Rigorous quantization of the Hamiltonian of ECE2 special relativity

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3 Computational and graphical analysis analysis

In Eq.(19) the gradient of $\gamma^2/(1+\gamma)$ is given for the Coulomb potential (20) which has no angular dependence in spherical coordinates. If the potential has a Z dependence exclusively, the gradient takes the general form:

$$\frac{d}{dZ}\left(\frac{\gamma}{1+\gamma}\right) = -\left(\frac{\frac{d}{d\,Z}\,\mathrm{U}\,(Z)}{m\,c^2\sqrt{1-\frac{2\,(H_0-\mathrm{U}(Z))}{m\,c^2}}} + \frac{2\,\left(\frac{d}{d\,Z}\,\mathrm{U}\,(Z)\right)}{m\,c^2}\right) \cdot \left(-\frac{2\,(H_0-\mathrm{U}\,(Z))}{m\,c^2} + \sqrt{1-\frac{2\,(H_0-\mathrm{U}\,(Z))}{m\,c^2}} + 1\right)^{-2} \tag{36}$$

with potential $U(Z)$.

The energy splitting of spin-orbit coupling has been demonstrated in Paper 332. In Hydrogen the spin-orbit splitting is small ($\approx 10^{-5}$ eV). In heavy atoms the splitting becomes high and the linear momentum is significantly larger than in Hydrogen. Therefore the A factor defined by Eq.(21) grows significantly, giving additional enlargement of splittings in Eq.(25). To demonstrate the effect, we plottet the A factor in dependence of a normalized p_0, i.e. a variable

$$\bar{p}^2 = \frac{p_0^2}{2m}, \tag{37}$$

see Fig. 1. The factor A goes to infinity for $\bar{p}$ reaching unity which corresponds to velocity $v_0 = c$. For comparison the gamma factor (5) is plotted. It is seen that A rises much faster than the relativistic gamma factor. An effect should be detectable in spectra of heavy elements.

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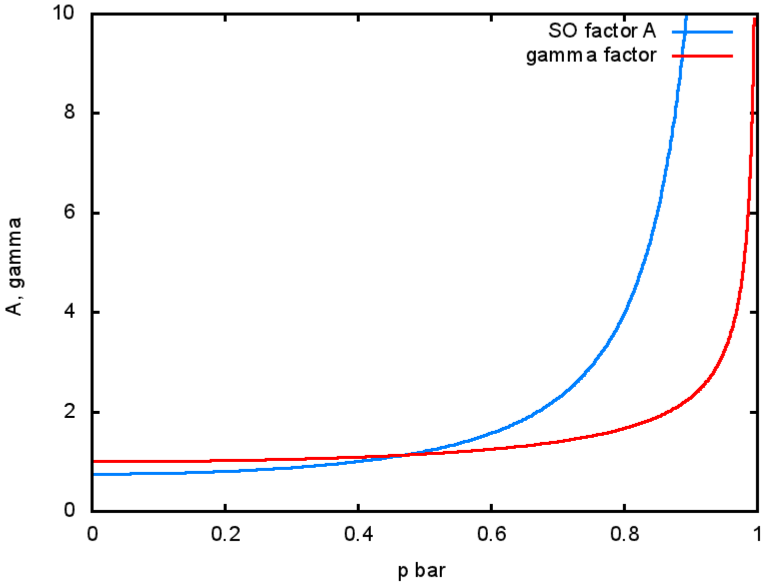

Figure 1: Functions $A(\bar{p})$ and $\gamma(\bar{p})$.