SPH 625: Spectrophysics

(Instructor: Dr Angeyo H. Kalambuka)

Scope

In this course we discuss how observations of atomic and molecular spectra can be related to the environment (chemical and structural) of the emitting and/or absorbing particles (atoms, ions, molecules, clusters); with particular applications to laser spectroscopy and to atomic physics in hot plasmas (also called *plasma spectroscopy*). We describe the relations between the structure of atoms and simple molecules (diatomic and polyatomic) and their spectra, including complex atoms, which are not normally covered in basic texts. We then treat the effects of temperature, density, pressure, collisions with other particles, etc. Finally we describe and compare the experimental methods of spectroscopy, from microwave to far-UV regions, and address selected important practical matters in analytical spectroscopy such as sources, detectors, instrumentation, wavelength and intensity calibration, signal-to-noise ratio, etc.

Content

Thermodynamic equilibrium. Temperature: Maxwell velocity distribution. Planck's law for radiational energy density of a black body. Boltzmann occupation of atomic and ionic internal energy levels. Saha equations for ionization equilibrium. Radiation Parameters: Einstein A and B transition probabilities - relationship with line strength and oscillator strength, intensity, radiance, radiation density. Population of energy levels: collisional excitation and deactivation, radiational excitation and decay, dissociation of molecules, ionization. Spectral Line Profiles: Natural broadening – Lorentz profile, thermal motion, Doppler broadening and Gaussian profiles. Convolution of line profiles, Voigt profile from the convolution of a Lorentz or Gaussian profile. Line broadening mechanisms. Many atom system levels. Vibrational states. Band structures. Vibrational temperatures. Molecular orbitals. Molecular spectroscopy. Plasma diagnostics. Spectroscopic temperature measurement techniques. Electron density determination. Spectroscopic Instrumentation: Lab radiation sources. Spectrometer configurations. Radiation detectors and measurement systems. Spectroscopic techniques: Atomic emission, absorption and fluorescence.

Outcome

To skill students at an advanced level in the theoretical concepts, techniques and methods needed in analytical atomic and molecular spectroscopy, particularly plasma-source spectroscopy laser spectroscopy and molecular dynamics research techniques.

Strength: 45 hours

Examination	1 (out of 70 marks)
CATS	2 (out of 15 marks) in week 7 and 11
Tutorials	2 (out of 15 marks) in week 4 and 8

Recommended Texts

1. **Spectrophysics: Principles and Practice** by Anne P. Thorne, U. Litzén and S. Johansson
2. Spectra of Atoms and Molecules by P. F. Bernath
3. Laser Spectroscopy by W. Demtröder
4. Molecular Spectroscopy by I. N. Levine
5. Radiative Processes in Atomic Physics by V.P. Krainov, H. Reiss and B. Smirnov

Prerequisites

1. Atomic Physics
2. Quantum Mechanics