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Point-Particle Catalysis

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In certain situations, a heavy compact object can serve to catalyze otherwise forbidden low-energy processes. A particularly clean example in particle physics is the nucleus-induced neutrino-less conversion of muons into electrons, mu + N -> e + N (forbidden by kinematics in the absence of the nucleus). This process is possible but highly improbable in the Standard Model, so it can act as a very sensitive probe of new physics. While several new experiments search for evidence of this phenomenon, I will explore the theoretical side here and show how this type of reaction is naturally contained in the simplest point-particle effective field theory (PPEFT) for two species of light particle. A PPEFT exploits the hierarchy of scales between the size of a nucleus and the long wavelength of the interacting light particles to efficiently parameterize the influence of short-distance physics on low-energy observables. Concretely, I will show how scattering cross-sections are simply controlled by a total of three length scales characteristic of the heavy compact object, which together contain all information about the high-energy physics involved, including any flavour-changing interactions. I will further note the connection between these length-scales and the various length-scales that characterize the influence of nuclei on atomic energy levels. Finally, I will briefly touch on how this relates to nuclei with internal degrees of freedom, and nuclear transfer reactions.

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