The Search for Extrasolar Planets

Dr. Jennifer Marshall
Munnerlyn Astronomical Instrumentation Lab
Mitchell Institute for Fundamental Physics and Astronomy
Department of Physics and Astronomy
Texas A&M University

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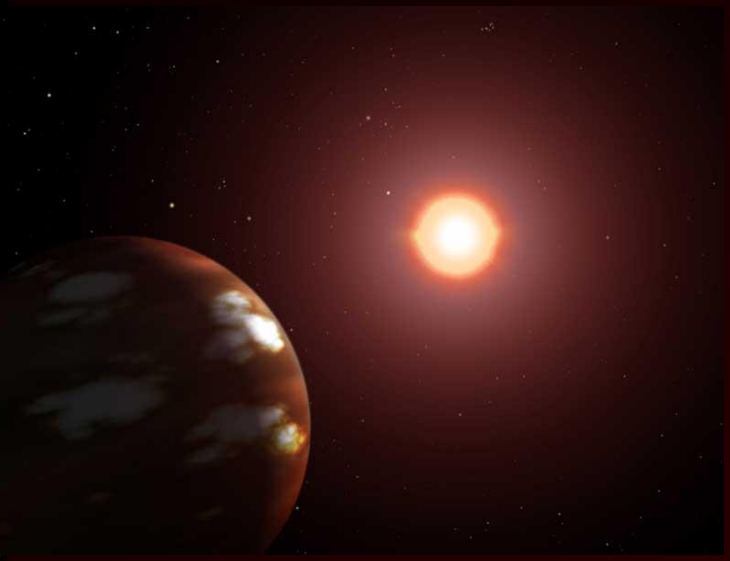
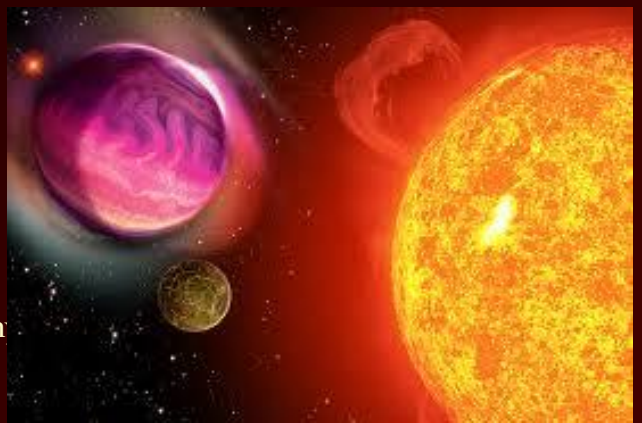
What is an extrasolar planet?



Artist's View of an Ultra-Short-Period Planet

NASA, ESA, and A. Schaller • STScI-PRC06-34c



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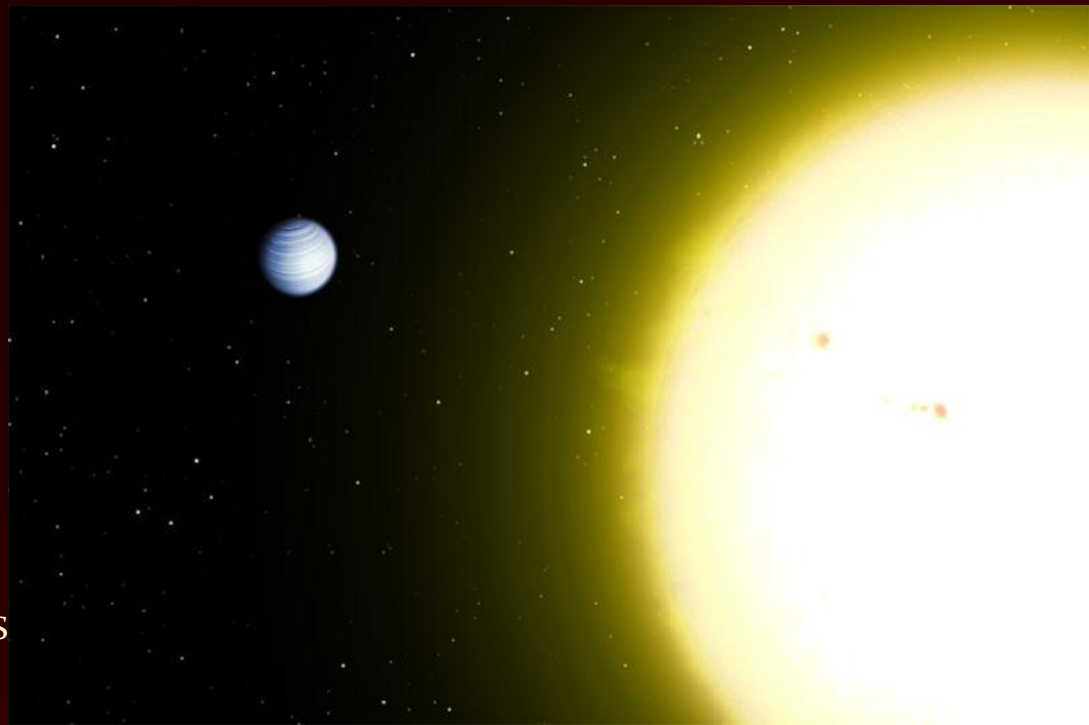
What is an extrasolar planet?

