Theory of neutrinoless double beta decay

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AbstractNeutrinoless double beta decay is a very old and yet elusive process. Its observation will signal that lepton number is not conserved and the neutrinos are Majorana particles. More importantly it is our best hope for determining the absolute neutrino mass scale at the level of a few tens of meV. To achieve the last goal certain hurdles have to be overcome involving particle, nuclear and experimental physics [1].
Nuclear physics is important for extracting the useful information from the data. One must accurately evaluate the relevant nuclear matrix elements, a formidable task. To this end, we review the sophisticated nuclear structure approaches recently been developed, which give confidence that the needed nuclear matrix elements can be reliably calculated employing different methods: a) the various versions of the Quasiparticle Random Phase Approximations, b) the interacting boson model, c) the energy density functional method and d) the large basis Interacting Shell Model. It is encouraging that, for the light neutrino mass term, these vastly different approaches now give comparable results.
From an experimental point of view it is challenging, since the life times are long and one has to fight against formidable backgrounds. One needs large isotopically enriched sources and detectors with high energy resolution, low thresholds and very low background.
If a signal is found, it will be a tremendous accomplishment. Then, of course, the real task is going to be the extraction of the neutrino mass from the observations. This is not trivial, since current particle models predict the presence of many mechanisms other than the neutrino mass, which may contribute or even dominate this process:

(i) The neutrino induced, but neutrino mass independent contribution.
(ii) Heavy left and/or right handed neutrino mass contributions.
(iii) Intermediate scalars (doubly charged etc).
(iv) Supersymmetric (SUSY) contributions.

We will show that it is possible to disentangle the various mechanisms and unambiguously extract the important neutrino mass scale, if all the signatures of the reaction are searched in a sufficient number of nuclear isotopes.

Bibliography

[1] Most of the material of this talk has been drawn from the recent review:
J.D. Vergados, H. Ejiri and F. Simokvic, ROP (in press); arXiv: 1205.0649 (hep-ph)