

The Search for Exoplanets

“Exoplanet” – a planet which exists
outside of our solar system.

Reading:

§27.4: Planetary systems

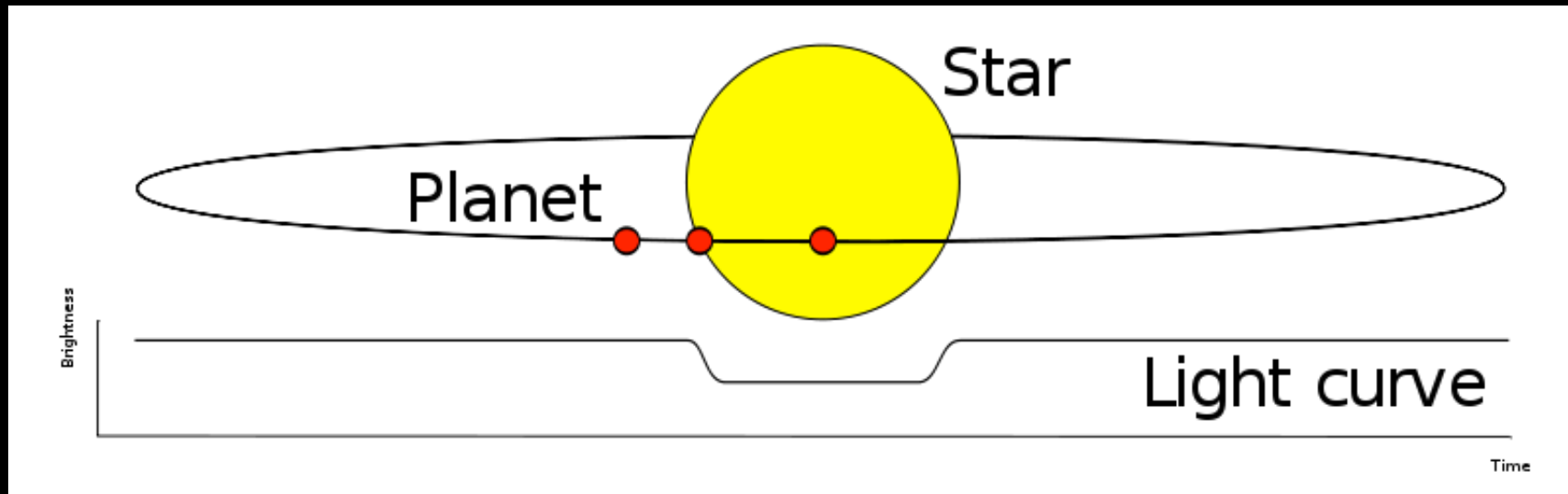
§22.3: Microlensing

§16.5: Spectra and Doppler Shift

Methods of Detection

- Transit method:
 - Periodic slight drop in brightness of star
- Wobble method:
 - Doppler shift in radial velocity of star
- Microlensing method:
 - Periodic slight rise in brightness of star
- Direct Imaging:
 - Say “Cheese”

Transit Method

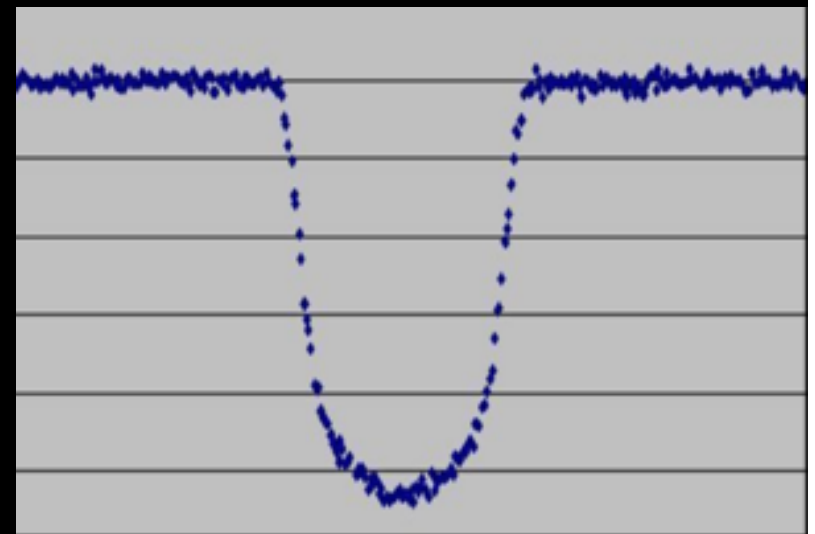


Brightness of star measured regularly to high precision, creating a Light Curve.

