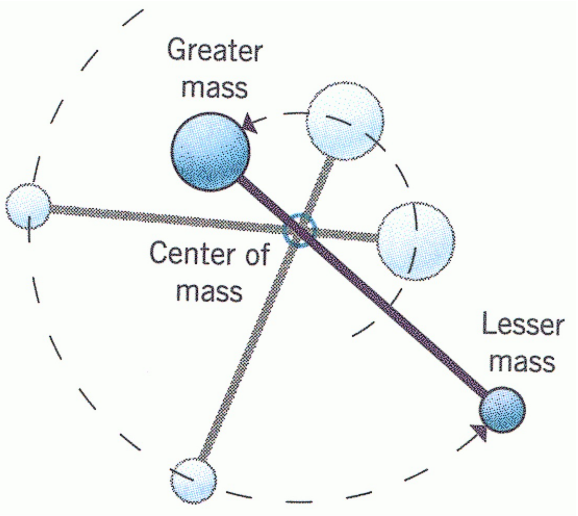
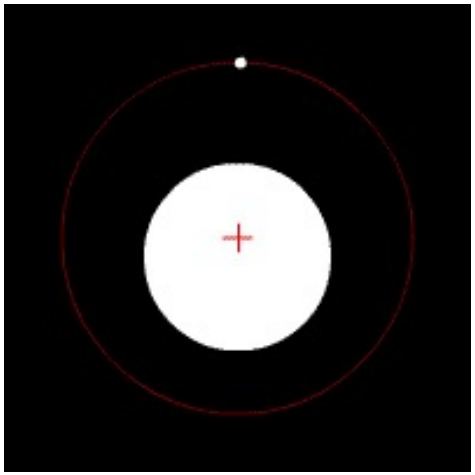
Exo-Planets and Radio Astronomy

- Planet Detection
- Radio detections of planets in Solar System
- Radio detections of exo-planets
- Search for Extra-Terrestrial Intelligence

Planet Detection

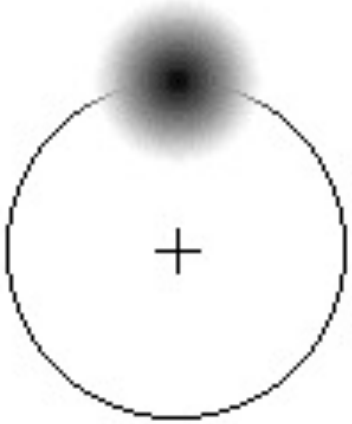
- The radial velocity technique relies on detecting the effect of a planet on the motion of its parent star





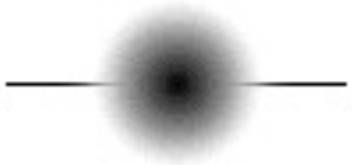
Observation of Stellar Motions Due to Presence of Extra-Solar Planet

Orbit of Star Around System's Center of Mass (Viewed from above)

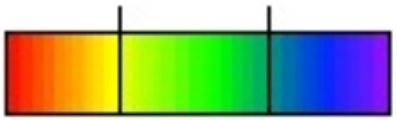


Earth

Astrometric Displacement (Detects movement *across* line of sight)



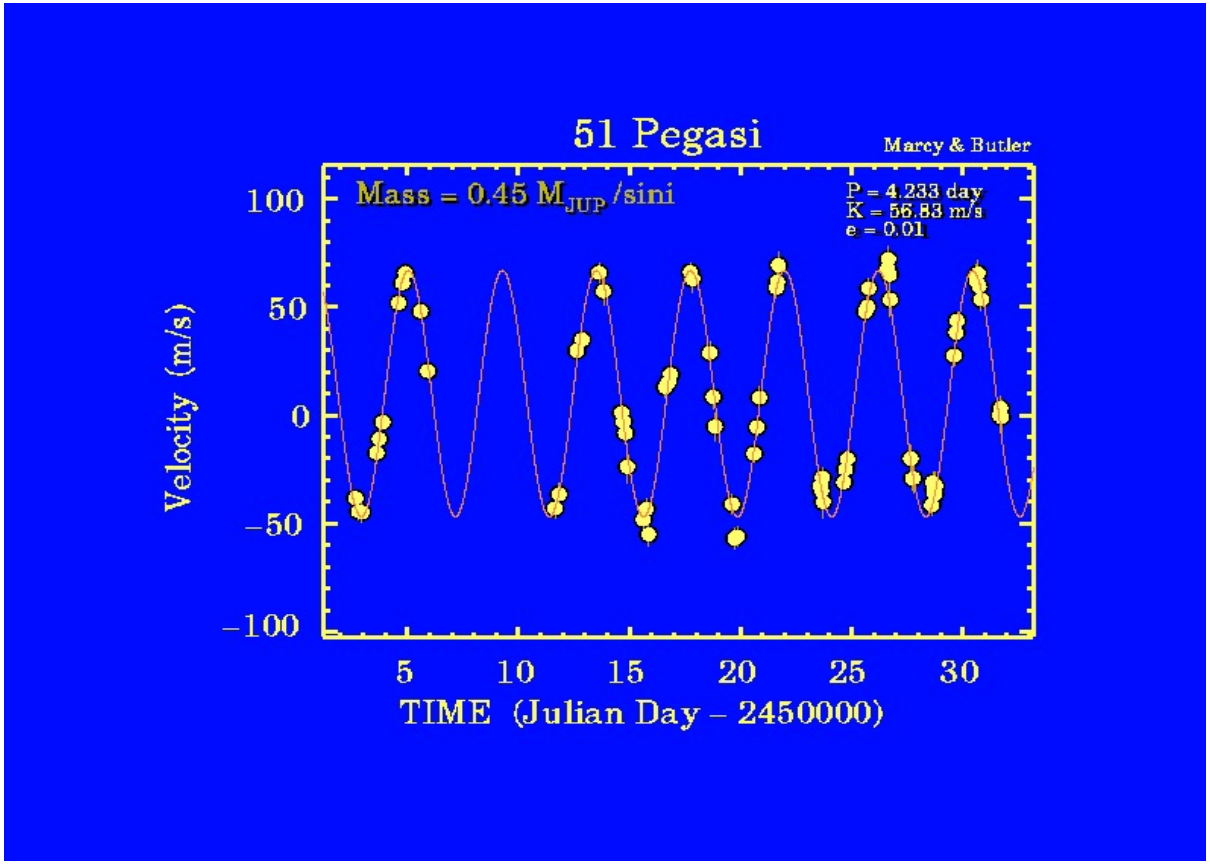
Doppler Shift (Detects movement *along* line of sight)



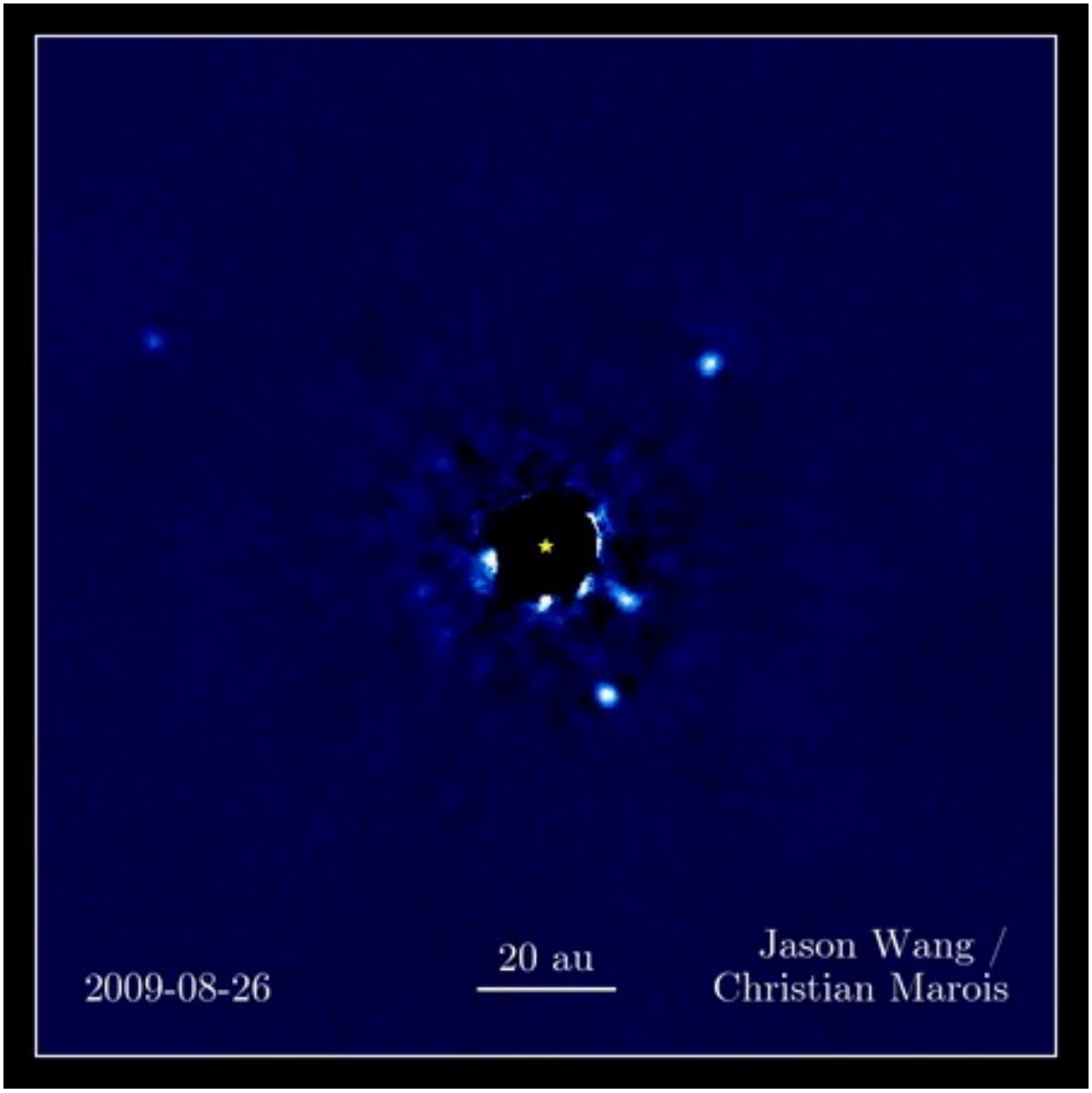
eo.ucar.edu/staff/dward/sao/exoplanets/methods.htm