- A planet outside of our solar system orbiting a star other than our Sun
- First discovered by Mayor in 1995
- 847 extrasolar planets currently known!

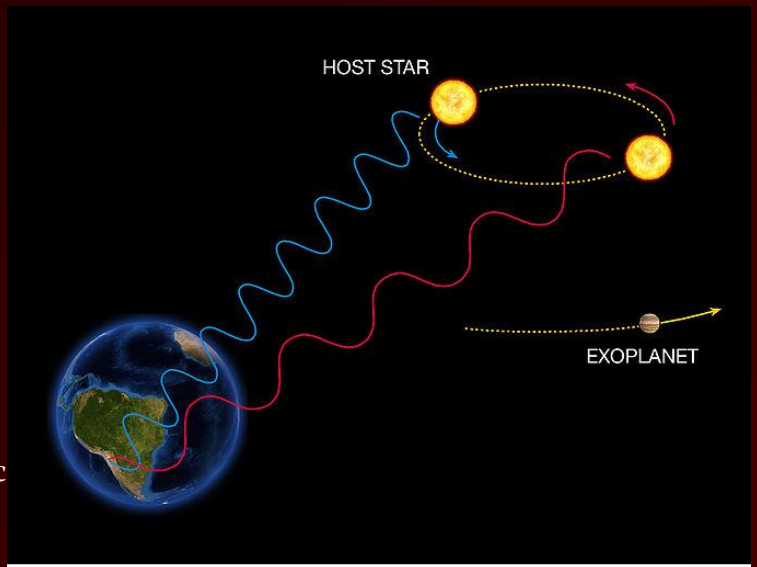


How do we find them?

