ASTRONOMY 380E – FALL 2010
RADIATIVE PROCESSES AND RADIATIVE TRANSFER

Unique No. 47770

Course Web Page

Course information, including homework assignments, solutions, and lecture notes, will be made available within the University's Blackboard Learning System: https://courses.utexas.edu

Instructor

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COURSE OBJECTIVES

This is a graduate course designed to lay the foundations of radiative processes and transfer in the astrophysical context. Radiative processes entail the interaction of charged particles, neutral and ionized atoms, molecules, and dust particles with radiation. Radiative transfer entails mathematical and computational modeling of the propagation of radiation fields in diffuse media, such as stellar atmospheres, the intergalactic and interstellar medium, and the universe as a whole. Key results will be derived from the first principles and applications relevant to current research topics will be discussed. The course also provides training in the skill of estimating the relative magnitude of physical effects without deriving the rigorous mathematical result (the so-called "order-of-magnitude" approach).

PREREQUISITES, LECTURES, OFFICE HOURS, AND STUDENTS WITH DISABILITIES

Prerequisites

This is a graduate course without formal prerequisites, but undergraduate preparation in electromagnetism and quantum mechanics for physics or astronomy majors is assumed.

Hours and Venue

The class meets in Robert Lee Moore Hall (RLM) 15.216b on Mondays, Wednesdays, and Fridays at 10:00 – 10:50 a.m.

Office Hours

Instructor office hours: Mondays 2-3 p.m., or by appointment, in RLM 17.214.

Students with Disabilities

Students with disabilities may request appropriate academic accommodations from the Division of Diversity and Community Engagement, Services for Students with Disabilities, 471-6259.

REQUIRED AND RECOMMENDED TEXTS[1]

Required Textbook

Radiative Processes in Astrophysics, by George B. Rybicki and Alan P. Lightman (Wiley-VCH)

Other Useful References for this Course

Radiative Transfer:

Foundations of Radiation Hydrodynamics, by Dimitri Mihalas and Barbara Weibel-Mihalas (e.g., Dover)

This is a classic, comprehensive reference on radiative transfer.

An Introduction to Radiative Transfer, by Annamaneni Peraiah (Cambridge University Press)

This is a comprehensive reference on radiative transfer with an emphasis on mathematical solutions.

The Interaction of Charged Particles with Radiation:

Classical Electrodynamics, 2nd Edition, by James D. Jackson (Wiley)

This is a comprehensive reference on the interaction of charged particles with radiation from the standpoint of classical physics.

Electromagnetic Processes, by Robert J. Gould (Princeton)

This is an advanced reference on the interaction of charged particles with radiation from the standpoint of quantum physics.

The Interaction of Atoms, Molecules, and Dust Grains with Radiation:

Astrophysics of Gaseous Nebulae and Active Galactic Nuclei, *1st or 2nd Edition*, by Donald E. Osterbrock [and Gary J. Ferland, in 2nd Edition] (University Science Books)

This is a classic reference on the interaction of radiation with the interstellar medium.

The Interstellar Medium, by James Lequeux (Springer)

This is a reference on radiative processes in the interstellar medium.

The Physics of Interstellar Dust, by Endrik Krügel, (Institute of Physics)

This is a reference on the interaction of radiation with dust grains.

Physics of Atoms and Molecules, 2nd Edition, by B. H. Bransden and C. J. Joachain (Benjamin Cummings / Prentice Hall / Harlow)

This is a comprehensive reference on the interaction of radiation with atoms and molecules.

[1] Since most texts have multiple printings, this list omits years of publication.

PREPARATORY READING, ATTENDANCE, EXAMS, AND GRADING

Preparatory Reading

Advance reading from the required textbook, *Radiative Processes in Astrophysics*, by Rybicki and Lightman, of from handouts, will be assigned for each lecture. A fraction of each lecture period will be devoted to discussion of the reading assignments, thus this form of preparation will be critical for effectiveness of the course and for a student's success in the course.

Exams

There will be 2 in-class exams and an open book take-home final exam. Please see the course schedule at the end of the syllabus for the dates of the in-class exams.

Homework

Problem sets will be assigned biweekly.

Attendance

Attendance of lectures is required. While lectures notes and other material may be provided and posted in Blackboard, in-class note taking is strongly recommended.

Calculation of the grade

Component	Percentage of Grade
Attendance	10%
Classroom Discussion	10%
Homework Assignments	30%
Two In-Class Exams	30%
Take-Home Final Exam	20%

Score Range[2]	Grade[3]
90 – 100	A
80 – 89	B
70 – 79	C

[2] These criteria may be relaxed at the midpoint of the course.
[3] Fractional grades may be assigned.

SCHEDULE

Lecture	Date	Day	
1	August 25	W	Introduction to the Course
2	August 27	F	Radiation Field
3	August 30	M	Radiation Transfer
4	September 1	W	Thermal Radiation
5	September 3	F	Absorption, Emission, Scattering
			~ Labor Day ~
6	September 8	W	Methods of Continuum Transfer
7	September 10	F	Methods of Continuum Transfer
8	September 13	M	Numerical Methods
9	September 15	W	Line Transfer
10	September 17	F	Methods of Line Transfer
11	September 20	M	Methods of Line Transfer
12	September 22	W	Numerical Methods
13	September 24	F	Electromagnetic Waves
14	September 27	M	Electromagnetic Polarization
15	September 29	W	**First In-Class Exam**
16	October 1	F	Radiation from Newtonian Moving Charges
17	October 4	M	Review of Special Relativity
18	October 6	W	Fields of Relativistic Moving Charges
19	October 8	F	Emission from Relativistic Particles
20	October 11	M	Bremsstrahlung
21	October 13	W	Synchrotron Radiation
22	October 15	F	Compton Scattering
23	October 18	M	Compton Scattering
24	October 20	W	X-Rays and Gamma Rays
25	October 22	F	Plasma Effects
26	October 25	M	Review of Atomic Structure
27	October 27	W	**Second In-Class Exam**
28	October 29	F	Review of Atomic Structure
29	November 1	M	Radiative Transitions
30	November 3	W	Radiative Transitions
31	November 5	F	Line Broadening
32	November 8	M	Lyman-α Radiation
33	November 10	W	21 cm Radiation
34	November 12	F	Radiation in an Expanding Universe
35	November 15	M	Molecular Structure
36	November 17	W	Interaction of Radiation with Molecules
37	November 19	F	Interaction of Radiation with Molecules
38	November 22	M	Dust Grains
39	November 24	W	Interaction of Radiation with Dust Grains
			~ THANKSGIVING ~
40	November 29	M	Selected Applications
41	December 1	W	Selected Applications
42	December 3	F	Review