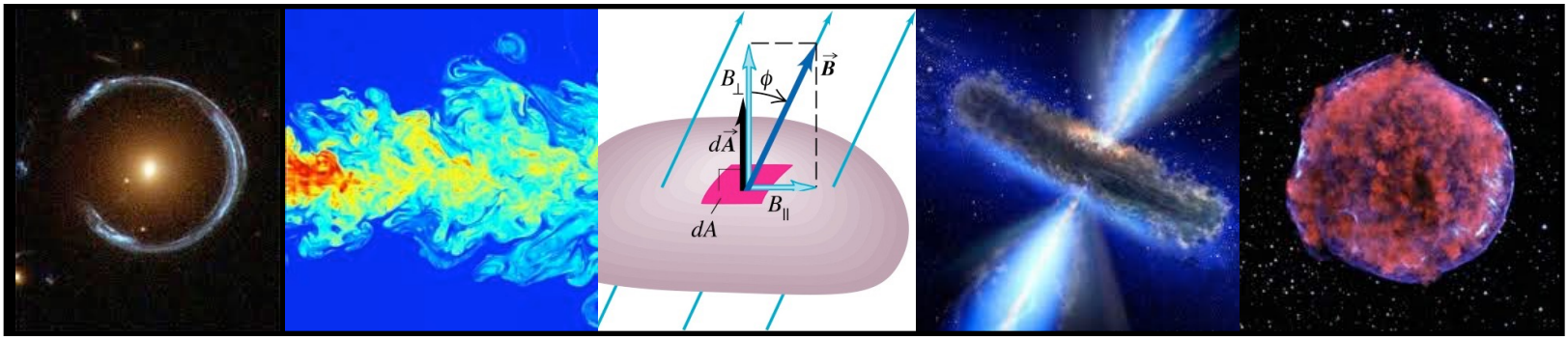
ASTRO 320; Spring Semester 2023
Physical Processes in Astronomy



Course Description

This course discusses physical processes relevant for astrophysics and consists of three main parts. Part I covers fluid dynamics. We will derive the continuity, momentum & energy equations, discuss hydrostatic equilibrium, viscous flows, fluid instabilities, equations of state, shocks, turbulence and focus on various astrophysical applications such as stellar structure and accretion disks. Part II deals with collisionless fluids. We will discuss potential theory and the viral theorem, introduce the collisionless Boltzmann equation from which we derive the Jeans equations, and study some applications of collisionless dynamics, including dynamical friction and impulsive shocks. Finally, in Part III, we address radiation. We discuss both thermal and non-thermal emission mechanisms, study the interaction of radiation and matter, and delve into radiative transfer.

Instructor: Prof. Frank van den Bosch (52 Hillhouse, Office: 320)
frank.vandenbosch@yale.edu

Course Website: https://campuspress.yale.edu/astro320/

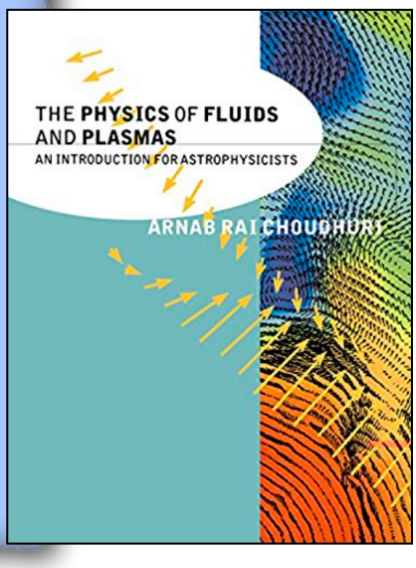
Lecture Hours: Tue & Thu: 9.00 - 10.15pm Location WTS B60

Office Hours : Wed: 4.00-5.00 pm Location 52HH#320

Recommended Textbook: The Physics of Fluids and Plasmas: An Introduction for Astrophysicists

Grading: 35% Final Exam
30% MidTerm Exam
35% Problem Sets

Lecture Format: Blackboard presentations + detailed lecture notes



Preliminary Schedule

week	Date	Topic
1	Tue 01/17	Fluid Dynamics: introduction
1	Thu 01/19	Fluid Dynamics: Dynamical Treatments of Fluids
2	Tue 01/24	Fluid Dynamics: Hydrodynamics Equations for Ideal Fluids
2	Thu 01/26	Fluid Dynamics: Viscosity, Conductivity & The Stress Tensor
3	Tue 01/31	Fluid Dynamics: Hydrodynamics Equations for Non-Ideal Fluids
3	Thu 02/02	Fluid Dynamics: Equations of State (ideal gas, photon gas & degenerate EoS)
4	Tue 02/07	Fluid Dynamics: Vorticity & Circulation
4	Thu 02/09	Fluid Dynamics: Hydrostatics and Steady Flows
5	Tue 02/14	Fluid Dynamics: Viscous Flow and Accretion Flow
5	Thu 02/16	Fluid Dynamics: Turbulence
6	Tue 02/21	Fluid Dynamics: Sound waves
6	Thu 02/23	Fluid Dynamics: Shocks
7	Tue 02/28	Fluid Dynamics: Instabilities
7	Thu 03/02	Collisionless Dynamics: Collisionless Boltzmann Equation & Jeans Equations
8	Tue 03/07	Collisionless Dynamics: Orbit Theory, Integrals of Motion & Jeans Theorem
8	Thu 03/09	**MIDTERM EXAM**
9	03/13-03/17	**SPRING BREAK — NO CLASSES —**
10	03/20-03/24	**SPRING BREAK — NO CLASSES —**
11	Tue 03/28	Collisionless Dynamics: Virial Theorem & Gravothermal Catastrophe
11	Thu 03/30	Collisionless Dynamics: Collisions & Encounters of Collisionless Systems
12	Tue 04/04	Radiative Processes: The Interaction of Light with Matter I. Scattering
12	Thu 04/06	Radiative Processes: The Interaction of Light with Matter II. Absorption
13	Tue 04/11	Radiative Processes : The Interaction of Light with Matter III. Extinction
13	Thu 04/13	Radiative Processes: Radiative Transfer
14	Tue 04/18	Radiative Processes: Thermal Equilibrium and the Saha Equatio0n
14	Thu 04/20	Radiative Processes: Continuum Emission Processes I
15	Tue 04/25	Radiative Processes: Continuum Emission Processes II
15	Thu 04/27	**Q&A**

The Road To Success

This course will make use of **vector calculus** and **multi-variable calculus**, and the students are expected to be familiar with this. Appendices **A**-**E** in the lecture notes summarize these materials, and the students are strongly encouraged to read these Appendices in detail. Also, Problem Set 0 (not graded) will test the student's ability with these topics.

➢ Attend **lectures**, and actively participate; ask questions in class!

➢ Carefully read **Lecture Notes** on related material, either before or after class. Study the relevant material using text books, internet etc. (**self-study**)

➢ Seek **help** from instructor
(after class, during office hours, or by arranging for an appointment via e-mail)

➢ **Problem Sets**:

* submit problem sets on time (points will be subtracted for late submissions)
* explain how you came to the solution (derivations), and use words/text to explain your line of thoughts. Failure to do so results in points being subtracted.
* Write clearly and neatly: if I can't read it, I won't give points for it.
* When working on the problem sets, you may consult your fellow students. However, when it comes to writing the solution down, you must do so all by yourself.