PROBLEMAS DO CAPÍTULO 19

Problems

1. Calculate the cross section for the emission of a photoelectron ejected when linearly polarized monochromatic light of frequency ω is incident on a complex atom. Simulate the initial state of the atomic electron by the ground state wave function of an isotropic three-dimensional harmonic oscillator and the final state by a plane wave. Obtain the angular distribution as a function of the angle of emission and sketch it on a polar graph for suitable assumed values of the parameters.

2. Calculate the total cross section for photoemission from the K shell as a function of the frequency of the incident light and the frequency of the K-shell absorption edge, assuming that $\hbar\omega$ is much larger than the ionization potential but that nevertheless the photon momentum is much less than the momentum of the ejected electron. Use a hydrogenic wave function for the K shell and plane waves for the continuum states.
3. By considering the double commutator
$$[[H, e^{i\mathbf{k}\cdot\mathbf{r}}], e^{-i\mathbf{k}\cdot\mathbf{r}}]$$
obtain as a generalization of the Thomas-Reiche-Kuhn sum rule the formula
$$\sum_n (E_n - E_s)|\langle n|e^{i\mathbf{k}\cdot\mathbf{r}}|s\rangle|^2 = \frac{\hbar^2 k^2}{2m}$$
Specify the conditions on the Hamiltonian H required for the validity of this sum rule.
4. A charged particle moving in a linear harmonic oscillator potential is exposed to electromagnetic radiation. Initially, the particle is in the oscillator ground state. Discuss the conditions under which the electric dipole–no retardation approximation is good. In this approximation, show that the first-order perturbation value of the integrated absorption cross section is equal to the sum of dipole absorption cross sections, calculated exactly.
5. For the system described in Problem 4, derive the selection rules for transitions in the electric quadrupole approximation, which correspond to retaining the second term in the expansion (19.64). Calculate the absorption rate for quadrupole transitions and compare with the rate for dipole transitions.