51 Pegasi b – the first exo-planet

- The radial velocity curve (against time)

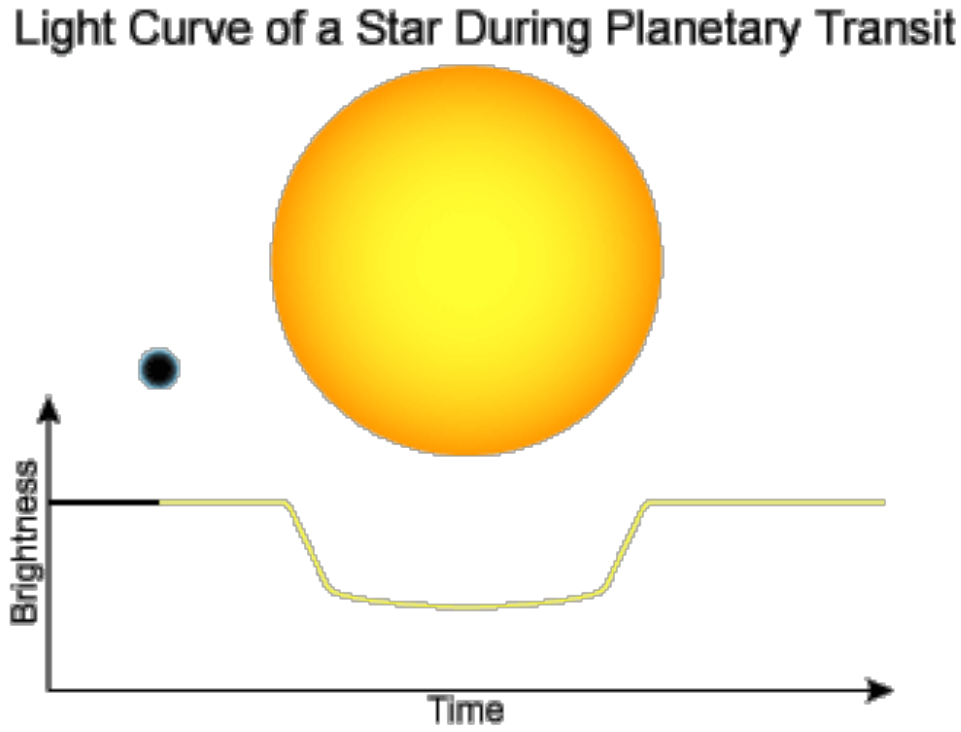


Direct Detection



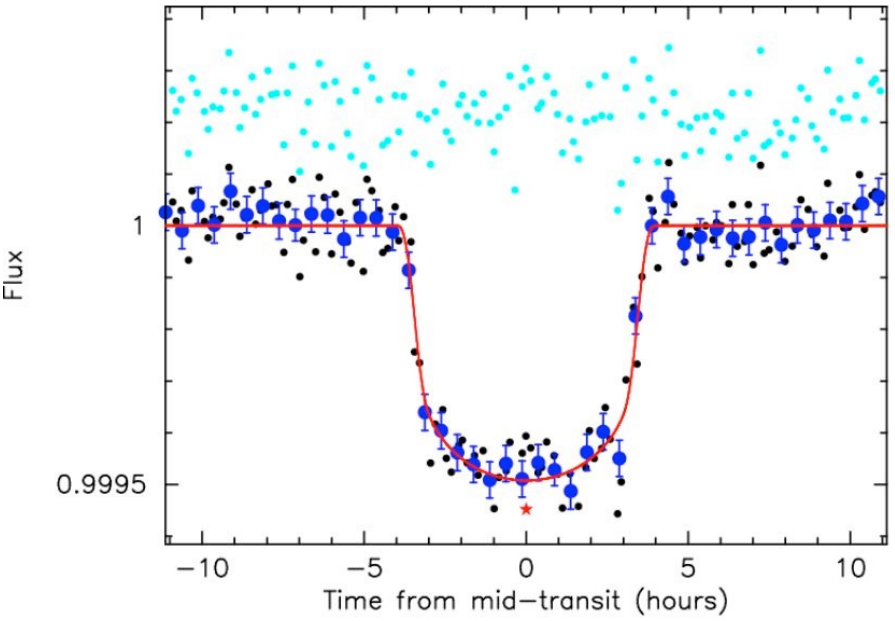
Transits

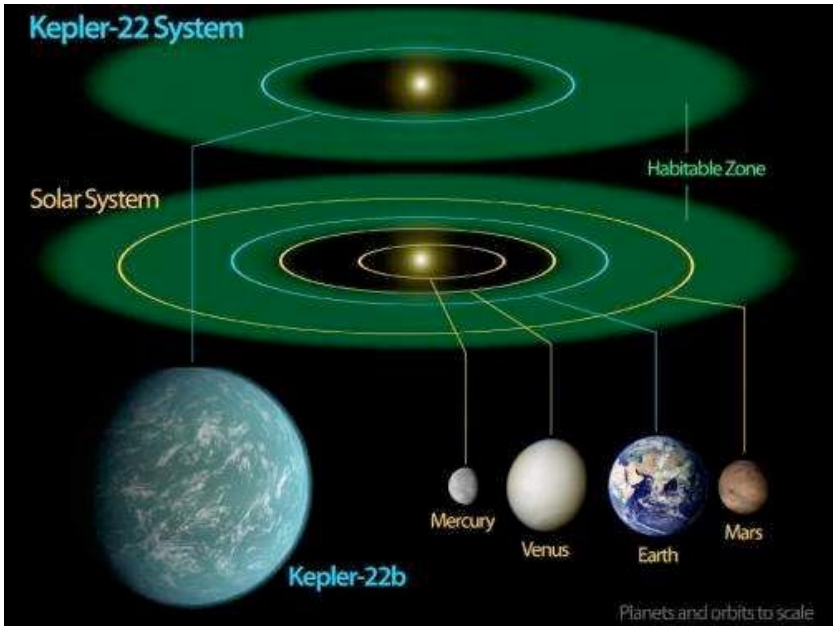
- A transit occurs when a planet crosses in front of the disc of the star



Kepler Satellite Mission

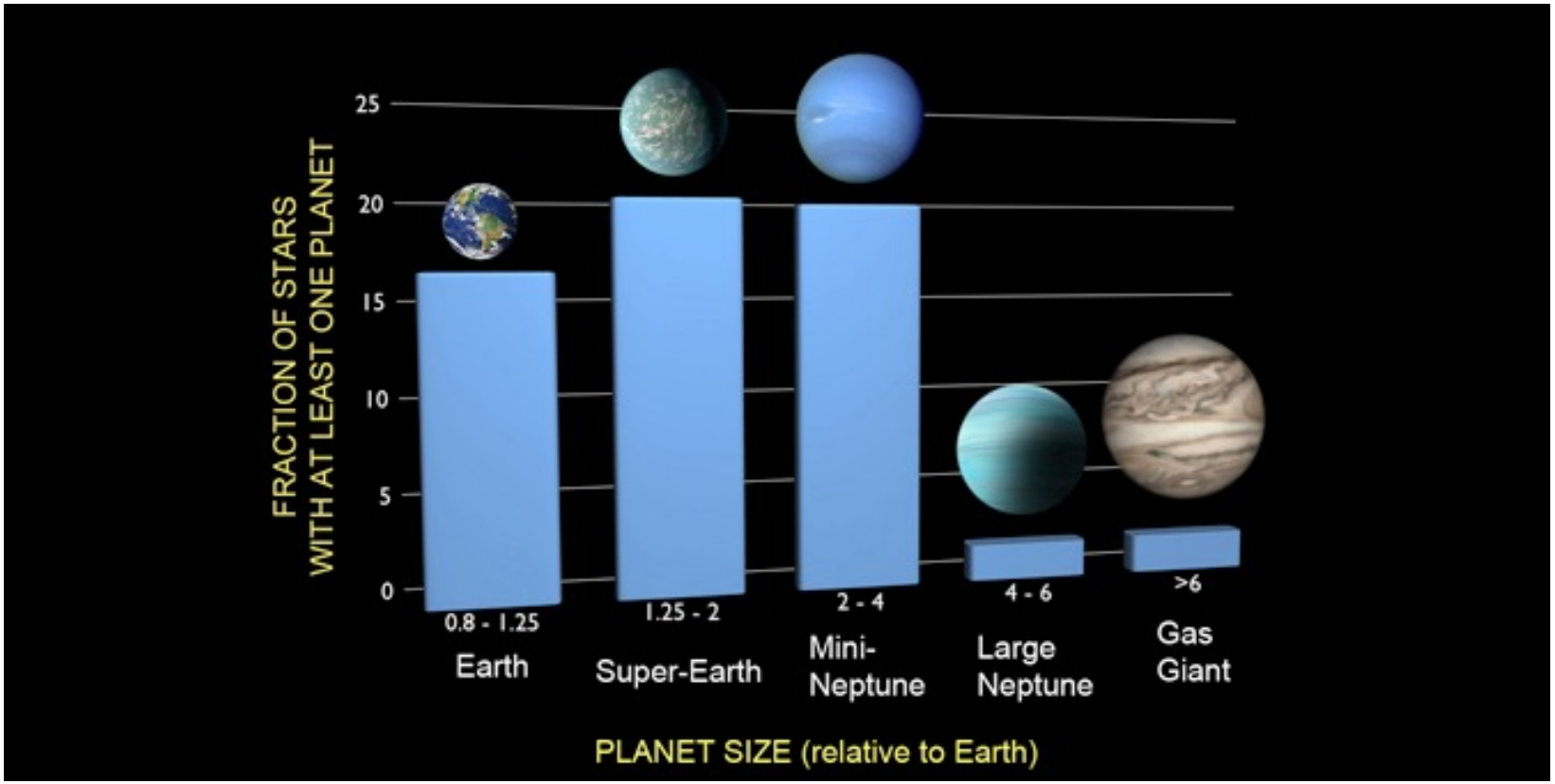
- Looked for transits in a sample of 100 000 stars
- Finding rocky planets in habitable zones