Slight drop in brightness may be due to planet passing in front of star.

Regular repetition establishes period of orbit.

Duration of transit measures planet size.



Kepler 6b photometry

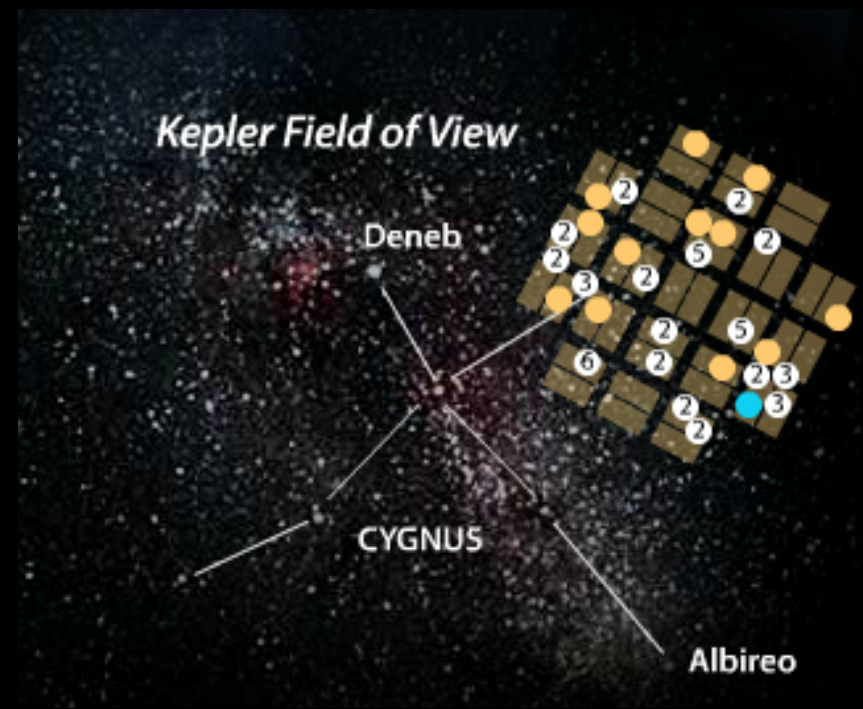
Kepler Mission

<http://kepler.nasa.gov/>

