Atomic and Molecular Physics (2 ECTS)

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I. Molecular Physics

An introduction to molecular physics and molecular spectroscopy

Chapter 1: **Diatomic Molecules**

- Molecular Hamiltonian, the molecular frame;
- Born-Oppenheimer approximation ;
- Vibration and rotation: rigid rotor harmonic approximations;
- Improvements to the approximations, vibration-rotation interactions;
- Hund's coupling cases ;

Chapter 2**: Spectra of Diatomic Molecules**

- Transition Matrix Elements and selection rules (electric dipolar transitions);
- Rotational transitions ;
- Vibrational-Rotational transitions ;
- Electronic transitions, Franck-Condon principle ;

II. Atomic physics of internal states

An introduction to X-ray and Auger spectroscopy - Moseley's Law

Chapter 1: **Atomic Structures of Internal States**

- One-electron system: Bohr model and scaling law - Schrödinger equation (wave function and energy) - Dirac equation (relativistic effects and spin-orbit interaction) - H-like applications;
- Two electron system: Hamiltonian - Perturbative theory and variational method - Coupling scheme (LS and jj) - He-like applications;

N-electron atom: Independent electron model - Thomas Fermi's model and 1/Z theory - Slater's semi-empirical model

Chapter 2: **Radiatives Transitions : X-rays**

- Classification of transitions (neutral atom and multi-charged cases) ;
- Exact and approximate selection rules - Multipolar transitions - Application to H-like and He-like ;
- Transition probabilities and lifetime - Scaling laws - Application to H-like and He-like atoms;

Chapter 3: **Non-radiative transitions: Auger electrons**

- Nomenclature of transitions;

- Energy calculations using the Slater model;
- Probability of non-radiative transitions - total and partial widths - fluorescence yield and Auger yield