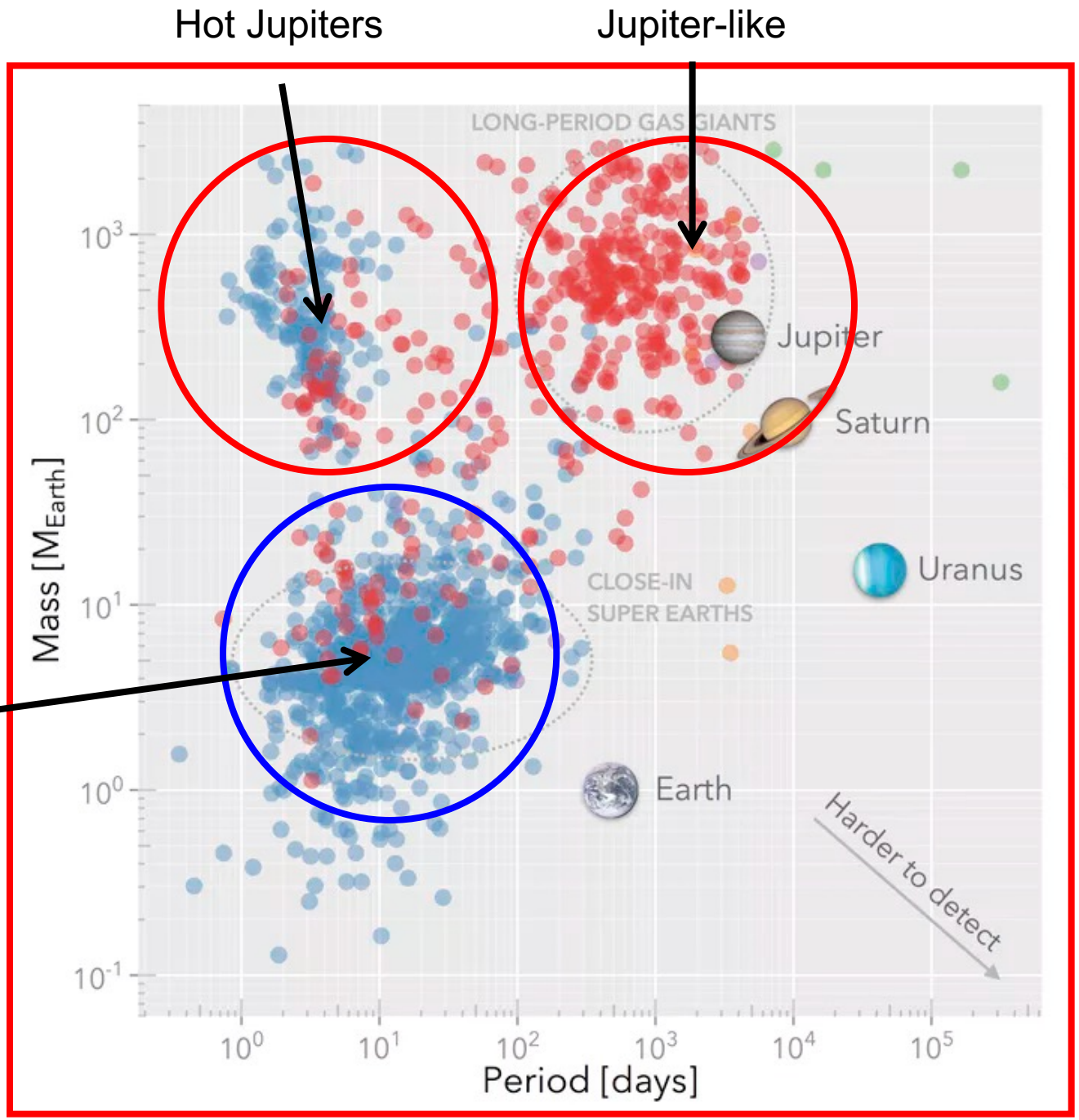


Kepler Mission Results

- All stars have planetary systems

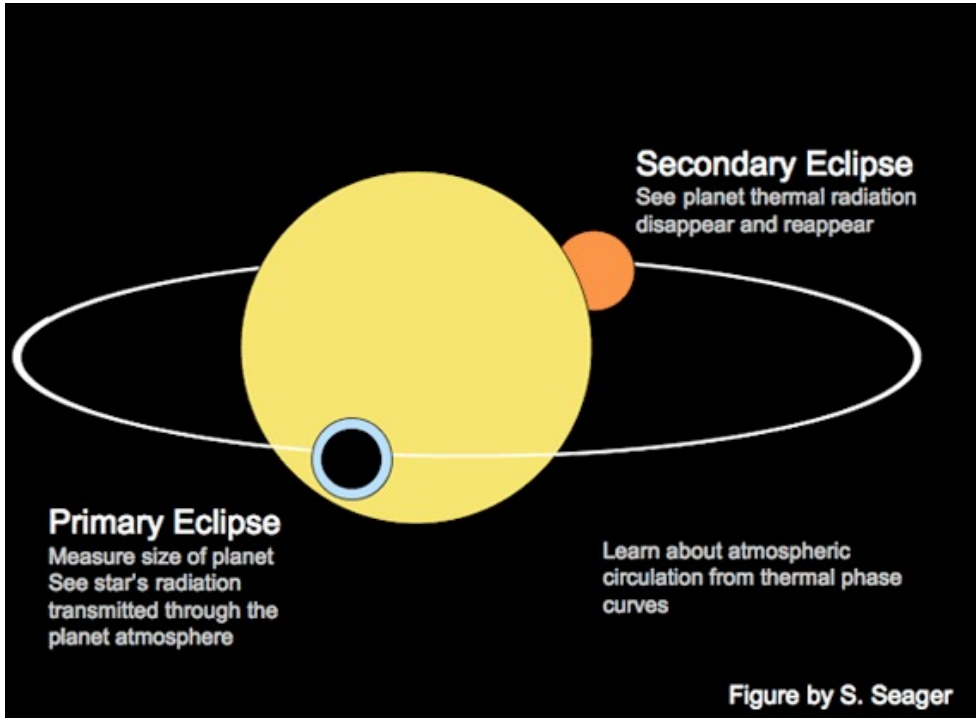


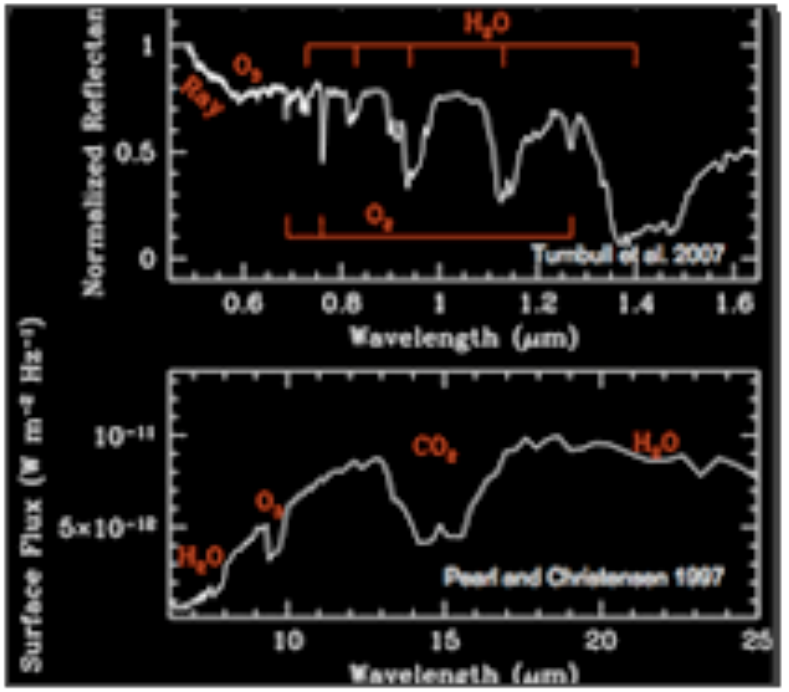
What type of exo-planets have been found?