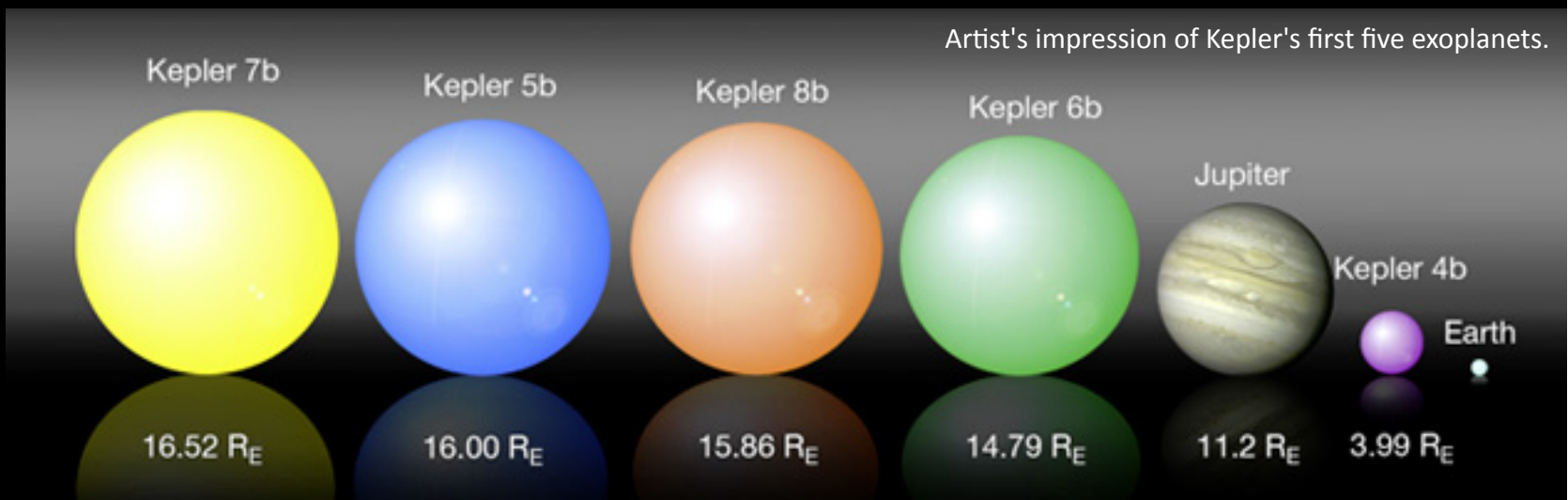
Launched March 7, 2009

Continuously monitors 145,000 stars in a fixed field of view

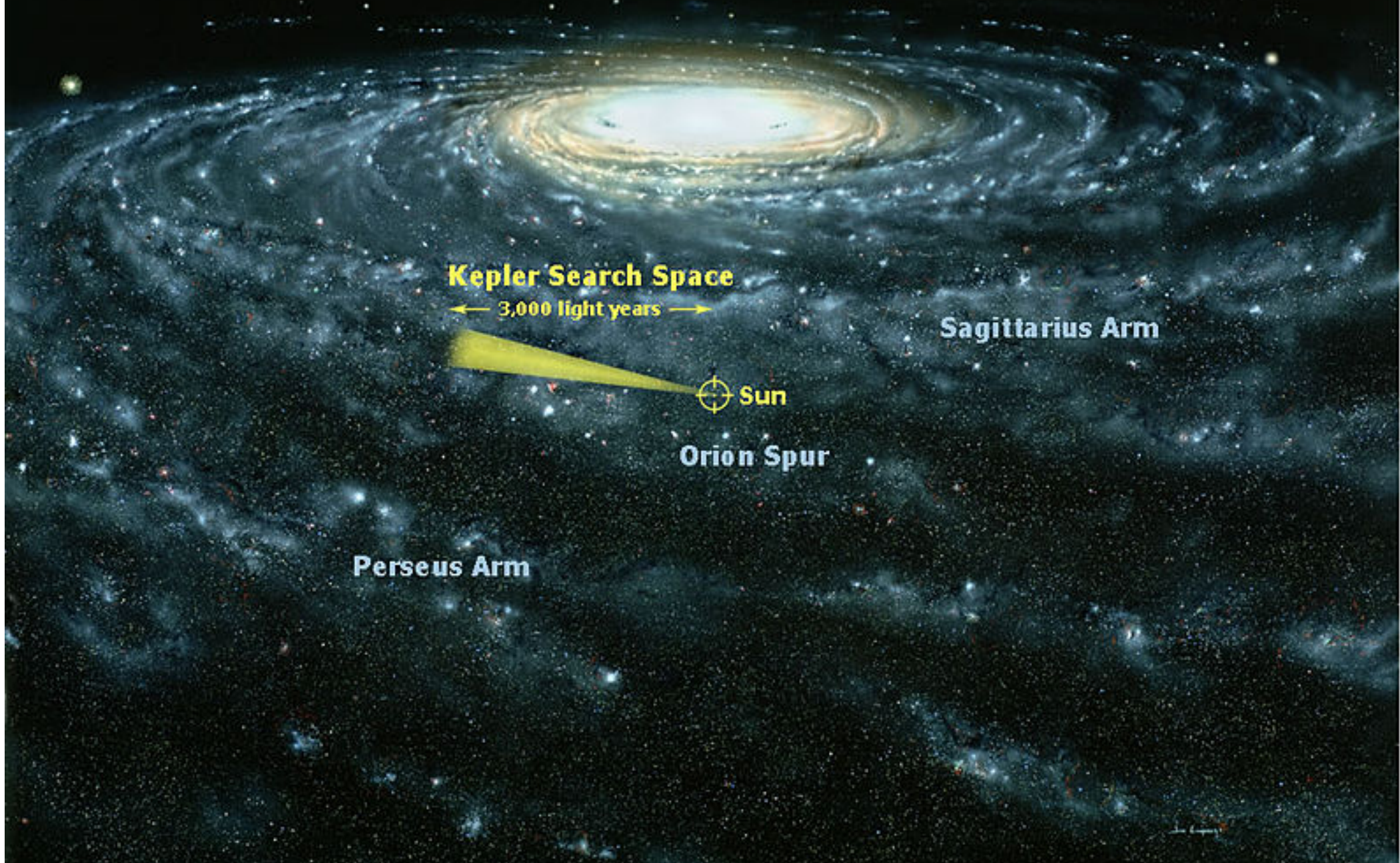
Candidates which show possible transits are called Kepler Objects of Interest (KOI's),



