Overview

This course aims to provide the theory and practical experience in making measurements of thermodynamic parameters by using the spectral distribution of light. We will present the theoretical foundations for spectroscopic measurements of temperature, pressure, and concentration, including structure of matter, nature of light, statistical mechanics, and matter/light interactions. After these foundational topics, basic applications of emission spectroscopy, absorption spectroscopy, and fluorescence will be covered. A basic review of practical optics will be conducted, followed by a more detailed coverage of instrumentation for spectroscopic measurements, with a hands-on component. Scattering theory and non-linear optics will be reviewed, followed by a discussion of Rayleigh scattering and Raman scattering.

Topics Covered:

Fundamental Physics


Measurement of Light


7) **Optical Instrumentation:** Detector types for different wavelength ranges. Optical materials. Photon statistics, NEP, signal to noise considerations, array detectors: CCD, CMOS, InGaAs, MCT, microbolometer, etc. Aligning a monochromator. Converting images to spectra. Wavelength and intensity calibration.

8) **Light Sources:** incandescent, arcs, sparks, LEDs, infrared sources, argon candle. Laser theory. Laser types: solid state, semiconductor, gas. Nd:YAG, dye, HeNe, excimer, diode, QCL, Ti:sapphire, etc.

Spectroscopic Measurements


12) **Spectroscopic scattering diagnostics.** Raman spectroscopy, Rayleigh scattering, filtered Rayleigh scattering, CARS. Practical Raman spectroscopy: fast spectrometers, notch filters, time-gating, signal augmentation techniques.

**Conduct of the Course:**

3 hours lecture (4th hour for graduate students available as special project). Weekly homework. Mid-term exam. Final exam. Laboratory projects.
Grade Distribution:

Homework 20%, Mid-term Exam: 25%  Final Exam: 30%  Project 25%

Some Helpful Texts (you don’t need them, but I’ll draw a lot from them):

Two most relevant:


Probably the text that I’ll draw most material from for the class. Laurendeau was an optical diagnostics pioneer, and his text is less stat thermos, and more preparation for diagnostics. Covers quantum, stat mech, light interactions, and a decent coverage of laser diagnostics.


Another very good self contained book that doesn’t get a lot of love in the field, but I like it. Fills in some detail to supplement Laurendeau. Table of contents reads a lot like the class syllabus.

Good Supplemental Sources:


Great text that covers almost everything in the course. Out of print, and expensive if you find a copy. But a spectacular work.


On the spectroscopy side, there’s probably no better text than this small work by Piotr Bernath who is a king in the field.


Another pretty good work on laser diagnostics for combustion. Modern.