Super Earths (rocky)

We can probe their atmospheres to study composition





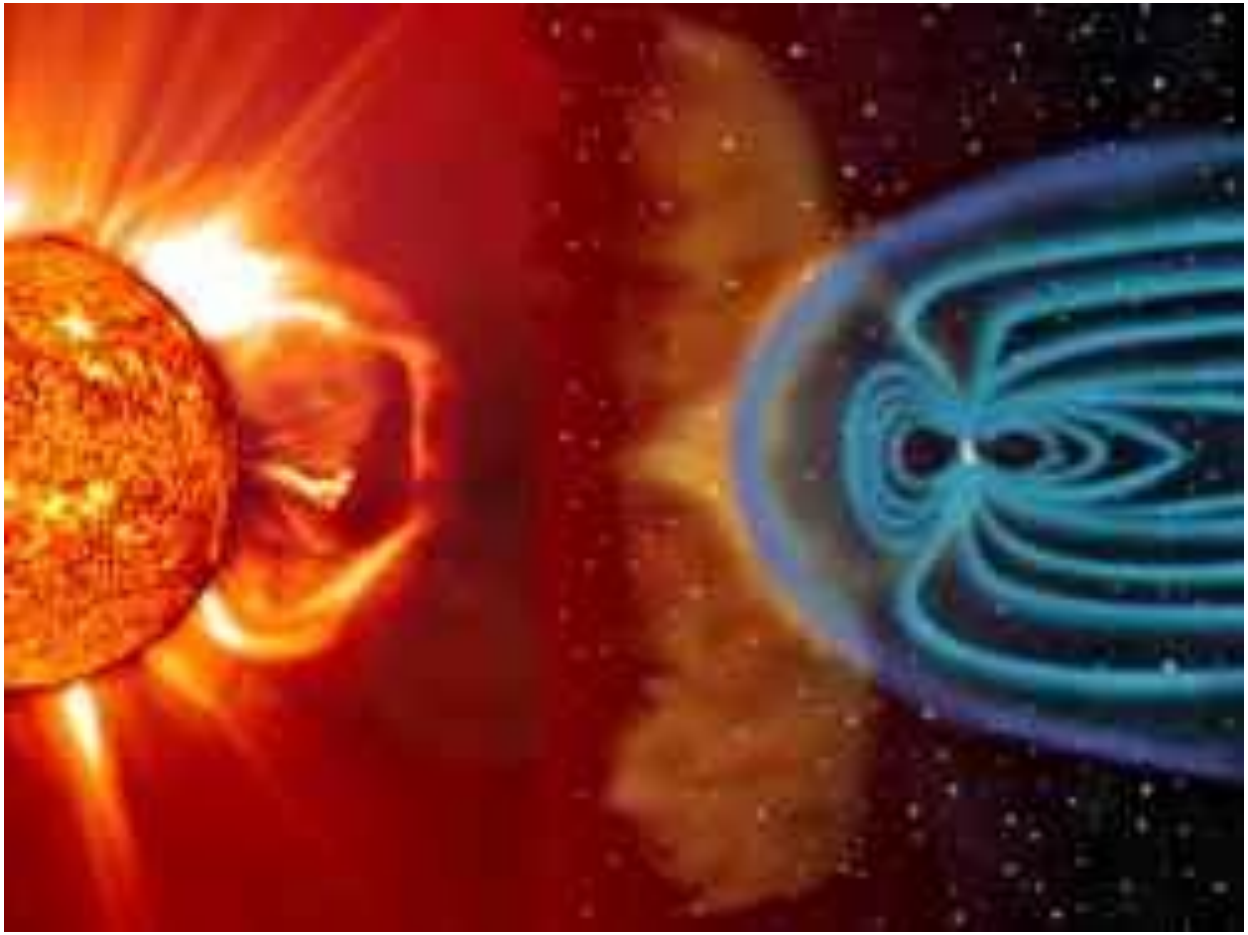
Discussion

- Why is it so difficult to detect planets similar to the Earth around other stars?

Exo-planet characterization

- What can radio studies of exo-planets tell us?
- Radio emission from interaction between solar wind from host star and planetary magnetic field
- Compare with planetary radio emission in our own Solar System

Solar Wind Interaction

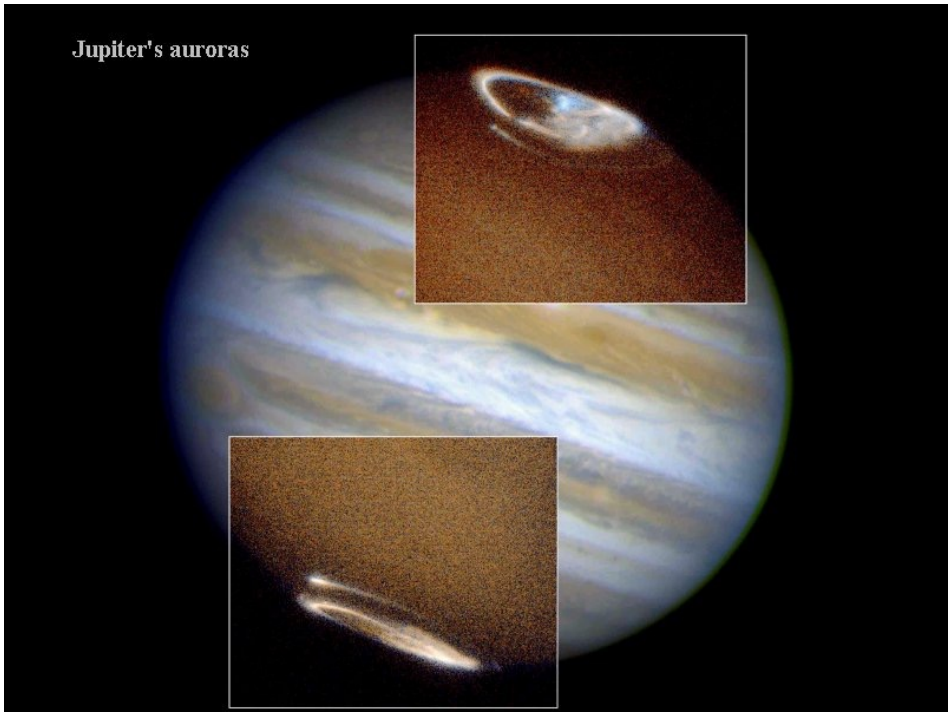


Aurorae

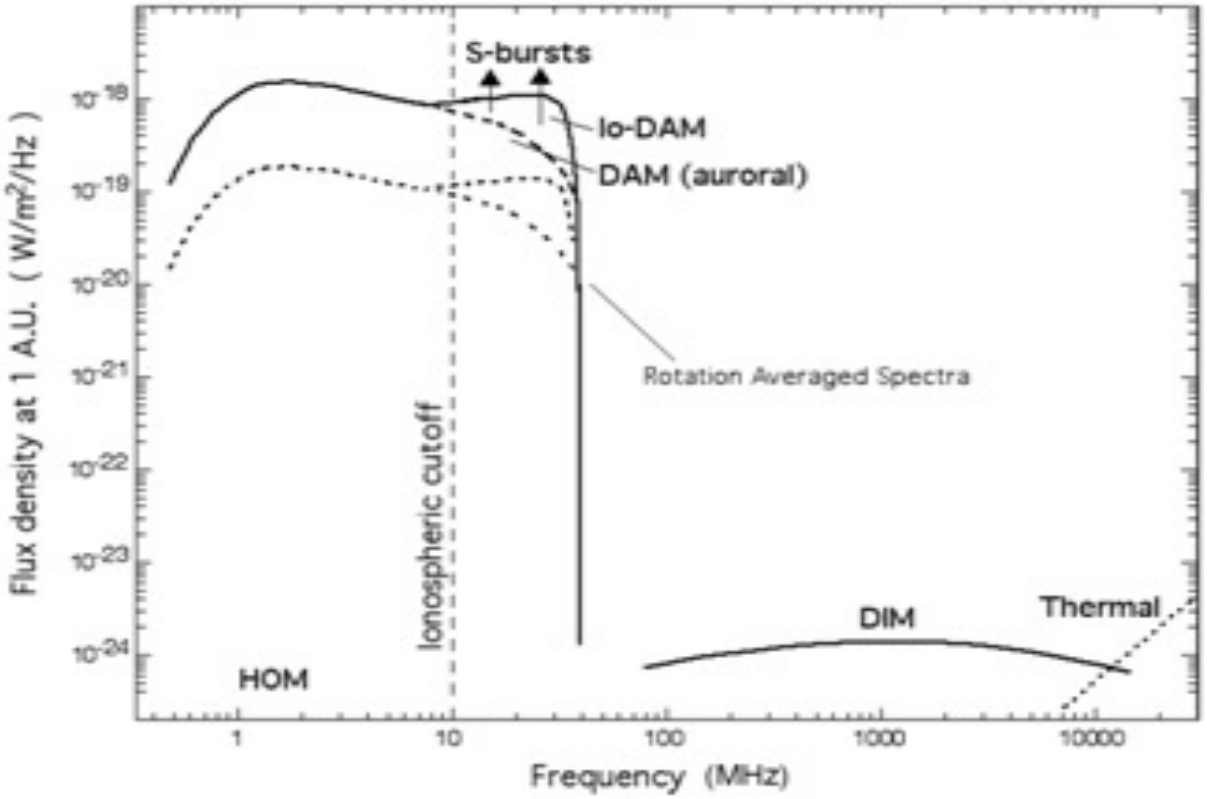
Figure 9-21c
***Universe*, Ninth Edition**

