states, about 20% of the L=0 strength goes to excited 0^+ states in the ^{100}Mo case. Apparently ^{100}Ru is more on the spherical side of the well known shape transition in A≈100 nuclei, whereas ^{100}Mo seems to be more easily deformable. This shape change between the two partners of the 0ν2β decay tends to make the calculation of the matrix element complicated.

Another 0ν2β pair is the ^{150}Nd-^{150}Sm system. For the intermediate nucleus ^{150}Pm, although next to two stable isobars, there was no knowledge about excited states until three years ago. From a (^{3}He,t) and (t,^{3}He) study with moderate energy resolution [2] there were about 20 states known before our own work. We studied excited states in ^{150}Pm via the ^{152}Sm(d,α) reaction using our high resolution Q3D spectrograph and with the ^{150}Nd(p,nγ) reaction at the Bucharest tandem accelerator [3]. We identify in total about 50 levels below 1.5 MeV of excitation.

REFERENCES

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Figure 1: ^{152}Sm(d,α)^{150}Pm spectrum at 30°, beam energy 25 MeV, energy resolution 13 keV (FWHM), peaks are labelled with their excitation energy in keV.