Phys106, II-Semester 2019/20, Assignment 7

Instructor: Sebastian Wüster

1. A photon an a particle have the same wavelength. Relate their linear momenta, relate photon energy and particle's total energy, relate photon energy and particle's kinetic energy.

2. Show that the de-Broglie wavelength of a particle of mass m with total energy $E_{\rm tot} \gg mc^2$ is approximately that of a photon with the same total energy.

3. Find the energy levels of a neutron in a one-dimensional box of size $L = 10$ fm. This corresponds roughly to the diameter of a nucleus. Discuss your results.

4. Find the de-Broglie wave-length of the objects below (treat the all non-relativistically). Discuss your results and expectations. Compare with the sizes of the objects.

   - An electron with velocity 1m/s.
   - An electron with velocity 5000m/s.
   - An proton with velocity $0.01c$.
   - A plane with mass $m = 150$ t and velocity 1000km/h.
   - A bacterium with mass $m = 10^{-12}$ g and velocity 50μm/s.

5. Consider the wave function $\Psi(x) = \mathcal{N} \sin(kx)$ if $|x| \leq L$ and $\Psi(x) = 0$ if $|x| > L$, where $L = 2\pi/k$.

   (i) Draw the wave function $\Psi(x)$, and its modulus.

   (ii) Find $\mathcal{N}$ so that the wave function is correctly normalized.

   (iii) Find the probability for the particle to be at $x > 0$.

   (iv) Find the probability for the particle to be in the region $a < x < b$, with $a = \pi/k$ and $b = L$.