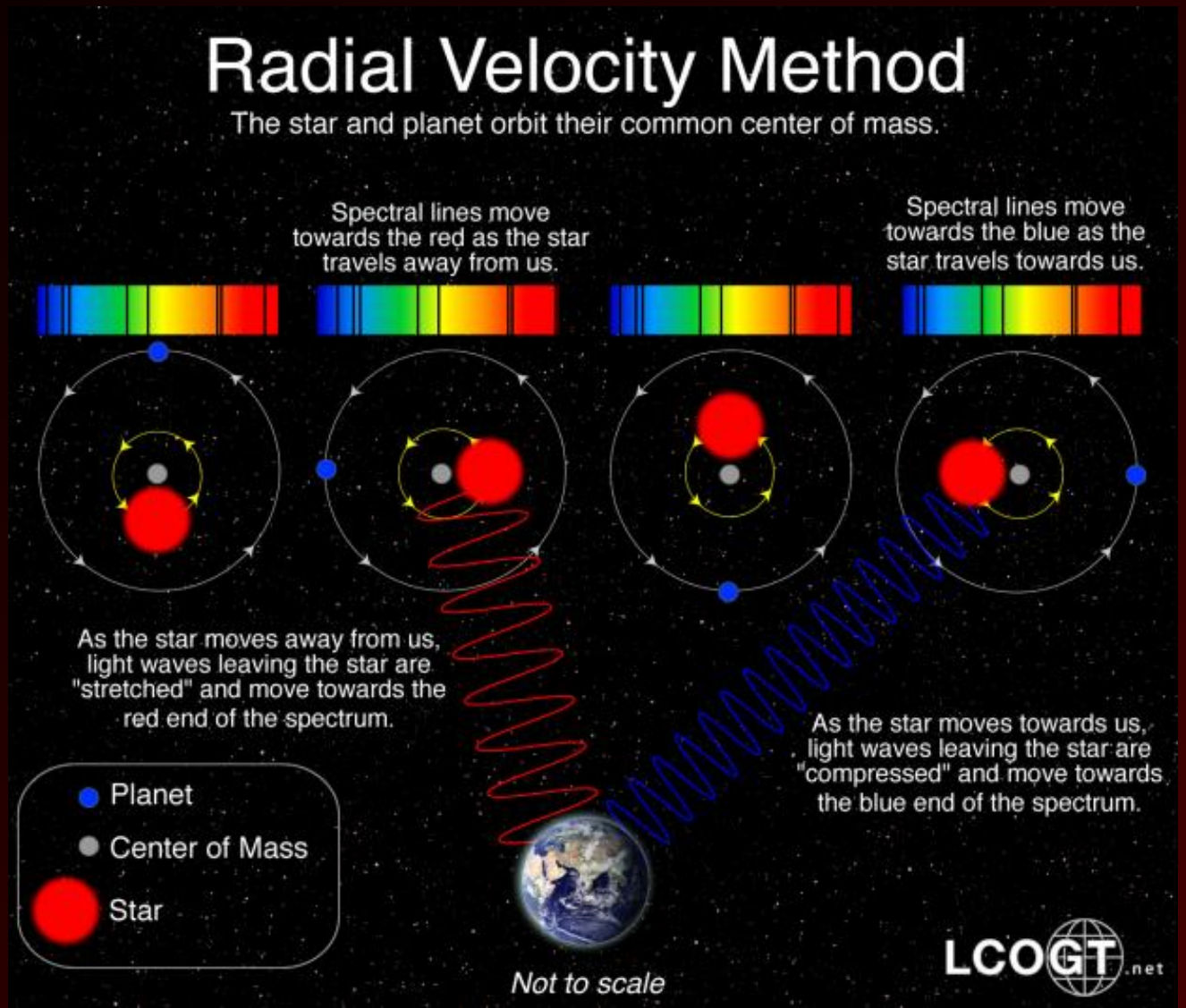
- Radial velocity method
- Planetary transit method
- Gravitational microlensing
- Direct imaging

Radial velocity method

- Radial velocity: speed of an object to or from observer along line of sight
- Can be measured in the spectrum of the object
- Light is shifted:
  - to the red when moving away from the observer
  - to the blue when moving towards the observer



Radial velocity method



HET telescope

- High resolution spectrograph on the HET telescope has found many planets
- Used nightly to study properties of extrasolar planets

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Planetary transits

- Orbiting planet crosses in front of host star slightly dimming light from the star
- Hard to measure: a 1% effect!
- Allows radius of planet to be measured along with period
- Sometimes can also study atmosphere of planet