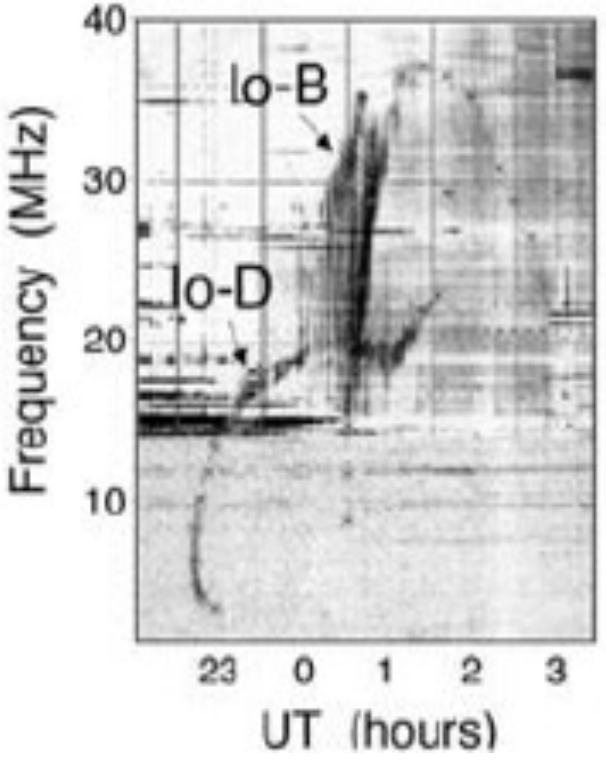
Aurora on the Earth

Aurorae on Jupiter and Saturn

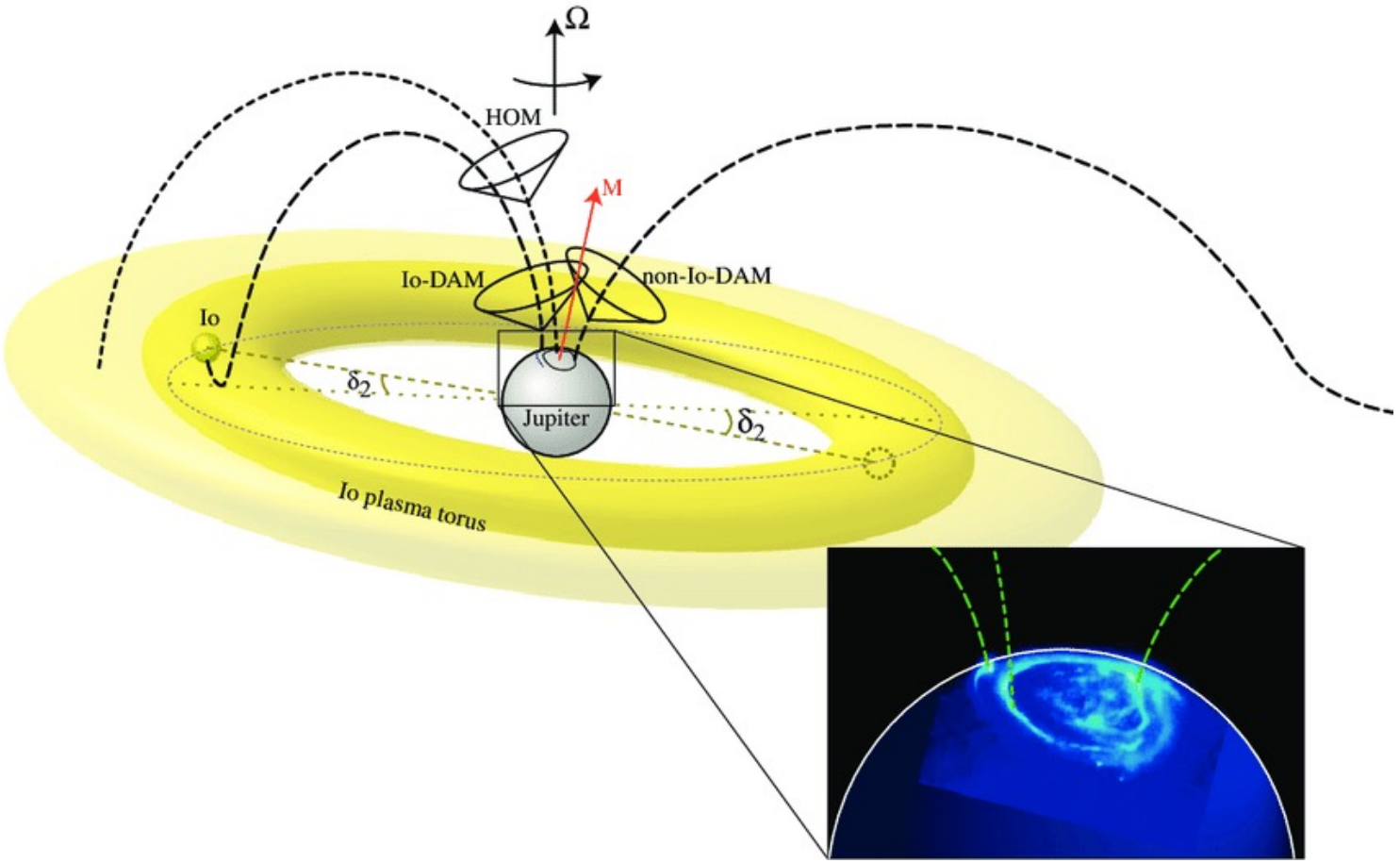


Jupiter's Radio Emission



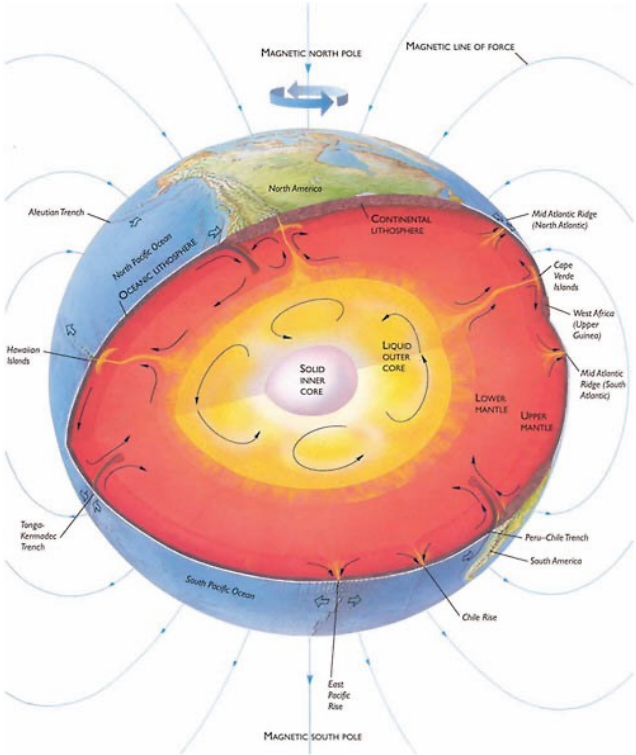


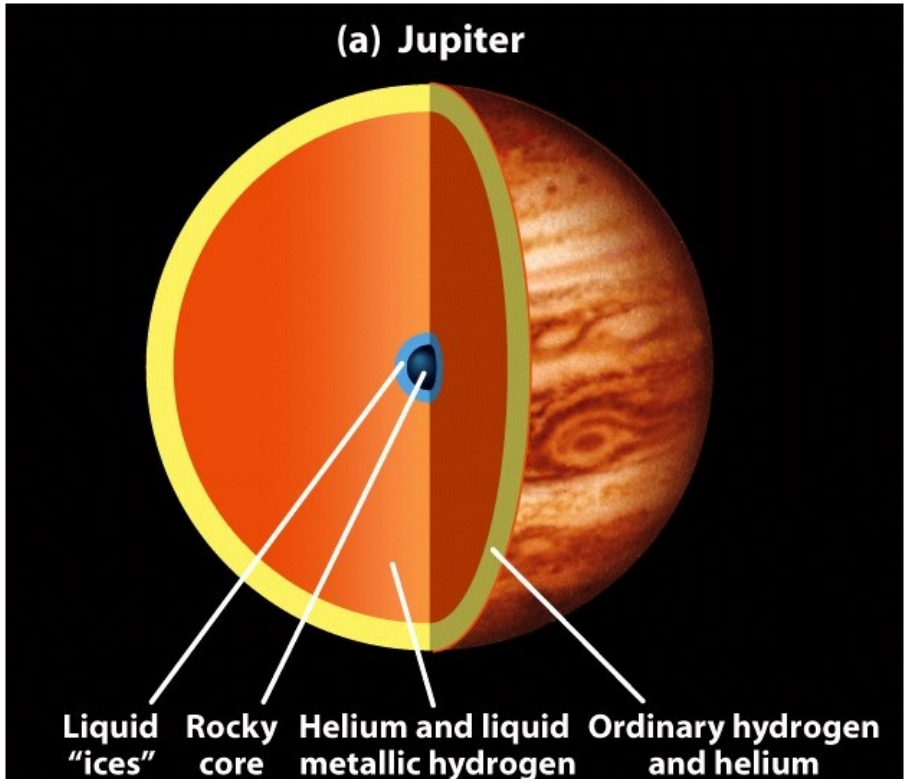
Circularly Polarized Emission



Planetary Magnetic Fields

- Tells us about the interior of the planet



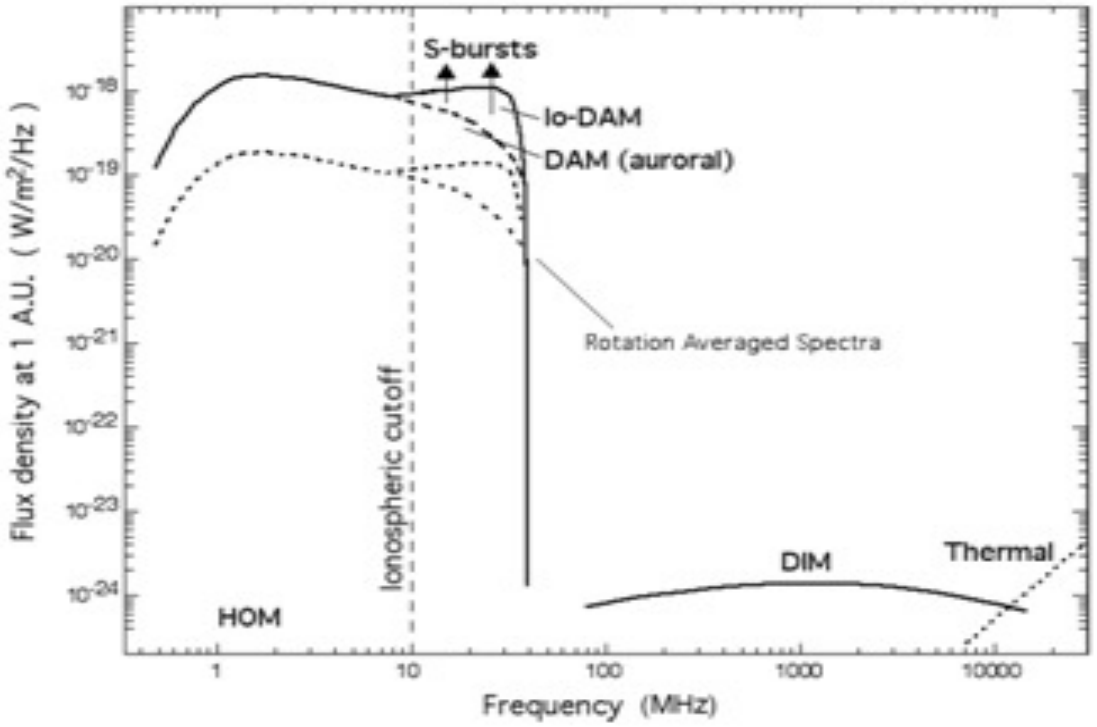


Discussion

- Why does Mars no longer have a magnetic field?

