系所別：天文研究所　科目：近代物理

1. Explain the followings briefly
   (1) Stern-Gerlash experiment (5%)
   (2) Aharanov-Bohm effect (5%)
   (3) Normal Zeeman effect (5%)
   (4) Stefan-Boltzmann law (5%)

2. (i) (10%) Show that the scattered photon frequency through the Compton scattering with an electron can be written as

   $\nu' = \nu / [1 + (h\nu/m_e c^2)(1-\cos\theta)]$

   where ν is incident photon frequency; m_e is electron mass; θ is scattering angle (i.e. the angle between incident and scattered photons) and h is Planck constant.

   (ii) (5%) What is the maximum energy that can be transferred from photon to electron in a single Compton scattering?

3. (10 %) A pair of electron-positron can be generated through pair production by a pair of γ–ray photons with sufficient high energies (i.e. $\gamma + \gamma \rightarrow e^- + e^+$) in vacuum. Explain why the pair production can never be made by a SINGLE γ–ray photon (i.e. $\gamma \rightarrow e^- + e^+$) in vacuum even if the γ–ray photon has sufficient energy.

4. (15%)A beam of photons whose frequency is ν normally incidents on a mirror which is moving in the opposite direction of the incident photons with constant velocity V shown as Fig. 1. Find the frequency of reflected photons.

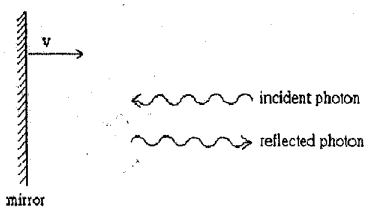

Fig. 1

5. (i) (5%)Find the eigenenergies and eigenfunctions of the non-relativistic one dimensional Schrodinger wave equation with infinite square well potential, that is

   $V(x) = 0 \quad -a < x < a$

   $= \infty \quad$ elsewhere

   (ii) (15%) A particle is in the ground state of the potential described in (i). Very suddenly the sides of the well are moving to $x = \pm b$ ($b > a$). What is the probability that the particle will be found in the ground state for the new potential? What is the probability that the particle will be found in the first excite state? In the latter case,

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the simple answer has a simple explanation. What is it?

6. (10%) Prove that the group velocity of a de Broglie wave for a free particle is identical to its classical velocity in both non-relativistic and relativistic cases.

7. (10%) Show that at T=0°K the average energy of non-interacting fermion gas is equal to 3/5 ε_F where ε_F is Fermi energy.