Theoretical studies of rare weak processes in nucle i

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The various neutrino-oscillation experiments have v erified the existence
of the neutrino mass but still there is no determin ation of the absolute
mass scale of the neutrino. Much effort is being in vested
in expensive high-resolution neutrino experiments b ased on weak-interaction
decays of atomic nuclei. The most intriguing of the se processes is the
neutrinoless double beta decay which not only can a ccess the absolute
mass scale and the hierarchy of the neutrinos but a lso can reveal if
the neutrino is its own antiparticle, the so-called Majorana neutrino.

Since atomic nuclei are used as probes of the neutr ino properties one needs
to understand well the nuclear-structure part of th e involved decay processes
in the form of calculated nuclear matrix elements. These elements are
instrumental in accessing the neutrino properties f rom the results of
underground experiments. Exciting results are expec ted to emerge as
outcomes of the large next-generation experiments t hat can fully cover
the inverted-hierarchy region of neutrino masses.

Recent advances in this fascinating field of physics come from studies
of the positron-emitting/electron capture modes of double beta decay.
During the last few years experimental attention has been directed to a new
interesting possibility to access the neutrino properties, namely the
neutrinoless double electron capture (0vECEC). In particular, it has
been speculated that the resonant 0vECEC could be detected due to its
potential million-fold resonant enhancement relative to the double-positron
emitting processes. The Penning-trapp mass measurements together with
nuclear-structure calculations and atomic data have recently been used
to analyze the potential cases for the resonant enhancement. Further
striking results concern the quenching of the weak axial-vector
coupling constant in heavy nuclear systems. This quenching can be
probed, e.g. by aiming at simultaneous theoretical description of
double beta decays and their adjacent single beta decays.