Introduction to Astronomy and Astrophysics

Lecture 1

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Course Website

http://www.ncra.tifr.res.in/∼yogesh/introastro2024/

Best way to reach me is by email at *yogesh@ncra.tifr.res.in*
The PDF file for each lecture will be put on the website immediately after it is given. So, don't bother copying stuff that is already on the slide.

Course will be in classroom mode

Lectures will be live in the NCRA Lecture Hall. There will be a total of 14 lectures over 7 weeks, each of 1 hour duration.

Introductions

Circulate sheet for names and email addresses

Assessment

- 25% weightage for mid-term written exam
- 50% weightage for end-term written exam
- 25% for class participation. Asking and answering questions

I don’t like to give exams

However, recent advances in generative AI technologies have made assignments impractical.

Mid term and End term exam

These will a closed book exam with a number of short questions to test your conceptual understanding. Duration: 1 hour for the mid-term and 2 hours for the end-term.

The official syllabus

Earth-solar system - The Sun as a star - Stellar structure and evolution - The HR diagram - Colours, magnitudes, Spectral classification - White dwarfs, neutron stars, black holes - Binaries - ISM - Structure of Milky Way - Stellar population and galactic structure - Cosmology - Brief description of Galaxy morphology and evolution - Active Galaxies - Clusters of Galaxies.

This syllabus is 25 years old and astronomy has changed a lot. I will place greater emphasis on topics that are actively researched in our two institutions. Many recent areas - Gravational waves, FRBs, Extrasolar planets etc. not covered in the syllabus.

This course has linkages to all your 7 other astronomy courses

The goal of this course is to give you a broad overview of all the sub fields of modern astronomy and to introduce the jargon and *methodology* of the subject.

Textbooks and reference material

Unfortunately, I cannot find one textbook that is both comprehensive and current for our purposes. I will put up a list of books that I am refering to that you may also find useful, on the website. This list is likely to grow as the course progresses.
I put in a lot of effort to make good slides for my talks. Use these as your primary reference material and remember to stop me and ask questions if you don't understand something. Some of the slides will cite papers which you are encouraged to read to know more.

Questions about the course content and organisation?

Astronomy is the oldest science

Which astronomical discoveries occurred the earliest and why?

Modern astronomy can be traced to the invention of the telescope around 1610.

What is the difference between astronomy and astrophysics?

Is there any difference in today's context?

Astronomy is the last refuge of generalists

Various field of physics are involved - nuclear physics, atomic and molecular physics, quantum mechanics, relativity (special and general), newtonian gravity, electromagnetism and associated radiative processes, fluid mechanics, solid state physics, gravitational wave physics, early universe physics, plasma physics, acoustic waves, optics, thermodynamics.
This means that to do astrophysics well, expertise is needed in several branches of physics.

Fundamental cheat sheet for astrophysics

- Every unknown law is a power law
- Every unknown power law index is ± 0.5
- Every unknown scaling coefficient is 0.1
- $A = kB^{\alpha}$, or $A = 0.1B^{\pm 0.5}$

But remember, this power law cannot operate at all value of B

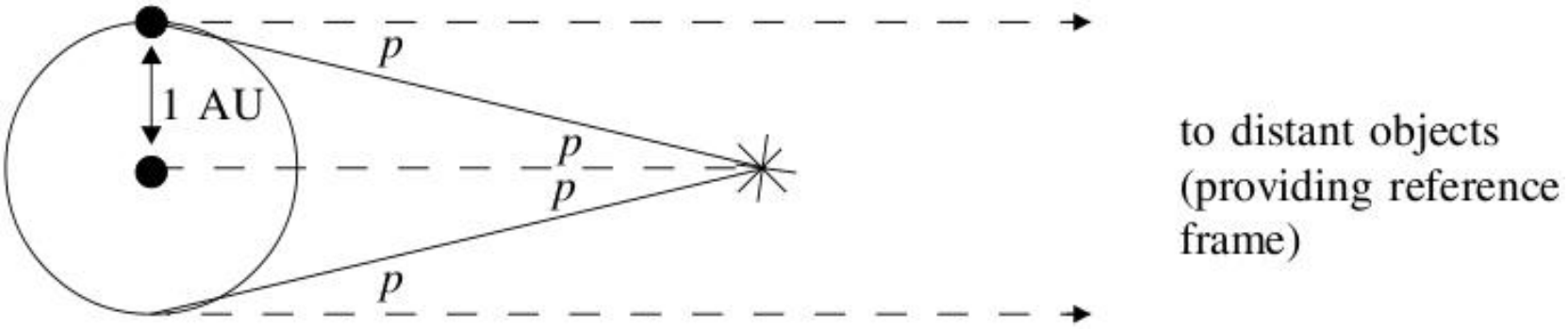
A quick tour of the Universe

See Powers of Ten video
https://www.youtube.com/watch?v=0fKBhvDjuy0

Light Year

Distance that light travels in a year - 9.461×10^{12} km.
One AU $\sim$ 8.33 light minutes
Nearest star - 4.2 light years
Diameter of Milky Way - $\sim$ 1 Lakh light years

Parallax second (parsec)



If $p = 1$ arcsec, distance to the star is one parsec. How much is a parsec in AU units? The nearest star is 1.3 parsec away. If the earth-sun distance were 1 meter, how far away is the nearest star? The galactic center is 8 kpc away. How far is that?

Some more **luminosity distances**

- Andromeda galaxy: $\sim$ 780 kpc
- Virgo cluster: $\sim$ 16.5 Mpc
- Coma cluster: $\sim$ 99 Mpc
- Nearest quasar (3C 273): $\sim$ 749 Mpc
- Farthest galaxy known (GN-z11): $\sim$ 32 Gpc

Hipparchos and Gaia

Between 1989 and 1993, the Hipparcos satellite, launched by the European Space Agency (ESA), measured parallaxes for about 100,000 stars with an astrometric precision of about 0.97 milliarcseconds, and obtained accurate measurements for stellar distances of stars up to 1,000 pc away.
ESA's Gaia satellite, launched in 2013, is intended to measure one billion stellar distances to within 20 microarcseconds, producing errors of 10% in measurements as far as the Galactic Center, about 8,000 pc away.