

**Homework Set 1**

Instructor: Ralf W. Gothe

**1/17/24****1.1) There is Nothing as Certain as the Uncertainty**

- 1.1.1) [4] Express at least four uncertainty relations and their meanings!
- 1.1.2) [4] Which color have 2.11 eV photons and what is the smallest distance they can resolve?
- 1.1.3) [2] What is the smallest distance one can resolve in scattering 6 GeV electrons off a infinitely heavy target?
- 1.1.4) [4] Estimate from the typical size of an atom ( $10^{-10} m$ ) and a nucleus ( $10^{-14} m$ ) the needed binding energies! Explain why the results are meaningful even without knowing anything about the underlying forces!

**1.2) Spectroscopy with Electromagnetic Fields**

- 1.2.1) [4] Show why the magnetic field can be used as a momentum and the electric field as an energy filter!
- 1.2.2) [2] How can you determine the velocity of a particle of unknown but nonzero charge and mass?
- 1.2.3) [3] How can a particle travel on a straight line through a magnetic field? Name at least three scenarios!
- 1.2.4) [2] How can the charge-over-mass ratio of an unknown particle of unknown velocity be determined in a combination of magnetic and electric fields?

**1.3) The Hydrogen Atom**

- 1.3.1) [3] Rewrite the Coulomb potential energy in terms of  $\alpha$  and  $\hbar c$  and calculate it for an electron at  $r = 0.529 \cdot 10^{-10} m$  in a hydrogen atom.
- 1.3.2) [2] Calculate the kinetic energy of an electron localized in such a small spatial volume.  
[GS] Why is it half the potential energy?
- 1.3.3) [GS] [4] Calculate the potential energy by integrating the electric field energy density from  $r = 0.529 \cdot 10^{-10} m$  to  $\infty$ .