Planetary transits

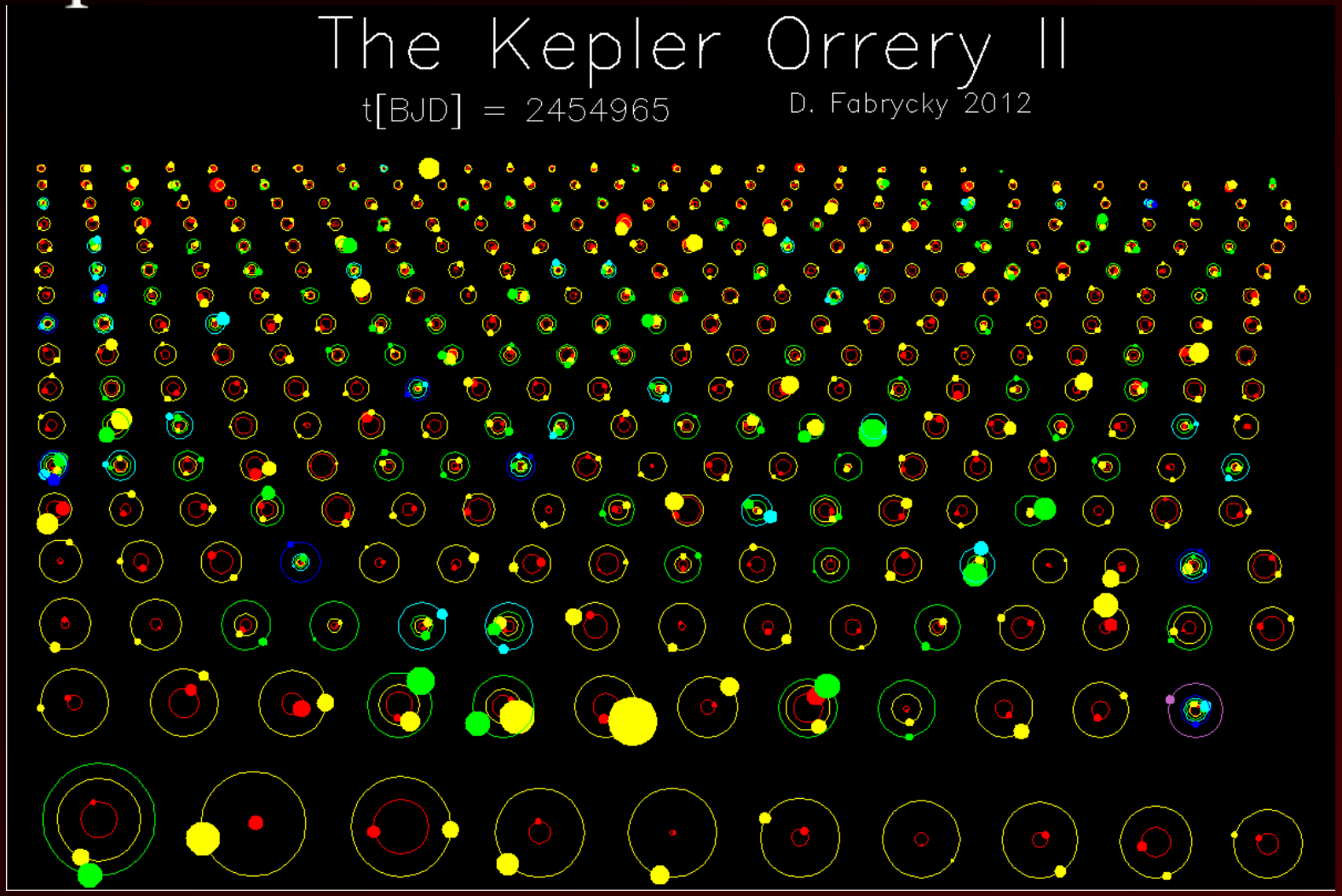
Kepler

Kepler

A Search for Terrestrial Planets

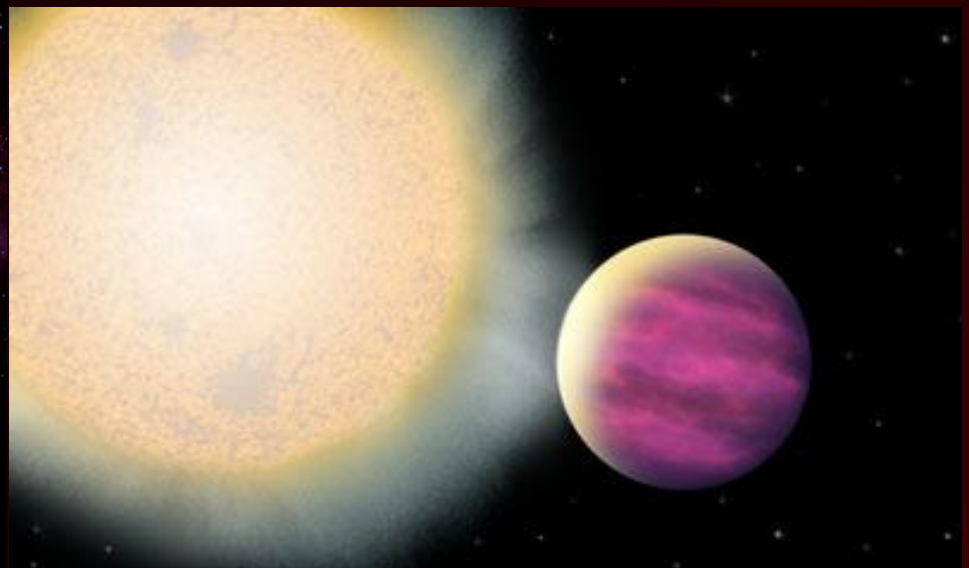
- NASA space mission
- Launched March 2009
- Discovered 116 planets and 2740 candidates as of January 2013

