Bound muon lifetime

Saturday, 15 February 2025 19:30 (15 minutes)

Calculation of the free muon lifetime is a classical particle physics problem that was solved long time ago and its solution can be found in various textbook. Evaluation of the bound muon decay rate is significantly more complicated problem that requires a lot of laborious calculations and contains some non trivial physical effects as well. First calculation of the bound muon lifetime was done by Uberall [1] and invokes only non-relativistic approximation for the bound muon wave function and electron wave function was calculated up to second order in αZ. The correction to the free muon decay rate in this paper is then of the second order of αZ, which can be interpreted as relativistic time dilation. Subsequent calculations by Watanabe [2, 3] do not agree with the Uberall result. Watanabe numbers show that lower orders in αZ also contribute. In the present work, we derived analytical formula for the bound muon decay rate using exact muon and electron wave functions (to all orders in αZ) and obtained our own results by numerically evaluating the decay rate formula.

References
[1] H. Uberall, Decay of Mu- Mesons Bound in the K Shell of Light Nuclei, Phys. Rev. 119, 365-376 (1960).
[2] R. Watanabe, M. Fukui, H. Ohtsubo, and M. Morita, Angular Distribution of Electrons in Bound Muon Decay, Progress of Theoretical Physics 78, 114-122 (1987).
[3] R. Watanabe, K. Muto, T. Oda, T. Niwa, H. Ohtsubo, R. Morita, and M. Morita, Asymmetry and Energy Spectrum of Electrons in Bound-Muon Decay, Atomic Data and Nuclear Data Tables 54, 165-178 (1993).

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