61 confirmed planets, 2,326 candidates



Milky Way Galaxy



Kepler Search Space

← 3,000 light years →

Sagittarius Arm

Sun

Orion Spur

Perseus Arm



THE MEARTH PROJECT

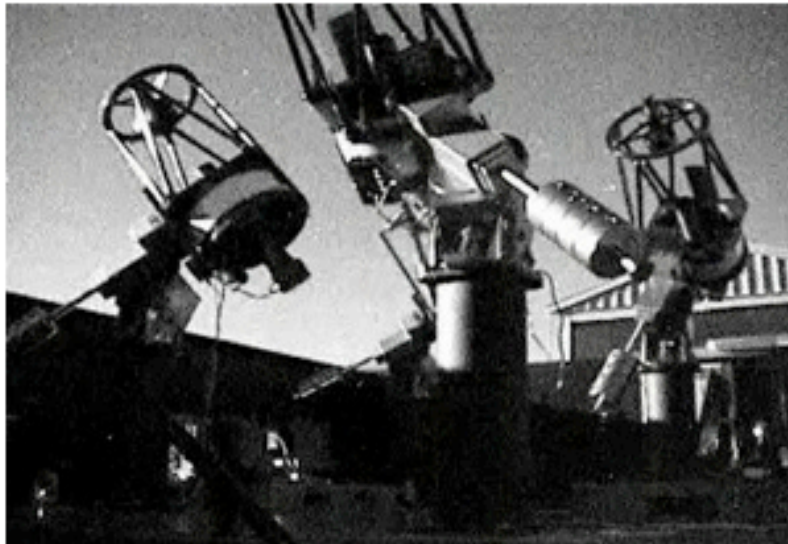
WELCOME

SCIENCE

TEAM

TELESCOPES

DISCOVERIES



*The **MEarth** Project (pronounced "mirth") is an astronomical survey that is using robotic telescopes to observe nearby **M** dwarf stars in search of new **Earth-like** exoplanets.*

*Please explore this website to learn more about exoplanets, **M** dwarfs, and our project!*

Searching for Habitable Exoplanets around Nearby Small Stars

An exciting frontier of modern astronomy is the quest to find planets around stars other than the Sun. Of particular interest are those planets that are the right size and

