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Measurements of 2ν-double-beta decay matrix elements: some surprises in nuclear physics.

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I will talk about high-resolution charge-exchange reactions of (n,p) and (p,n) type at intermediate energies, which directly connect to the nuclear matrix elements in double-beta ($\beta\beta$) decay. Here, the (n,p) type reactions are realized through (d,^{2}He) reactions, where ^{2}He refers to two protons in a singlet $^1S_0$ state and where both of these are momentum analyzed and detected by the same spectrometer and detector. These reactions have been developed and performed exclusively at KVI, Groningen (NL). The (p,n) type (^{3}He,t) reaction was developed at the RCNP facility in Osaka (Japan) allowing measurements with a resolution of 30 keV at incident energies of 420 MeV. Using both reaction types one can extract the Gamow-Teller transition strengths B(GT$^+$) and B(GT$^-$), which define the two "legs" of the $2\nu\beta\beta$ decay matrix elements. The high resolution available in both reactions allows a detailed insight into the excitations of the intermediate odd-odd nuclei and, as will be shown, some rather unexpected and surprising features are being unveiled. Special emphasis will be placed on the $\beta\beta$ decay nuclei ^{76}Ge, ^{96}Zr, ^{100}Mo and also recent results for ^{128,130}Te and ^{136}Xe will be presented as well. In the case of ^{76}Ge, an extreme fragmentation of low-energy B(GT) strength is observed, contrary to ^{96}Zr and ^{100}Mo, where the entire low-energy GT-strength is concentrated in a single level, which in the case of ^{100}Mo also happens to be the ground state of ^{100}Tc. Also, the pathologically large half-life of the ^{136}Xe $2\nu\beta\beta$ decay [1] finds a natural explanation.

I will also talk about future directions using ion traps at the TRIUMF radioactive beam facility in Vancouver (Canada) to measure electron-capture branching ratios of the intermediate odd-odd nuclei, which are poorly known or not known at all. Together with the β^- decay, these decays define the ground-state properties of the intermediate nucleus and thereby also connect to the nuclear $\beta\beta$ decay matrix elements of both, the 2ν and the 0ν part. The setup and first test measurements have been completed and some results will be communicated [2].

[1] N. Ackermann et al., Phys. Rev. Lett. 107, 212501 (2011).

A. Gando et al., Phys. Rev. C 85, 045504 (2012).

[2] I express appreciation to my collaborating partners from the KVI, the RCNP and from TRIUMF, who I cannot entirely list in this abstract, but who I will give credit to in the presentation.