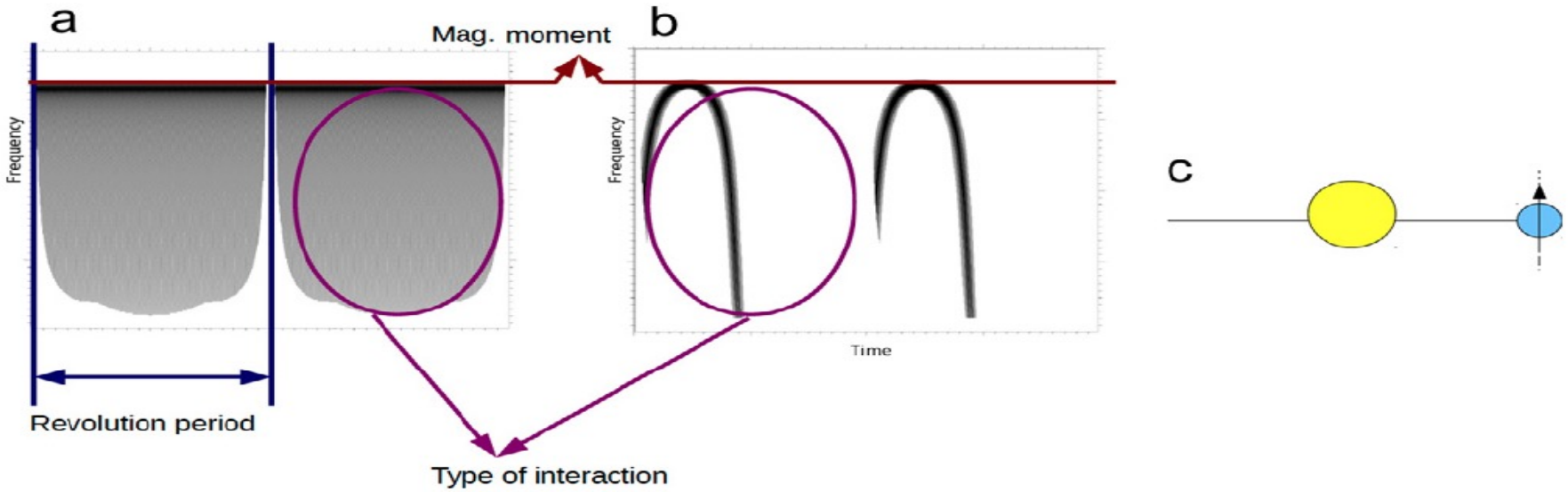
Magnetic Field Strength

- Cut-off in radio spectrum gives strength of magnetic field



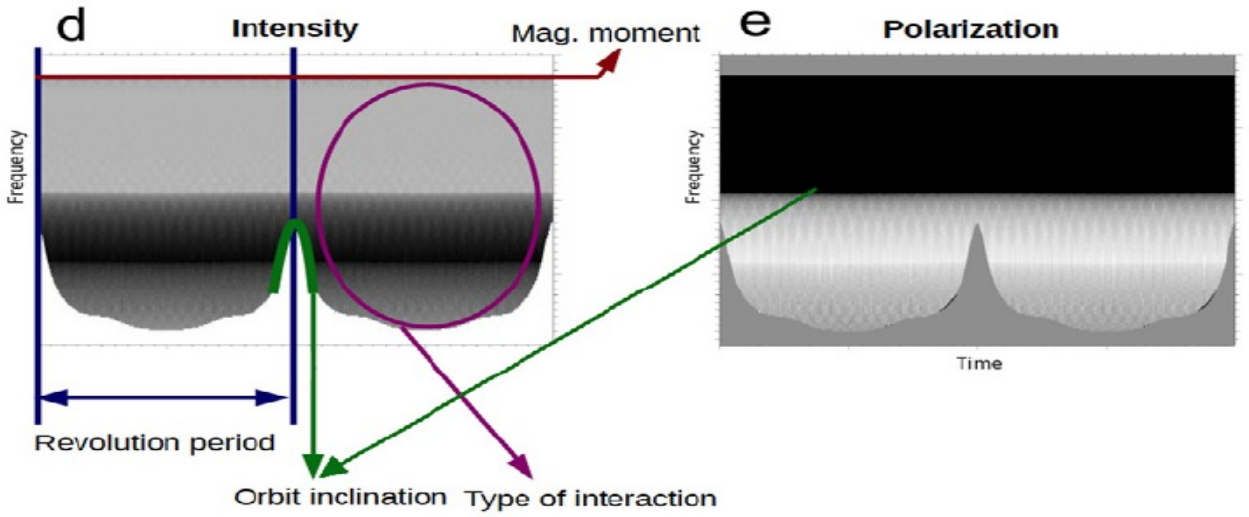
Planetary Rotation Period

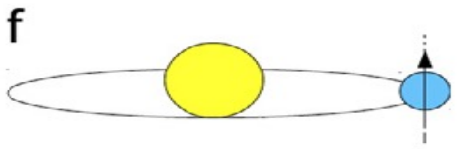
- The dynamic spectra and polarization would tell us various parameters



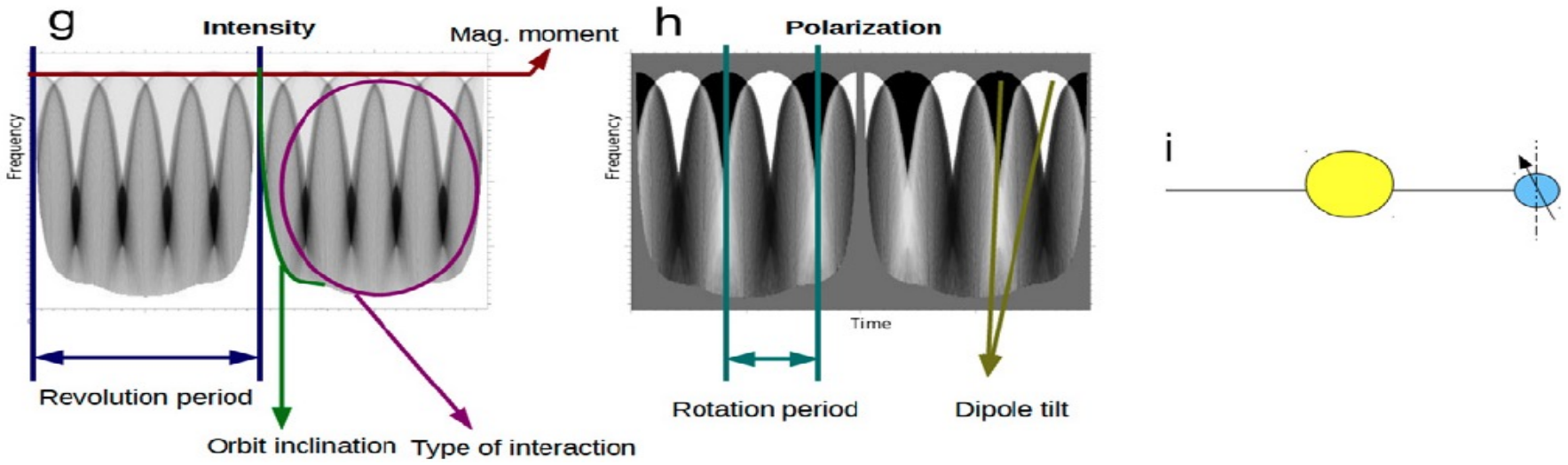
Model dynamic spectra (Hess, Zarka et al., 2008, 2011)