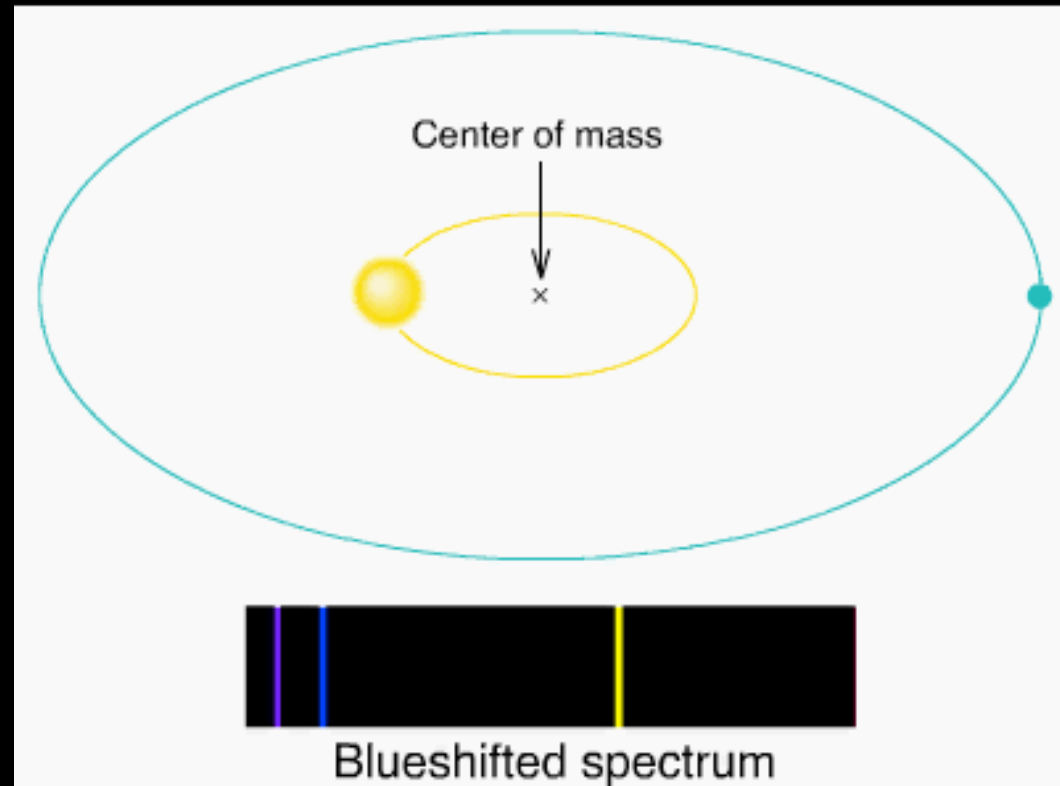
Wobble Method

Also called “Radial velocity” method,
or “Doppler Shift” method.

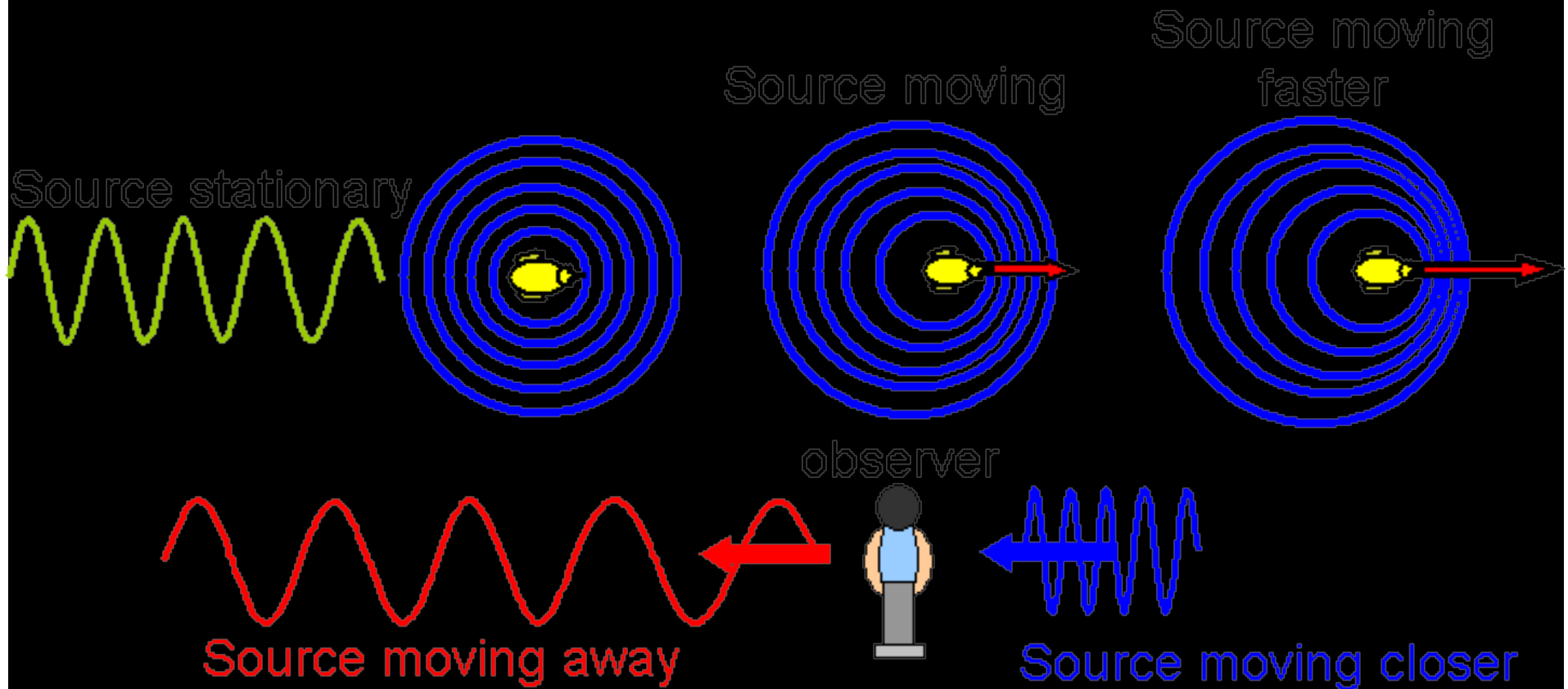
Spectral lines of a star are measured
with very high precision.