Kepler



KELT

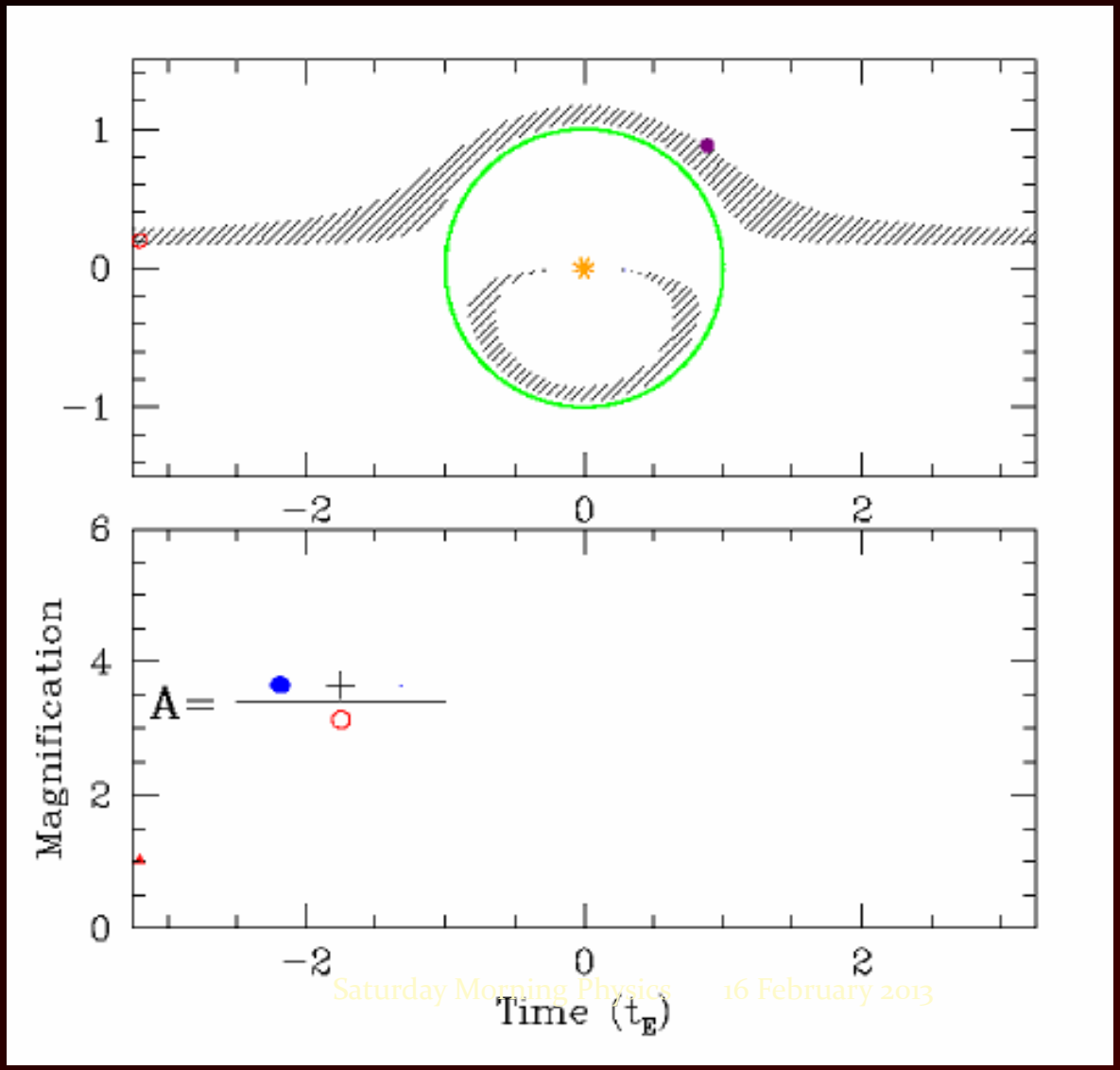
- Kilodegree Extremely Little Telescope
- Small telescope in Arizona operates nightly to find planets around bright stars
- Allows follow-up of candidates for more in-depth study
- Amateur astronomers conduct follow-up