Orbital Inclination



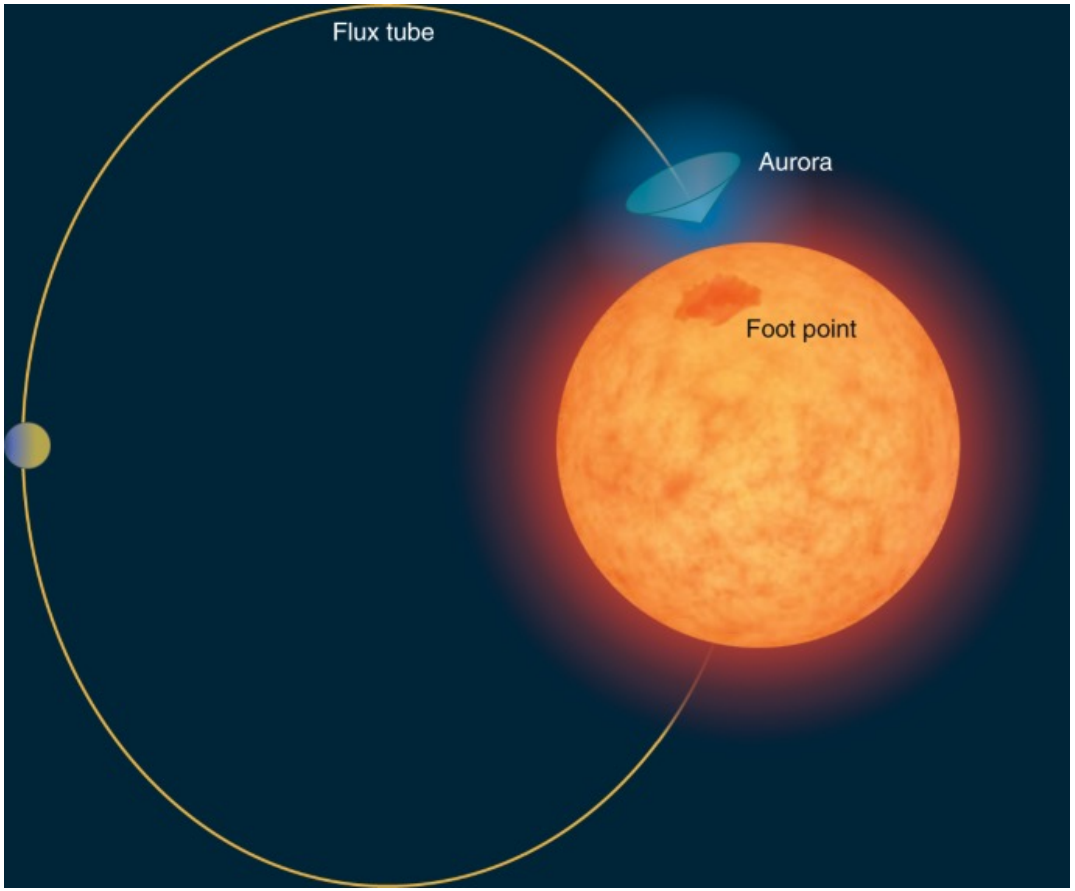


Tilt of the Magnetic Axis



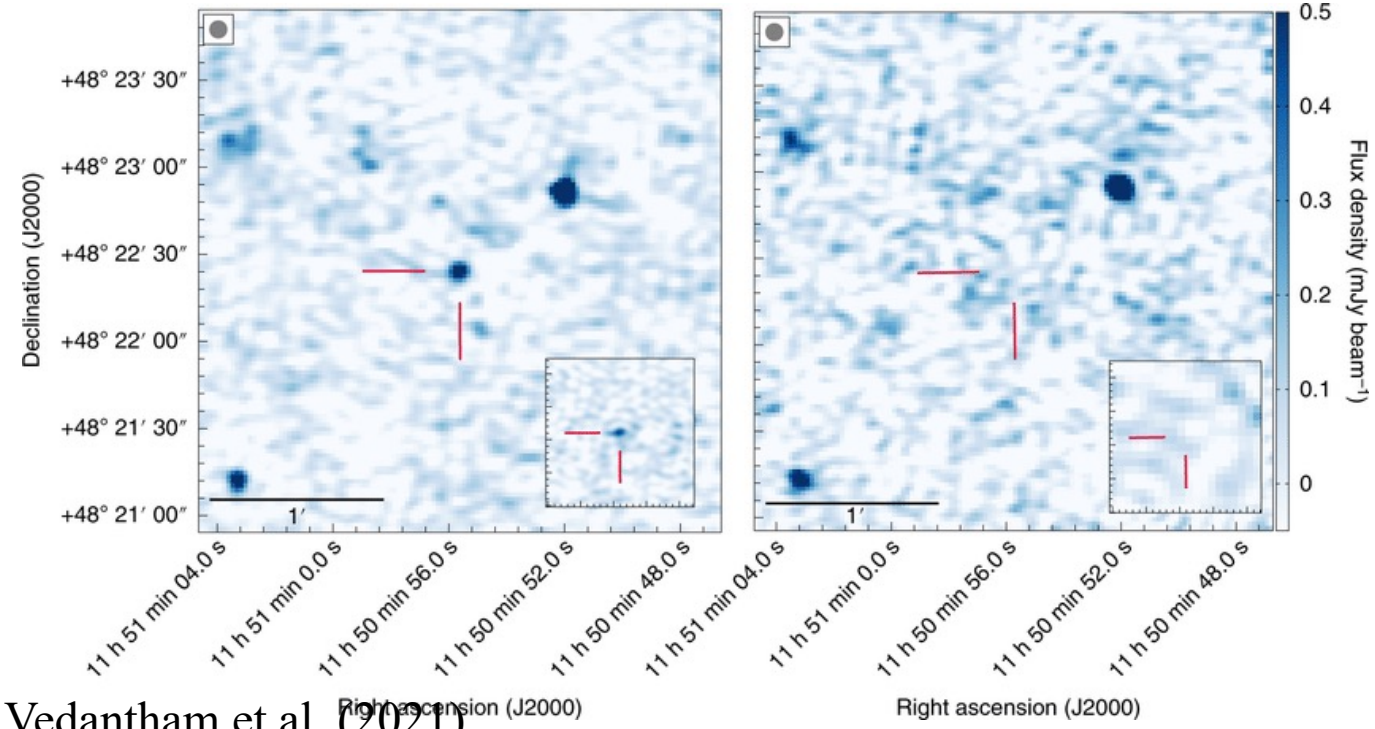
Star-Planet Interaction

- Planets can also generate aurora on the host star
- Similar to Io-Jupiter mechanism

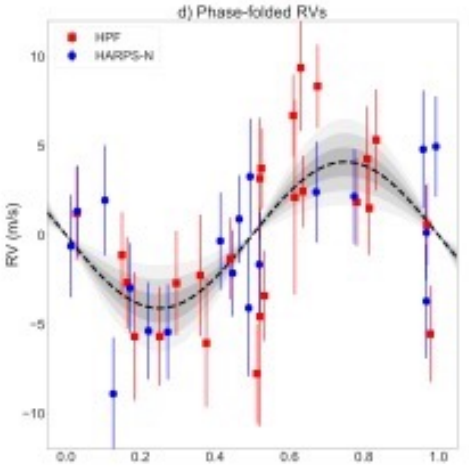


Possible Detections

- LOFAR detection of nearby star with variable, circularly polarized emission

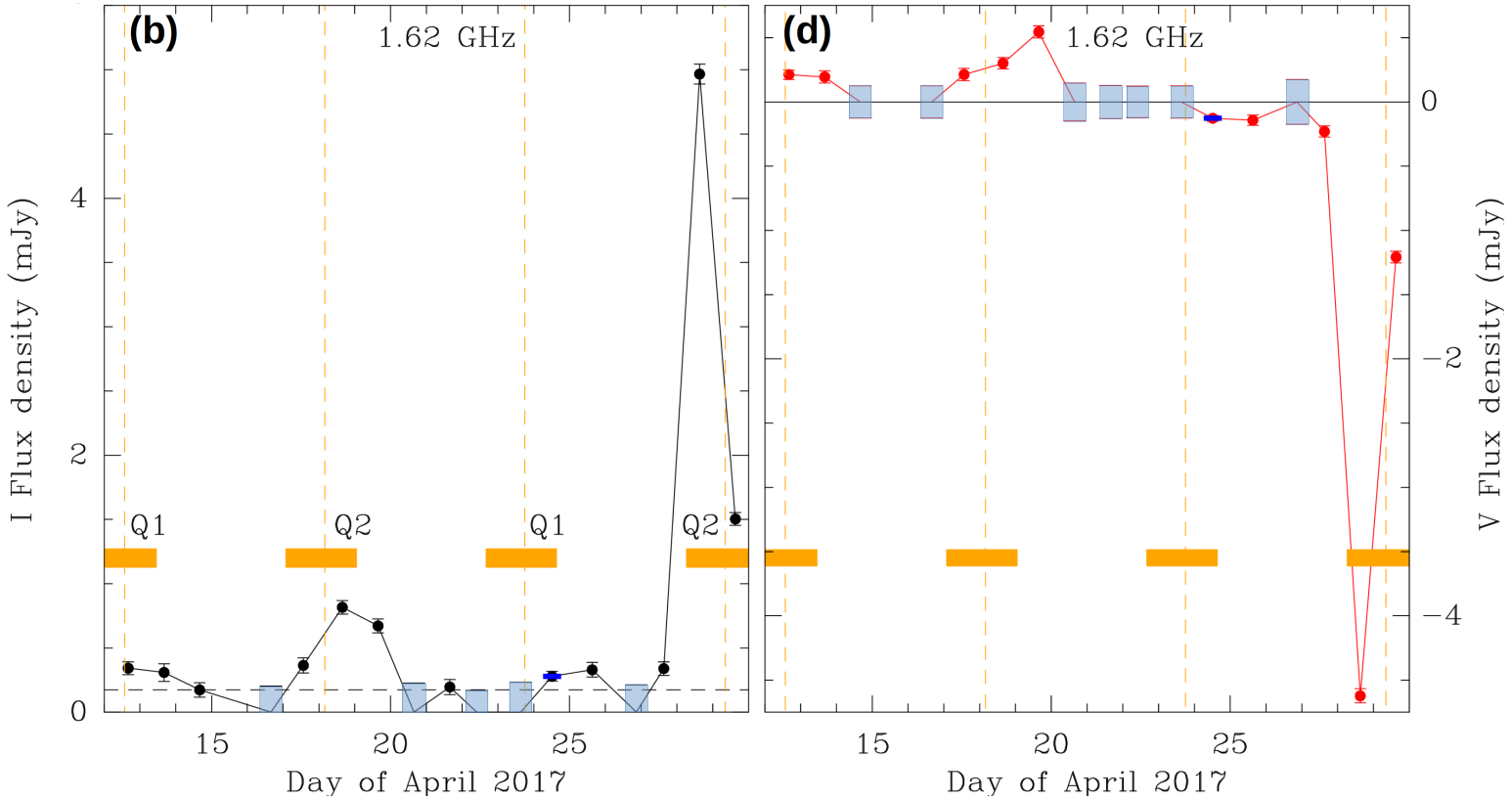


Vedantham et al. (2021)