Small changes due to the *Doppler
Effect* indicate changes in radial
velocity of the star.

Periodic variations can indicate a
companion.



Dopper Effect



Source moving away \Rightarrow longer wavelength = "Red Shift"
Source moving towards \Rightarrow shorter wavelength = "Blue Shift"

Animation...

Microlensing

Light from a source star passing near a “Lens” star is bent toward observer, resulting in brightening of the image of the source star. Periodic changes in brightness can indicate the presence of a planet.



As of January 2011, eleven exoplanets have been detected via microlensing.

Microlensing also used to search for “MACHO”s (MASSive Compact Halo Objects) independent of any star.

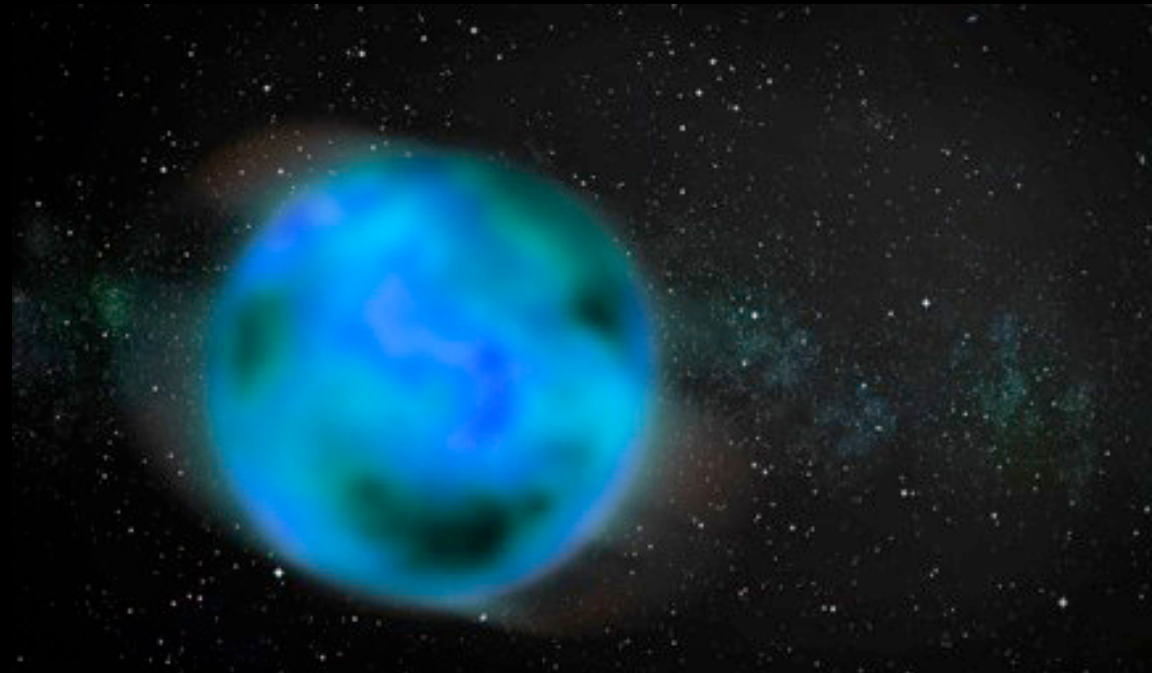
Nomad Planets

Around 12 planets detected by gravitational microlensing which are not bound to any star.

Conventional estimate suggests 2 nomad planets for every main sequence star in the galaxy.

Recent estimate from Kavli Institute at Stanford University suggests perhaps 50,000 nomad planets per star.

