Astronomy 501: Radiative Processes

Lecture 1

Aug 27, 2018

Announcements:

- Welcome!
- Pick up syllabus

Today's Agenda

⋆ Overview and Appetizer

⋆ Course Mechanics

⋆ Cosmic Messengers

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!

Academic New Year's Resolution: Astrophysical Workout

this is a "**tools**" course

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

all are crucial for our line of work

$\longrightarrow$ 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

$\longrightarrow$ 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!

- combines much of physics and astrophysics
  E&M, quantum mechanics, statistical mechanics, relativity ...
  ...and a lot of astronomy
- excellent opportunity to learn/review, synthesize these topics
- radiation inherently relativistic = cool
- now also: 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

observational astronomy: map the sky (at great cost)
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,` > 1 `GeV`

Decoding and Diagnosing Spectra

Pre-test: guess the spectra

⋆ a Sun-like star
Q: optical around 6563Å? UV around 3950Å? IR?

⋆ a planetary nebula: Ring
Q: what's that? optical spectrum?

⋆ galaxy cluster
Q: optical? X-ray? microwave?

⋆ ionized gas cloud (HII region)
Q: optical?

⋆ mystery spectra
Q: what are the sources?

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

Bruce Draine

The Physics of Interstellar Matter, Princeton (2011)

Required.

"I wish I'd bought a copy when I took 501."

– Advanced Grad Student

George Rybicki and Alan Lightman

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

"*Recommended.*"

Free (personal use) pdf posted on Compass