Astronomy 2110 – Intro. to Astrophysics I

Contact Information

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if those don't work contact me for arrangements

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http://www.astro.virginia.edu/class/skrutskie/astr2110/
Fan Mountain Infrared Camera

- Telescopes are only as good as the instruments that collect light attached to the back end.
- This infrared camera was designed and fabricated from scratch by UVa graduate and undergraduate students.
The Large Binocular Telescope

- UVa is a partner in developing and operating the world's current largest optical telescope.
- The “LBT” is TWO 8.4-meter mirrors on a single mount.
- UVa has developed an infrared imaging system for planet hunting on this telescope.
The Large Binocular Telescope

HR 8799

LBT AO/LMIRCam 3.3 μm

b
c
d
e

HR 8799
The Wide-Field Infrared Survey Explorer

“WISE” has mapped the entire sky at infrared wavelengths

3, 5, 12, and 23 micrometers to be specific.

Solid hydrogen cooled the detectors and telescope to temperatures as low as 8 degrees above absolute zero.

WISE was launched from Vandenberg Air Force Base on a Delta-2 rocket on December 14, 2009.

WISE is in a 500 km high orbit that keeps it continually over the sunrise/sunset line.
How Do You Make Sense of it All?
Astronomy: A Search for Organization?

Stars....

Galaxies....
Astronomy: A Search for Organization?

Galaxy Cluster Abell 2218
NASA, A. Fruchter and the ERO Team (STScI, ST-ECF) • STScI-PRC00-08
Astronomy: A Search for Structure?

- Hierarchical structure in the Universe leads to an extended mailing address.....

Earth
The Solar System (in capital letters)
The Milky Way Galaxy
The Local Group
The Local Supercluster
The Universe

- Implicit in understanding this structure is knowing how far away things actually are.... not an easy task!
Understanding Structure: Divining Depth
Astronomy: A Search for Origins!!!

- Where did all the structure and organization come from?
- How did it emerge over time?
- What were the starting conditions?
- What physical processes were important?

  - We wish to explain, not just observe.
Astronomy: A Search for Origins!!!

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- How did it emerge over time?
- What physics/physical processes were important?

Hydrogen + Helium + Gravity $\Rightarrow$ Stars, Galaxies, and Humans
given about 14 billion years.
Astronomy: A Search for Origins!!!

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= PHYSICS
Evolution of Understanding

Shaking fist at skies in anger and frustration and awe
Evolution of Understanding

Ad hoc explanations of heavenly phenomena based up fanciful beliefs and stories
Physical, but unrealistic, models of the heavens that have predictive power
Evolution of Understanding

Simple mathematically-based physical models and laws (physics) that provide an accurate context for astronomical understanding.
Evolution of Understanding

Powerful mathematical/physics formalism combined with extensive observational and computational capability enabling precise modeling and realistic global simulation.
Evolution of Understanding

- Intuitive mastery of physical law.

- Understanding through insight.
  - Developing a “feel” for problems and problem solving

- Ability to scale solutions independent of rote calculation.
  - Developing intuition for “the answer”.
Channel Your Inner Feynman

- Intuitive mastery of physical law.

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Orbital Velocity in the Solar System

Circular orbital velocity derives from equating centripetal to gravitational force.

\[ F_c = \frac{mv^2}{R} \]
\[ F_g = \frac{GM_1m_2}{R^2} \]
\[ v_{orbit} = \sqrt{\frac{GM}{R}} \]
Orbital Velocity in the Solar System

You're set for life if you remember that the Earth orbits the Sun at a speed of 30 km/s.

\[ v_{\text{orbit}} = \sqrt{\frac{GM}{R}} \]

\[ 30 \text{ km/s} \sqrt{\frac{1}{R}} \]

Where \( R \) is expressed in astronomical units.
Orbital Velocity in the Solar System

Derivation of this scaling ... basically multiply by “1” at various locations and extract the equation for Earth's orbital speed (the 30 km/s). $M_o$ is the mass of the Sun. $R_e$ is the Earth's distance from the Sun.

$$v_{\text{orbit}} = \sqrt{\frac{G M_o}{M}} \frac{M}{M_o} \frac{R}{R_e} R_e$$

$$30 \text{ km/s} = \sqrt{\frac{1}{R}}$$

where $R$ is expressed in astronomical units

Mass of the star compared to the Sun

Distance from star in astronomical units
How Can it be Practical to Deliver Your Own Interplanetary Launch Platform to the Surface of the Moon???
How Can it be Practical to Deliver Your Own Interplanetary Launch Platform to the Surface of the Moon???
Escape Velocity

Make an object's energy positive.
That is, kinetic energy exceeds gravitational potential/binding energy.

\[ K.E = \frac{1}{2} m v^2 \quad P.E. = \frac{G M_1 m_2}{r} \]

Equating the two gives you the “escape velocity”

\[ v_{escape} = \sqrt{\frac{2GM}{r}} \]

Escape velocity from the surface is \sqrt{2} larger than orbital velocity.
\[ \Delta v = v_e \ln \frac{m_o}{m_1} \]

\[ \frac{m_o}{m_1} = e^{\frac{\Delta v}{v_e}} \]