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Neutrino-nucleus interactions and the axial coupling

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Neutrino-nucleus interactions play a role in (anti)neutrino scatterings off nuclei, nuclear beta and double beta decays, nuclear electron and muon captures, etc. These processes involve nucleons, protons and neutrons, and their (collective) conglomerates, the nuclei. Neutrino-nucleus interactions are driven by the weak neutral and charged currents, consisting of a vector and an axial-vector part. The vector part scales by the weak vector coupling g_V, and its value $g_V = 1$ is protected by the conserved vector current (CVC) hypothesis. The axial part is scaled by the weak axial-vector coupling g_A, with its quark-level value $g_A(quark) = 1$. At the nucleon level the value of g_A is, however, not so well protected by the partially conserved axial-vector current (PCAC) hypothesis, and in the decay of a free neutron its measured value turns out to be $g_A(nucleon) = 1.27$.

In nuclei an effective value $g_A(eff)$ has to be adopted for various reasons: (1) to take into account non-nucleonic degrees of freedom, (2) the deficiencies in the nuclear many-body models (too small single-particle valence spaces and/or restricted numbers of many-nucleon configurations and/or lack of three- and higher-body nucleon-nucleon forces) used to describe the neutrino-nucleon interactions at the nuclear level, and (3) omission of the meson-exchange two-body currents in the nucleon-nucleon interactions. For neutrino-nucleus scatterings in the low momentum-exchange regime (reactor, solar and supernova neutrinos, and sub-leading effects in the CEνNS) $g_A(eff)$ can be studied by surrogate processes like beta and two-neutrino double beta decays. For the accelerator neutrinos with momentum exchanges of few MeV the nuclear muon capture turns out to be a suitable surrogate. The recent reviews [1,2] shed light on these aspects of neutrino-nucleus interactions.

[1] J. T. Suhonen, Value of the axial-vector coupling strength in β and $\beta\beta$ decays: A review, Frontiers in Physics 5, 55 (2017).
[2] H. Ejiri, J. Suhonen, and K. Zuber, Neutrino-nuclear responses for astro-neutrinos, single beta decays and double beta decays, Physics Reports 797, 1-102 (2019).

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