UNIVERSITÄT LEIPZIG

Experimental Physics IV IPSP

Problem Set 12

Problem 37: 2+2+1 points

The Lennard-Jones potential

$$V(r) = \varepsilon\left(\left(\frac{r_0}{r}\right)^{12} - 2\left(\frac{r_0}{r}\right)^{6}\right)$$

is a basic model to describe the interaction of two non-charged atoms.

a) Calculate the position $r_{\min}$ and the depth $V_{\min}$ of the minimum of the potential
b) Derive the Taylor series at the minimum $r_{\min}$ up to the second order (harmonic oscillator order) to obtain an approximate potential.
c) Draw a sketch of both potentials.

Problem 38: 4 points

Show, that the annihilation of an electron and a positron into a single photon in free space ($e^- e^+ \rightarrow \gamma$) violates the energy and/or momentum conservation.

How many photons do you need (at least) for this decay if the spin of the electron and positron are

a) anti-parallel ↑↓ ?
b) parallel ↑↑ ,

Use this to explain why positronium ("atom" which consists of an electron and positron) has two different lifetimes ($\tau_1 \approx 140\,\text{ns}$, $\tau_2 \approx 125\,\text{ps}$). Which annihilation corresponds to τ_1 and τ_2, respectively?