Habitability Outside the Solar System

A discussion of Bennett & Shostak
Chapter 11
HNRS 228
Dr. H. Geller

Chapter Overview

- Distant Suns (11.1)
  - Life cycle of stars and their habitability zones
- Extrasolar Planets: Discoveries and Implications (11.2)
  - detection methodologies
- The Possibilities that Earth is Rare (11.3)
- The Process of Science in Action: Classifying Stars (11.4)

Are Habitable Planets Common?

- Really two questions
  - Are planets common?
  - How many exoplanets are habitable?
- Review formation of stars and planets
  - evidence from HST

Habitability Zone Around Other Stars in Our Galaxy

- Use the range from our solar system as a basis for analysis
  - In our solar system, 4 rocky planets that orbit the Sun from 0.4 to 1.4 AU and spaced 0.4 AU apart
- If typical, likelihood of other solar systems having continuous habitability zone is just width of the zone divided by the typical spacing
  - 0.2/0.4 = 0.5
  - Probability of 50%
  - Discuss this probability

Habitability Zone in Our Galaxy

- Other factors also relevant
  - Several stars in our galaxy with planets the size of Jupiter within terrestrial zone from their sun
  - Mass of star
    - Larger mass, greater luminosity, shorter life
    - Most abundant stars in galaxy are least luminous and longest-lived (red dwarfs)

Habitability Zones Elsewhere in the Galaxy
Different Stars – Different Habitable Zones

Another View of Habitability

iClicker Question

• Compared to a star of spectral type K, a star of spectral type A is generally
  - A hotter, more luminous, and more massive.
  - B hotter, more luminous, and less massive.
  - C cooler, dimmer and less massive.

iClicker Question

• Stars of types O and B are unlikely to have planets with life because
  - A they have short stellar lives.
  - B their intense ultraviolet light would sterilize any planets.
  - C they don't have enough heavy elements.
  - D Both A and B above are true.
  - E A, B, and C above are true.

iClicker Question

• How does the habitable zone around a star of spectral type M compare to that around a star of spectral type G?
  - A It's larger and farther from its star.
  - B It's hotter and brighter.
  - C It's smaller and closer to its star.

How to Find an Extrasolar Planet

• Think about how a planet affects the star around which it orbits
  - light seen from star
  - gravitational effects
    - translate into visual effects
  - spectroscopic effects
    - translate into observed spectroscopic observations
    - remember Doppler Effect
Four Main Ways to Find an Extrasolar Planet

- **Photometrically**
  - light from star blocked by planet decreasing light seen from star in concert with orbit
- **Astrometrically**
  - change in position caused by “dance with planet”
- **Spectroscopically**
  - Doppler Effect on spectral lines due to “dance with planet”
- **Gravitational Microlensing**
  - large gravitational force effecting light path

Change in position of Sun due to Jupiter as seen from 10 parsecs distant

Remember Doppler

Applying Doppler

Applying Einstein

Gravitational Microlensing
Light from a distant star is bent and focused by gravity as a planet passes between the star and Earth.
Considerations for Habitability

- Distance from sun
- Luminosity of sun
- Planet size
- Atmospheric loss processes
- Greenhouse effect and gases in the atmosphere
- Source of energy (internal/external)
- Presence of water
- Presence of carbon biomolecules
- Biota

Phases of Water and CO₂
Planet Size Questions

• Tectonics: why important
• Magnetosphere and solar winds
• Gravity and tectonics

Atmospheric Loss Processes to Consider

• Solar winds of charged particles
  - Sweeps away atmosphere in episodic wind events
• Planet’s magnetic field (magnetosphere)
  - Deflect solar winds
  - Earth and Mercury have magnetospheres
  - Mars and Venus do not have magnetospheres
• Atmospheric loss processes
  - Escape velocity of gases

iClicker Question

• About how many extrasolar planets have been detected to date?
  - A between 10 and 100
  - B between 100 and 1000
  - C more than 1000

iClicker Question

• How have we detected most extrasolar planets discovered to date?
  - A Transits
  - B Hubble Space Telescope images
  - C the Doppler related technique

iClicker Question

• Which technique will the Kepler mission use to search for Earth size planets around other stars?
  - A Transits.
  - B The astrometric technique.
  - C The Doppler related technique.
  - D Gravitational lensing.

iClicker Question

• Nearly all the extrasolar planets discovered to date are
  - A terrestrial-like planets.
  - B jovian-like planets.
  - C large, icy worlds.
Is Earth Rare?

- What are the odds?
  - Location, location, location
  - Special events
- What are the odds of any special event?
  - Example of coin toss