

Radiative Processes (GR6001) - Fall 2021

General Information:

Instructor: Prof. Zoltan Haiman

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Classes: Held MW, 2:40pm-3:55pm in 401 Chandler

Main Goal: to develop a fairly rigorous background in understanding the generation, propagation, and transfer of electromagnetic radiation – in contexts relevant to various branches of astrophysics.

Prerequisites: introductory quantum mechanics, special relativity, thermodynamics, electrodynamics, (vector) calculus, differential equations, and basic statistical mechanics.

Textbook: *Radiative Processes in Astrophysics*, by George B. Rybicki & Alan P. Lightman (Wiley, 1979). We will follow this book very closely. In addition, we may occasionally use *The Physics of Astrophysics Vol. I : Radiation* by Frank Shu.

Problem Sets: Approximately 8 problem sets will be handed out.

Exams: There will be a 1-hour midterm (in class, tentatively on Nov. 3) and a final (3-hr, to be scheduled by registrar).

Grading: Homework (40%), Final (30%), Midterm (20%), Participation (10%)

The above is tentative and subject to change. Your inputs are welcome!

Tentative Syllabus

1. Introduction and Radiative Transfer

Definitions and Basic Properties of Radiation
Black-Body Radiation
Photon vs. Wave Approaches
Emission, Absorption, Scattering
Radiative Transfer Equation
Basic Applications

2. Classical Theory of Radiation Fields

Maxwell's Equations
Plane Waves
Polarization
Potentials
Limit of Validity of Classical Description

3. Generating Radiation in Vacuum

Retarded Potentials
Dipole Approximation/Multipole Expansion
Radiation from Nonrelativistic Moving Charges
Rayleigh/Thomson Scattering
Bremsstrahlung
Cyclotron
Radiation from Relativistic Charges
Compton Scattering
Bremsstrahlung
Synchrotron
Inverse Compton

4. Interaction of Matter with Radiation

Plasma Effects
Dispersion
Faraday Rotation
Cherenkov Radiation
Atomic Processes
Atomic Structure
Radiative Transitions

Line Broadening Mechanisms

Curve of Growth

Line Radiative Transfer

Molecular Processes

Molecular Structure

Born Approximation

Rotation, Vibration, Electronic States

Hydrogenic Molecules

More Complex Molecules

5. Miscellaneous Topics

Gravitational Radiation

Gravitational Lensing

Radiative Transfer in Cosmology

Cosmic Microwave Background

Recombination of H and He

Continuum and Line Transfer in Expanding Media