國立交通大學 107 學年度碩士班考試入學試題

科目：近代物理(4013)　　考試日期:107 年 2 月 1 日 第 3 節

系所班別：電子物理學系　　組別：電物系甲組　　第 / 頁,共 / 頁

【不可使用計算機】＊作答前請先核對試題、答案卷(試卷)與准考證之所組別與考科是否相符！！

共五題，合計 100 分

1. *Why* is Bohr's atomic theory referred to as the old quantum theory? (10%)

2. The following experiments challenged concepts of classical physics. For each experiment, *state* the experimental setups, the results, and the exploration.
   (a) The Franck-Hertz experiment. (12%)
   (b) The Stern-Gerlach experiment. (13%)

3. Suppose that light of total intensity 1.0mW/cm^2 falls on a clean Aluminum plate of 30.cm^2 in area. The spot size of the light is 3.0cm^2. Assume that the plate reflects 90% of the light and that only 6.63% of the absorbed energy lies in the violet region of the spectrum above the cutoff frequency.
   (a) *Find* the actual intensity available for the photoelectric effect. (5%)
   (b) Assuming that all the photons in the violet region have an effective wavelength of 250nm and one photon produces one electron, *calculate* the current in the phototube (in amperes). (5%)
   (c) *Find* the stopping voltage V_s for Aluminum if the photoelectrons are produced by the DUV light (λ=248nm). The work function ϕ for Aluminum is 4.1eV. (5%)
   Note: physical constants: h=6.63×10^{-34} Js, e=1.6×10^{-19} coulomb, and c=3.0×10^8 m/s; hc=1240 eVnm.

4. **3D simple harmonic oscillator (3D-SHO)**

   4.I. Consider a particle of mass m in a 3D simple harmonic oscillator whose Hamiltonian is given by $H_0 = \frac{p^2}{2m} + \frac{1}{2}m\omega^2\left(x^2+y^2+z^2\right)$. (20%)
   (a) *Find* the eigen energy of *the first excited states*.
   (b) *Find* the energy and degeneracy of the *second excited* states.

   4.II. Following the SHO-problem above, consider the initial wave function, $\Psi(x,t=0) = A\left[\varphi_{100}(x) + e^{i\frac{\pi}{4}}\varphi_{200}(x)\right]$, prepared at $t=0$ in the 3D-SHO system, where $\varphi_{100}(x)$ denotes the wave function of the *ground state* and $\varphi_{200}(x)$ is that of one of the *first excited states*. (15%)
   (c) *Find* the normalization constant A.
   (d) *Write down* the general expression for the *time-dependent* wave function at any later time instant, $\Psi(x,t)$.

5. **Operators**

   The hermitian conjugate (or adjoint) of an operator $\hat{A}$ is the operator $\hat{A}^\dagger$ such that
   $$\langle f|\hat{A}g\rangle = \langle \hat{A}^\dagger f|g\rangle \quad \text{(for all wave functions } f \text{ and } g\text{)}.$$
   An operator is hermitian if $\hat{A} = \hat{A}^\dagger$.
   Accordingly, *show* that the linear momentum operator $\hat{p} = \frac{\hbar}{i}\frac{d}{dx}$ is hermitian. (15%)