Lecture 4 Notes: Multiplanet Systems, Earth-like Planets, Time and Coordinates

Summary Notes

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1 Multiplanet Systems

1.1 Key Characteristics

- Over 800 known multiplanet systems
- Provide insights into planetary formation and evolution
- Often show compact orbital configurations
- Common orbital resonances between planets

1.2 Notable Examples

- TRAPPIST-1: 7 Earth-sized planets, 3 in habitable zone
- Kepler-90: 8 planets, similar to Solar System
- HD 10180: Up to 7 planets
- Gliese 581: 3 confirmed planets, potentially habitable

2 Earth-like Planets

2.1 Definition Criteria

- Size: 0.8-1.25 Earth radii
- Mass: 0.5-2 Earth masses
- Composition: Rocky
- Location: Within habitable zone
- Atmosphere: Present (ideally with biomarkers)

2.2 Promising Candidates

- Proxima Centauri b (4.2 light-years)
- TRAPPIST-1e
- Kepler-442b
- TOI-700 d

3 Future Missions & Technology

3.1 Space Telescopes

- JWST (operational)
- PLATO (2026 launch)
- Proposed: HWO and LUVOIR

3.2 Detection Techniques

- Improved direct imaging
- Extreme precision radial velocity (10 cm/s goal)
- Enhanced monitoring capabilities

3.3 Biosignature Search

- Atmospheric markers
- Surface features (vegetation red edge)
- Potential technosignatures

4 Time in Astronomy

4.1 Time Scales

- Local time
- Standard time
- Greenwich time
- Universal time (UT1 and UTC)

4.2 Special Considerations

- Sidereal vs Solar day differences
- Leap seconds in UTC
- Tidal friction effects (2.3ms increase per century)

5 Coordinate Systems

5.1 Key Concepts

- Earth's precession (25,800-year cycle)
- Altazimuth coordinates
- Right Ascension (α) and Declination (δ)

5.2 Measurement Units

- RA: hours/minutes/seconds or decimal degrees
- Dec: degrees/minutes/seconds or decimal degrees
- Importance of standardized epoch references

6 Notes for Further Study

- Monitor exoplanet database: https://exoplanet.eu/home/
- Watch Anjali Tripathi's IAU GA 2024 talk on Exoplanets