Course Learning Goals

• Successfully practice the ``scientific method'' during the course.

• Use physical principles to describe how stars and galaxies form and evolve over time.

• Learn and construct physical models of astronomical objects to explain observations.

• Recount the scientific story of the universe and our place and time within it.
Astro 2115

Professor: Diana Dragomir

Office Hours: Tuesdays 2h30-3h30pm/Wednesday 9h00-10h00am; Zoom

Class Web page: https://exoplanets.unm.edu/astr2115.html

Course Text: *Universe, 9th, 10th or 11th edition*, Freedman, Geller & Kaufmann

Lectures: Recorded lectures will be posted online on UNM Learn

Homework: Reading and homework assignments (roughly weekly) Help is available!

TAs: Ismael Mireles, Zoom,(mirelesi@unm.edu); Craig Taylor (ctaylor98@unm.edu)

Class Participation: quizzes via zoom polls

Grading: 10% class participation (+ up to 5% extra credit); 25% homework; 50% based on 2 tests (midterm and final); 15% final project.

NOTE: there will be NO makeup tests except by prior arrangement.
Announcements

• The Lab is required for all astrophysics majors
• We do have lab this week

• First Homework is posted and will be due January 28 by the beginning of class; submit via UNM Learn
Class Participation
(via single-question quizzes)

- question will be on material just covered in the lecture
- 10% of final grade
- you must participate in the polls for 20 classes to get the full credit
  - you must participate in every quizz given in each one of those 20 classes
- **Bonus:** if you answer correctly in at least one quizz per class, in at least 20 classes, you will get extra credit of 5% towards your final grade.
  - answering correctly in fewer than 20 classes will still earn you extra credit (but less than 5%)
High Solar Activity in Sep. 2017

SDO UV obs on 17Sep6
SOLAR ACTIVITY AND ITS EFFECTS ON EARTH

SUN

Particles drawn to poles and collide with atmosphere, causing polar lights

SOLAR FLARE AND ERUPTIONS

Billions of tonnes of superhot gas containing charged particles

149 million km

EARTH

EFFECTS
- Satellite microchips damaged
- Power grids disrupted
- Radio interference
Energy released by fusion in the Sun’s core...

...balances the radiative energy emitted from the Sun’s surface.
Optical telescope

Visible light
Betelgeuse

Jan 2019

Dec 2019
Optical telescope
Optical telescope
Gum Nebula - a supernova remnant
Central object: neutron star
Central object: neutron star

Crab pulsar imaged with LWA
Artist's conception

The Sun
Sombrero Galaxy

Me
(with a 1.0m telescope in Chile)
NGC3377
Centaurus A
The Hercules Cluster
Large Scale Structure
How did this structure form?

computer simulations
Cosmology

- Afterglow Light Pattern (380,000 yrs.)
- Dark Ages
- Development of Galaxies, Planets, etc.
- Dark Energy
  - Accelerated Expansion
- Inflation
- Quantum Fluctuations
- 1st Stars (about 400 million yrs.)
- Big Bang Expansion (13.7 billion years)
- WMAP
The Process of Astronomy Research

- What is it that we see? (observing)
- How does it work? (analysis)
- How was it formed, and how will it evolve? (theory & predictions)
What we need in order to explore

- To describe: angular measure, coordinate system, phases, apparent motion etc.
- To explain: orbital motion, atoms and molecules, EM radiation
We lack depth perception, therefore we use the angular measure to describe:

- The apparent size of a celestial object
- The separation between objects
- The movement of an object across the sky

To estimate angles, extend your arm and use your hands and fingers like this =>

Angles
Example of angular distance: the “pointer stars” in the big dipper

The Moon subtends about one-half a degree
How do we express smaller angles?

One circle has $2\pi$ radians = 360°

We subdivide the degree into 60 arcminutes (a.k.a. minutes of arc):

$1° = 60$ arcmin = 60'

An arcminute is split into 60 arcseconds (a.k.a. seconds of arc):

$1' = 60$ arcsec = 60''
Astronomy deals with very big and very small numbers – we talk about galaxies AND atoms.

Example: distance to the Sun is about 150,000,000,000 meters. Hard to handle!

Use “powers-of-ten”, or “exponential notation”. All the zeros are consolidated into one term consisting of 10 followed by an exponent, written as a superscript.
Note some familiar numbers in powers-of-ten notation (ch. 1.6):

One hundred  = 100 = $10^2$  hecto
One thousand = 1000 = $10^3$  kilo
One million  = 1,000,000 = $10^6$  mega
One billion   = 1,000,000,000 = $10^9$  giga

One one-hundredth  = 0.01 = $10^{-2}$  centi
One one-thousandth = 0.001 = $10^{-3}$  milli
One one-millionth  = 0.000001 = $10^{-6}$  micro
One one-billionth = 0.000000001 = $10^{-9}$  nano
Examples of powers-of-ten notation

\[ 150 = 1.5 \times 10^2 \]
\[ 84,500,000 = 8.45 \times 10^7 \]

\[ 0.032 = 3.2 \times 10^{-2} \]
\[ 0.0000045 = 4.5 \times 10^{-6} \]

The exponent (power of ten) is just the number of places past the decimal point.

• Example: distance to the Sun is about 150,000,000,000 meters. How do we write this in exponential notation?

e.g. distance to the sun is \( 1.5 \times 10^{11} \text{ m} \)
We can write the size of just about anything on this chart! (Sizes given in meters):

- An atom
  - Size: $10^{-4}$ m

- Cell is about $10^{-4}$ m

- Taj Mahal is about 60 meters high

- Earth diameter is about $10^7$ m