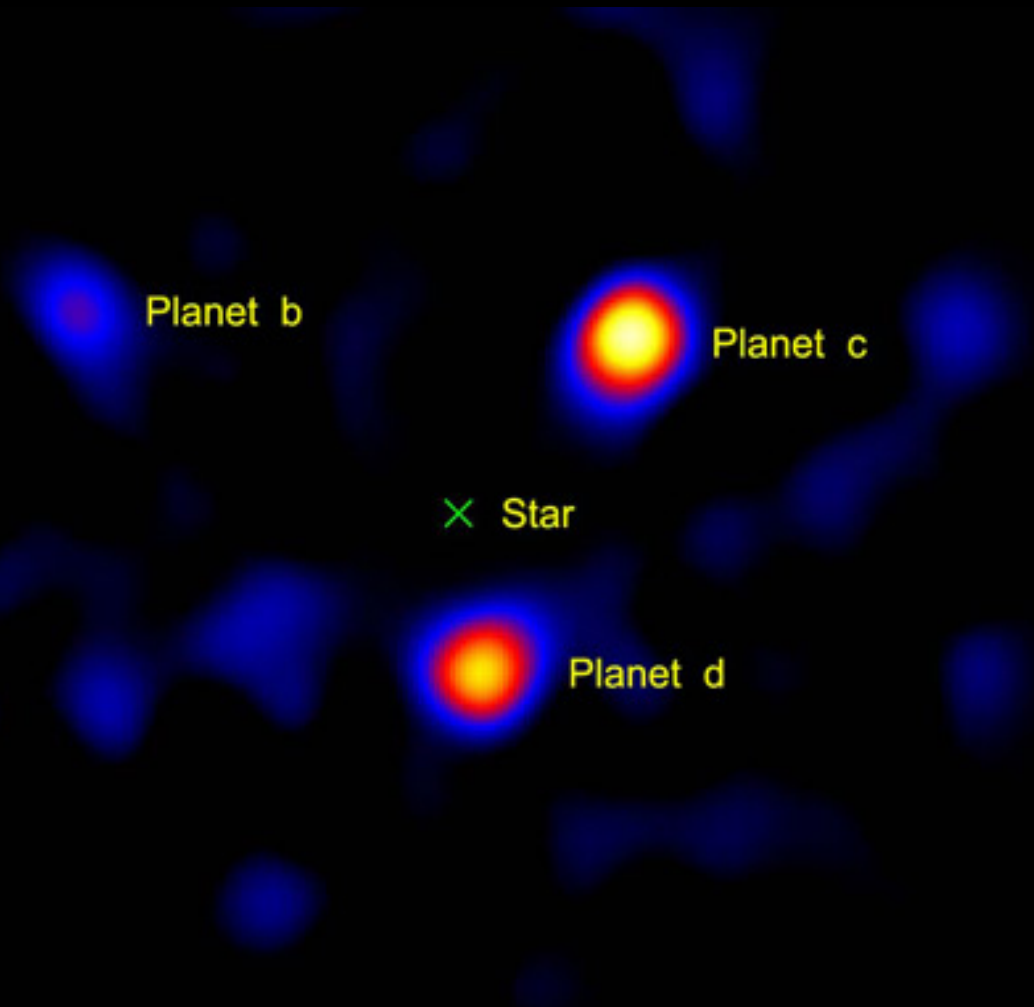
We shall see....



This image is an artistic rendition of a nomad object wandering the interstellar medium. The object is intentionally blurry to represent uncertainty about whether it has an atmosphere. A nomadic object may be an icy body akin to an object found in the outer solar system, a more rocky material akin to asteroid or even a gas giant similar in composition to the most massive solar system planets and exoplanets.

Direct Imaging

Three planets orbit the star HR8799 (which is blanked out). The planets are thought to be gas giants, larger than Jupiter, with orbital distances of 24, 38, and 68 AU.



