Welcome to Astro 150: Stars, Galaxies and Cosmology

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Prof. Jake Simon

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Recitations begin this Wednesday, August 19

Textbook required, free online

Fraknoi et al: Astronomy (via OpenStax)

“Astronomy is designed to meet the space and sequence requirements of one- or two-semester introductory astronomy courses. The book begins with relevant scientific fundamentals and progresses through an exploration of the solar system, stars, galaxies and cosmology. The Astronomy textbook builds student understanding through the use of relevant analogies, clear and non-technical explanations, and rich illustrations. Mathematics is included in a flexible manner to meet the needs of individual instructors.”

- Aldous Huxley

“There are only two worthwhile professions: medicine and astronomy. Medicine, because you are sure to help someone, and astronomy, because you are sure you won’t hurt anyone.”

- Aldous Huxley

- Astronomy concerns things that are
  - too large to imagine
  - too far to fathom
  - too old to comprehend, and
  - too small to see
The Universe is a BIG Place

<table>
<thead>
<tr>
<th>Object</th>
<th>Distance [km]</th>
<th>55 mph</th>
<th>100,000 mph</th>
<th>LIGHT*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moon</td>
<td>384,000</td>
<td>174 d</td>
<td>2.4 hr</td>
<td>1.25 s</td>
</tr>
<tr>
<td>Venus</td>
<td>42,000,000</td>
<td>54.5 yr</td>
<td>11 d</td>
<td>2.33 min</td>
</tr>
<tr>
<td>Sun</td>
<td>150,000,000</td>
<td>193 yr</td>
<td>2 months</td>
<td>8.33 min</td>
</tr>
<tr>
<td>Pluto</td>
<td>6,000,000,000</td>
<td>7,800 yr</td>
<td>4.25 yr</td>
<td>5.25 hr</td>
</tr>
<tr>
<td>α Centauri</td>
<td>40,000,000,000,000</td>
<td>30,000 yr</td>
<td>4.25 yr</td>
<td></td>
</tr>
</tbody>
</table>

One Way Travel Time

Astronomical Distance Units:

- an “a.u.” = mean distance between Earth and Sun
- a light-year = distance light travels in 1 year (=67,000 a.u.)
- 1 l.y. = 10,000,000,000,000 km = $10^{13}$ km = 10 trillion km

A Scale Model: Solar System Distances

1 a.u. = 10 meters

the Sun = a softball
Jupiter = a grape
Earth = a poppyseed

each step you take - 10 million miles!
The Rest of our Solar System

The Sun is one of ~400 billion stars in the Milky Way Galaxy

- Nearest similar galaxy: M31 (Andromeda)

- Most distant galaxies known: 13 billion ly away!

- There are as many as galaxies in the Universe as stars in our Galaxy!
The Universe is now expanding, following a Big Bang

- Age of the Sun: 4.5 billion years
- Age of the Universe: ~13.6 billion years
The Universe is (almost) empty

• Density of water: 1 gram/cc
• Density of Earth: 5 grams/cc
• Density of the Universe:

\[ = 0.00000000000000000000001 \text{ g/cc} = 10^{-23} \text{ g/cc} \]

Chemical composition:

75% Hydrogen
~ 24% Helium
< 1% everything else

All Earthly matter heavier than helium (carbon, oxygen, calcium, gold, ...) was transformed in the centers of long-dead stars billions of years ago
we are stardust...
we are stardust...

How did that stuff become us?

• That is what Astro 150 is all about!
  • structure and motions of planets, stars, and galaxies
  • content of our Universe
    • why stars shine
    • galaxies everywhere (?)
    • large scale structure of the Universe
  • origin, history, and future of the Universe
  • development of life in our solar system... and other solar systems

• Along the way we will explore
  • processes linking our Earth and Sun with distant and exotic places
    • light - visible and invisible
    • gravity and energy in all their manifestations
  • stars and their environments both familiar and utterly alien
  • catastrophes bigger than Hollywood has dreamed of
  • elusive and exotic Dark Matter and Dark Energy, and
  • whether we are the only civilization in the Galaxy
TYC 8998-760-1
a sunlike star w/ 2 imaged giant planets Bohn et al. (2020)

Some Other Solar Systems (over 4000 known)
Some Other Solar Systems (over 4000 known)

Credit: Jason Rowe, NASA Ames Research Center and SETI Institute

A Scale Model of Time

*From: The Evolution of Life, by Frank H.T. Rhodes*

<table>
<thead>
<tr>
<th>Event</th>
<th>Date</th>
<th>Time</th>
<th>Years ago</th>
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</thead>
<tbody>
<tr>
<td>Big Bang</td>
<td>Jan. 1</td>
<td>12:00:00 AM</td>
<td>13,600,000,000 yr</td>
</tr>
<tr>
<td>Galaxies form</td>
<td>Jan. 24</td>
<td>12:00:00 AM</td>
<td>12,000,000,000 yr</td>
</tr>
<tr>
<td>Sun forms</td>
<td>Sept. 13</td>
<td>noon</td>
<td>4,500,000,000 yr</td>
</tr>
<tr>
<td>Earth forms</td>
<td>Sept. 13</td>
<td>12:17 PM</td>
<td>4,470,000,000 yr</td>
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<td>1st life appears</td>
<td>Oct. 24</td>
<td>8:48 PM</td>
<td>2,800,000,000 yr</td>
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<tr>
<td>1st higher forms</td>
<td>Dec. 19</td>
<td>3:07 AM</td>
<td>570,000,000 yr</td>
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<tr>
<td>1st land animals</td>
<td>Dec. 25</td>
<td>4:29 AM</td>
<td>280,000,000 yr</td>
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<tr>
<td>1st dinosaurs</td>
<td>Dec. 26</td>
<td>12:36 PM</td>
<td>225,000,000 yr</td>
</tr>
<tr>
<td>DINOs RULE</td>
<td>Dec. 28</td>
<td>4:34 PM</td>
<td>136,000,000 yr</td>
</tr>
<tr>
<td>DINOs DIE</td>
<td>Dec. 29</td>
<td>10:02 PM</td>
<td>65,000,000 yr</td>
</tr>
<tr>
<td>Earliest “human”</td>
<td>Dec. 31</td>
<td>9:05 PM</td>
<td>5,000,000 yr</td>
</tr>
<tr>
<td>Neanderthal - C.M.</td>
<td>Dec. 31</td>
<td>11:50 PM</td>
<td>300,000 yr</td>
</tr>
<tr>
<td>Last Ice Age</td>
<td>Dec. 31</td>
<td>11:59:37 PM</td>
<td>1,000 yr</td>
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<tr>
<td>Pyramids</td>
<td>Dec. 31</td>
<td>11:59:53 PM</td>
<td>3,500 yr</td>
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<tr>
<td>USA</td>
<td>Dec. 31</td>
<td>11:59:59.6 PM</td>
<td>244 yr</td>
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<tr>
<td>YOU</td>
<td>Dec. 31</td>
<td>11:59:59.96 PM</td>
<td>20 yr</td>
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