Astro 501: Radiative Processes

Lecture 1

Jan 14, 2013

Announcements:

• Welcome!
• Pick up syllabus

Today's Agenda

⋆ Overview and Appetizer
⋆ Course Mechanics
⋆ Radiation Transfer

Welcome! ...and Introductions

Radiative Processes: Overview

radiative processes: tools to address fundamental questions

⋆ given an astrophysical system, how will it look?

⋆ given how an observed astronomical object looks
i.e., given an *image* and/or *spectrum*
what is the nature of the physical system?

radiative processes *link*
astrophysical systems with **astronomical observables**

so: we'll spend the semester at
the heart of astronomy and astrophysics!

New Year's Resolution: Astrophysical Workout

this is a "**tools**" course

$\rightarrow$ builds *astro-muscles*: *intuition, estimation, analysis*

all are crucial for our line of work

$\rightarrow$ you want to finish this course "radiatively buff"

can show off at the beach or at summer conferences

of course: to get fit, need to sweat a little!

adopt and keep a consistent workout regime

$\rightarrow$ lots of exercises = problem sets

But wait! There's more!

bonus: getting fit pays off

- conceptual depth and technical ability:
  skills to play the game well
- looks good and shows value to advisors,
  collaborators, search committees

bonus: radiative processes is a beautiful subject!

- covers many areas of physics and astrophysics
  E&M, quantum mechanics, statistical mechanics, relativity ...
  ...and of course a lot of astronomy
- excellent opportunity to learn/review, synthesize these topics
- radiation inherently relativistic = cool
- BDF extra: multimessenger radiative processes *Q: whazzat?*

Methods to the Madness

My goals: you will come away knowing:

⋆ how to assess what a system will look like
spatially and across the EM spectrum

⋆ the physics and astrophysics of the
underlying emission, absorption, scattering processes

⋆ the detailed spectra arising from idealized
examples of radiating systems, and how these arise

⋆ how to calculate spectra for realistic systems

⋆ how to interpret and analyze spectra
and to infer underlying physical properties

Appetizer: The Multiwavelength Sky

The Big Picture: All-Sky Views

survey sky in different bandpasses/lines

course goal: understand qualitatively and quantitatively

- what are the main sources of emission?
  i.e., what object(s) are emitting? by what mechanism(s)?
- why does the image look the way it does?

www: optical, microwave, radio continuum, 21 cm, infrared, X-ray, 1.809 MeV, > 100 MeV

Decoding and Diagnosing Spectra

⋆ a Sun-like star

Q: optical around 6563Å? UV? IR?

`www: spectra`

⋆ galaxy cluster

Q: microwave? X-ray?

`www: spectra`

⋆ ionized gas cloud (H II region)

Q: optical?

`www: spectrum`

⋆ mystery objects

`www: optical spectra`

Q: what are they?

Syllabus

Course Mechanics

Homework 70% of course grade
to build and keep your radiative muscles
need regular workouts

- 11 problem sets, drop lowest score
- collaboration fine, but...
  you must write and fully understand you own answers!

Midterm 10% of course grade

- “fitness test”
- **not** collaborative!

Final Exam 15% of course grade
to encourage you to synthesize entire course material

- comprehensive, but weighted to post-midterm
- **not** collaborative!

Q: what’s missing?

Class Participation 5% of course grade

Science is collaborative! Communication is essential!

I like to ask many Socratic *Q: whazzat?* questions

- to receive full credit, *I need to hear from* you in class about $\sim 1/N_{\text{students}}$ of the time
- "participation" counts both answers to my questions, but also questions of yours
- correctness not required, engagement is

Prerequisites

Formally: ASTR 404, Stellar Astrophysics
includes most of the physics and astronomy we'll need

Really: we will develop most of the course from "*first-ish* principles," so you just need the principles

you need to have seen (or come up to speed on)

- E&M, including comfort with Maxwell's equations
- elementary quantum mechanics, e.g., Bohr hydrogen atom, basics of wavefunctions, distinction between fermions and bosons
- basic thermal physics: e.g., Thermodynamic Laws 0 thru 3, Boltzmann distribution
- basic special relativity: e.g., Lorentz transformations

I know most of you and know you are good to go
If you are unsure/nervous about the prerequisites
please talk to me after class!

Course Texts

George Rybicki and Alan Lightman

Radiative Processes in Astrophysics, Wiley (1979, reprinted 2004)

Recommended. A classic, with an excellent treatment of the fundamentals that does not show its age. Much of the lecture material and homework will follow this book.

Bruce Draine

The Physics of Interstellar Matter, Princeton (2011)

Recommended. Complements Rybicki & Lightman with an updated choice of topics and discussion of observations, and a broader discussion of astrophysics. We will also draw on this for lectures and homework.