Mahadevan et al. (2021)

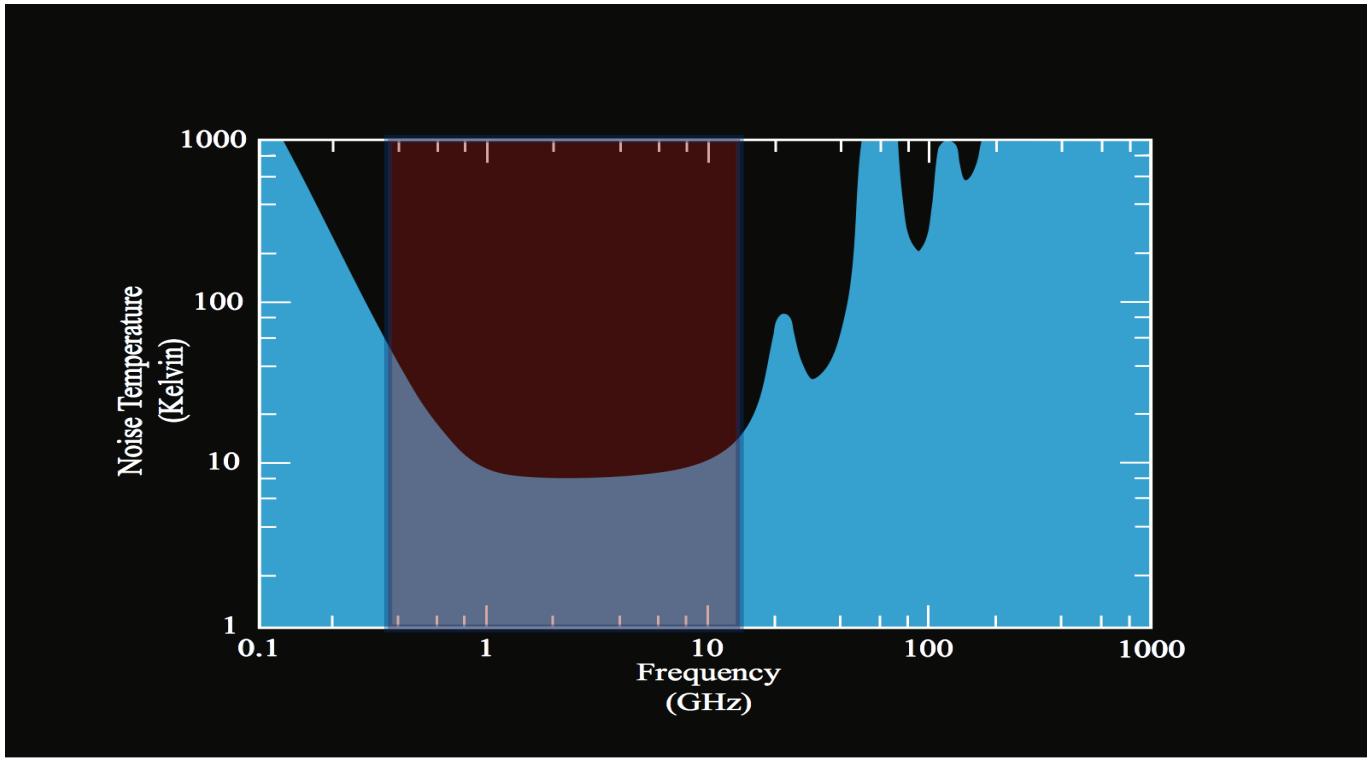
- Proxima Cen – closest star to us
- Radio emission properties consistent with known planet Proxima Cen b



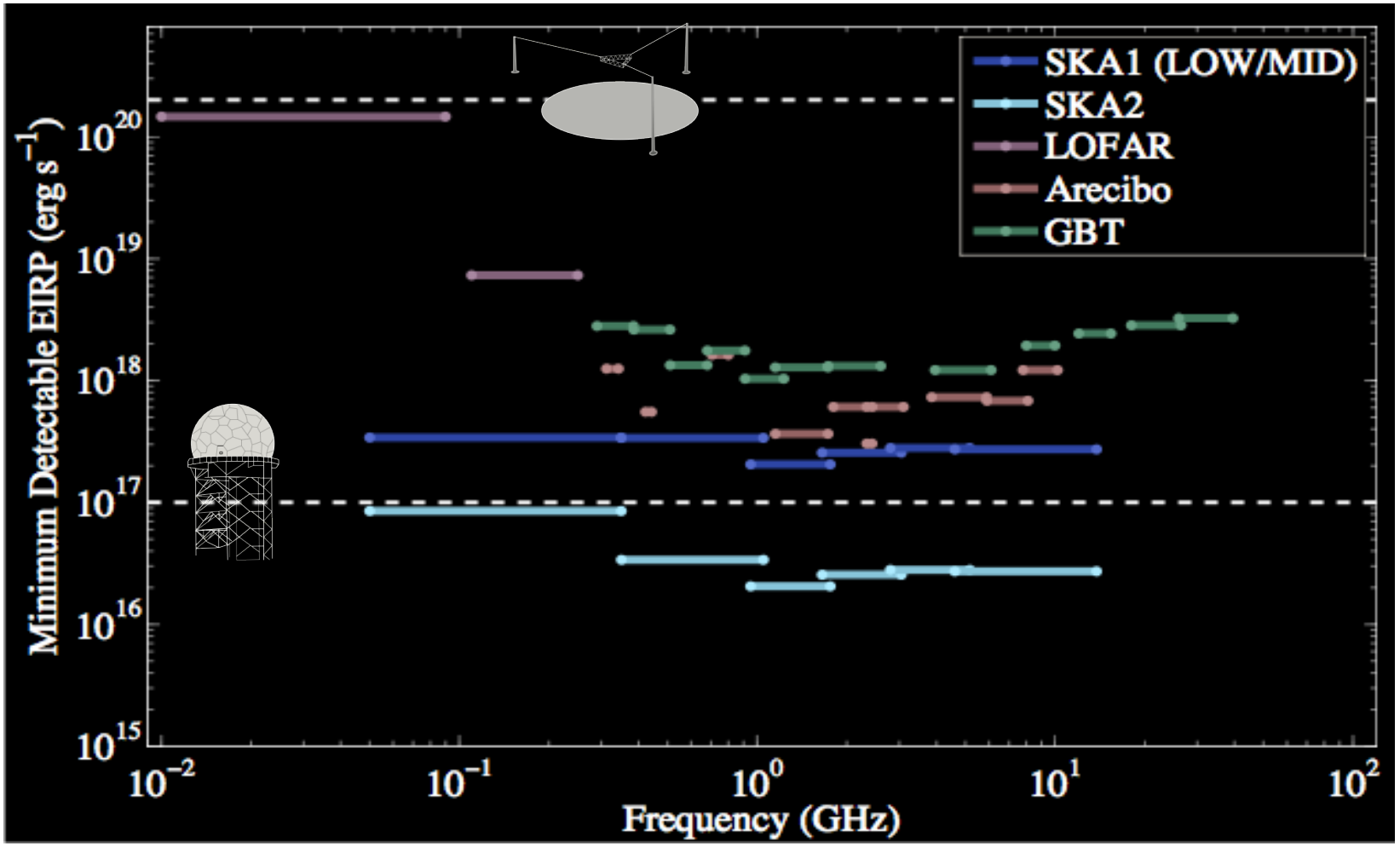
Perez-Torres et al. (2021)

SETI

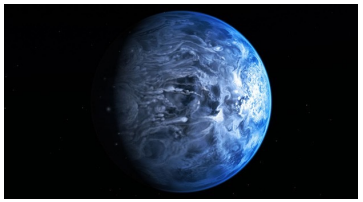
- Search for Extra-Terrestrial Intelligence
- Looking for non-natural radio signals



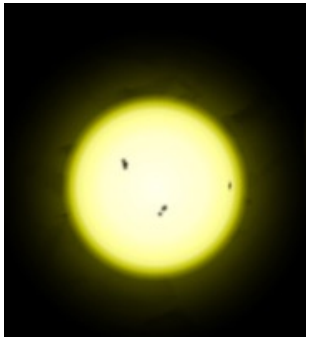
- SKA has sensitivity to detect Earth-like communications from near-by systems



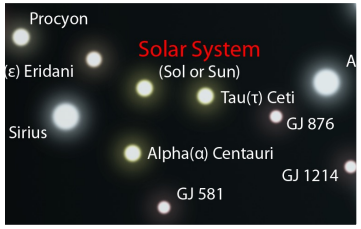
Potential Targets



Known Earth-like Exoplanets or Solar System-like Exoplanet Systems



Sun-like Stars



Nearby Stars

Summary

- Radio observations can contribute unique insights in to the study of exo-planets
- Detect and characterize the magnetic field of exo-planets
- Search for intelligent life