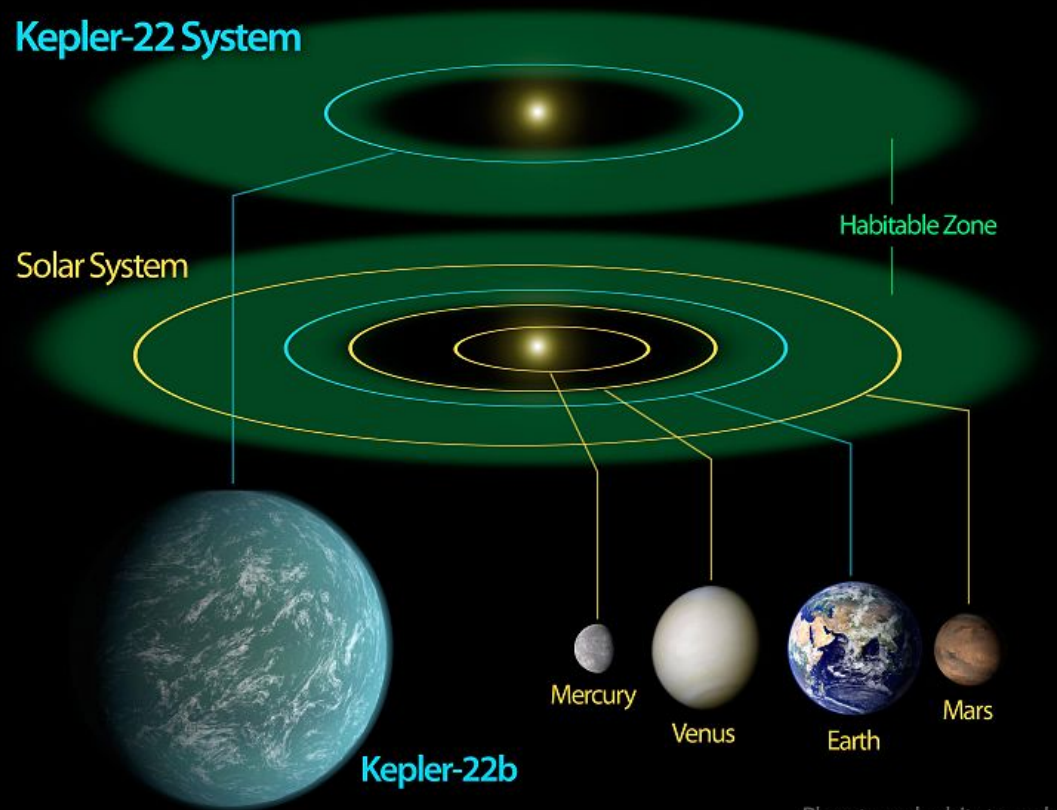
Currently 12 planets detected by direct imaging: [List](#)

Image credit: NASA/JPL-Caltech/Palomar Observatory

Habitable Zone

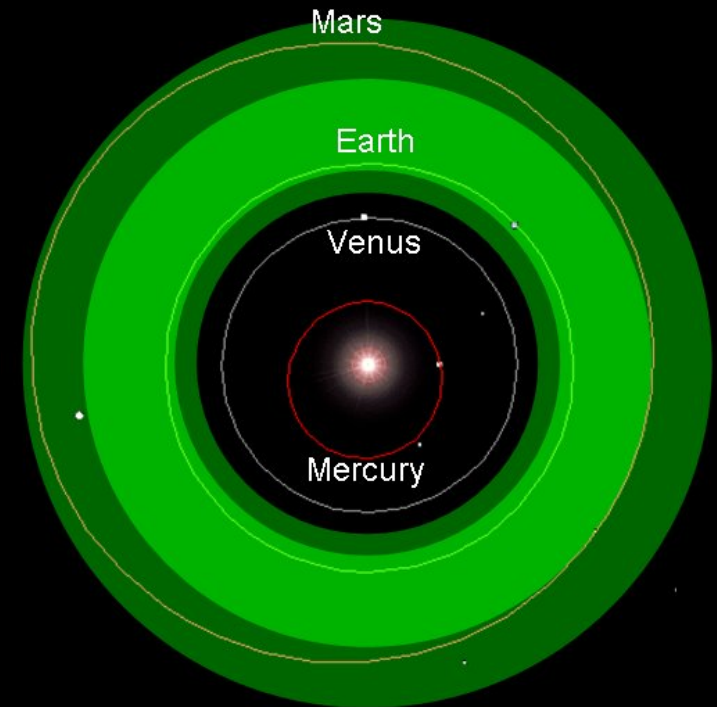
The region around a star where a planet with sufficient atmospheric pressure can maintain liquid water on its surface.

Kepler-22 System



Planets and orbits to scale

Sun's habitable zone



- Conservative
- Optimistic