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Relativistic Reduced-Mass and Recoil Corrections to Vacuum Polarization in Muonic Hydrogen, Muonic Deuterium and Muonic Helium Ions

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The reduced-mass dependence of relativistic and radiative effects in simple muonic bound systems is investigated. The spin-dependent nuclear recoil correction of order (Zalpha)^4 mu^3/m_N^2 is evaluated for muonic hydrogen and deuterium, and muonic helium ions (mu is the reduced mass and m_N is the nuclear mass). Relativistic corrections to vacuum polarization of order alpha (Zalpha)^4 mu are calculated, with a full account of the reduced-mass dependence. The results shift theoretical predictions. The radiative-recoil correction to vacuum polarization of order alpha (Z\alpha)^5 ln^2(Zalpha) mu^2/m_N is obtained in leading logarithmic approximation. The results emphasize the need for a unified treatment of relativistic corrections to vacuum polarization in muonic hydrogen, muonic deuterium and muonic helium ions, where the mass ratio of the orbiting particle to the nuclear mass is larger than the fine-structure constant.

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