Gravitational microlensing

- Light from distant star is bent by the gravitational field of a closer star passing in front of it
- Measurements of brightness vs. time = lightcurve
- Signature of planet can be seen as a characteristic "blip" in the lightcurve
- Requires constant monitoring of stars to search for planet signatures

Gravitational microlensing



LCOGT

- Worldwide network of telescopes can be used to search for microlensing events
- Amateurs also conduct follow-up observations

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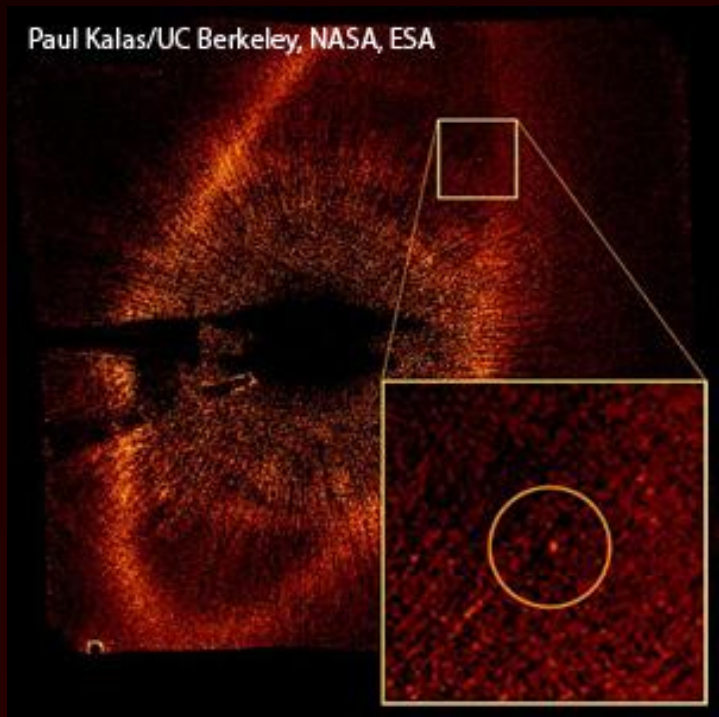
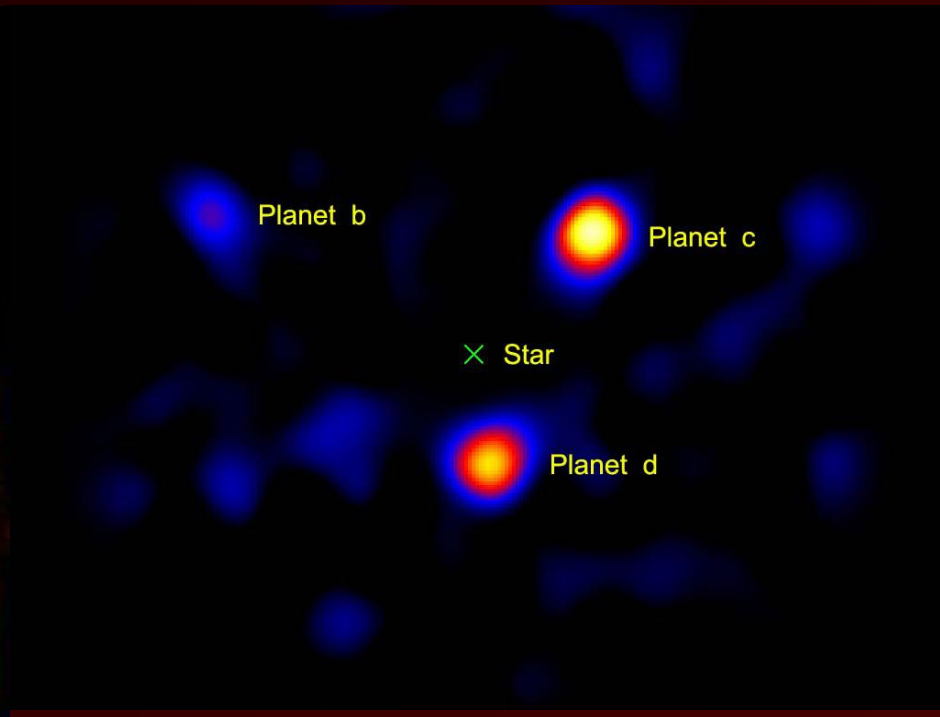
Direct Imaging

- Block light from host star to image planets
- Star is 1 million times brighter than the planet—this is difficult to do!



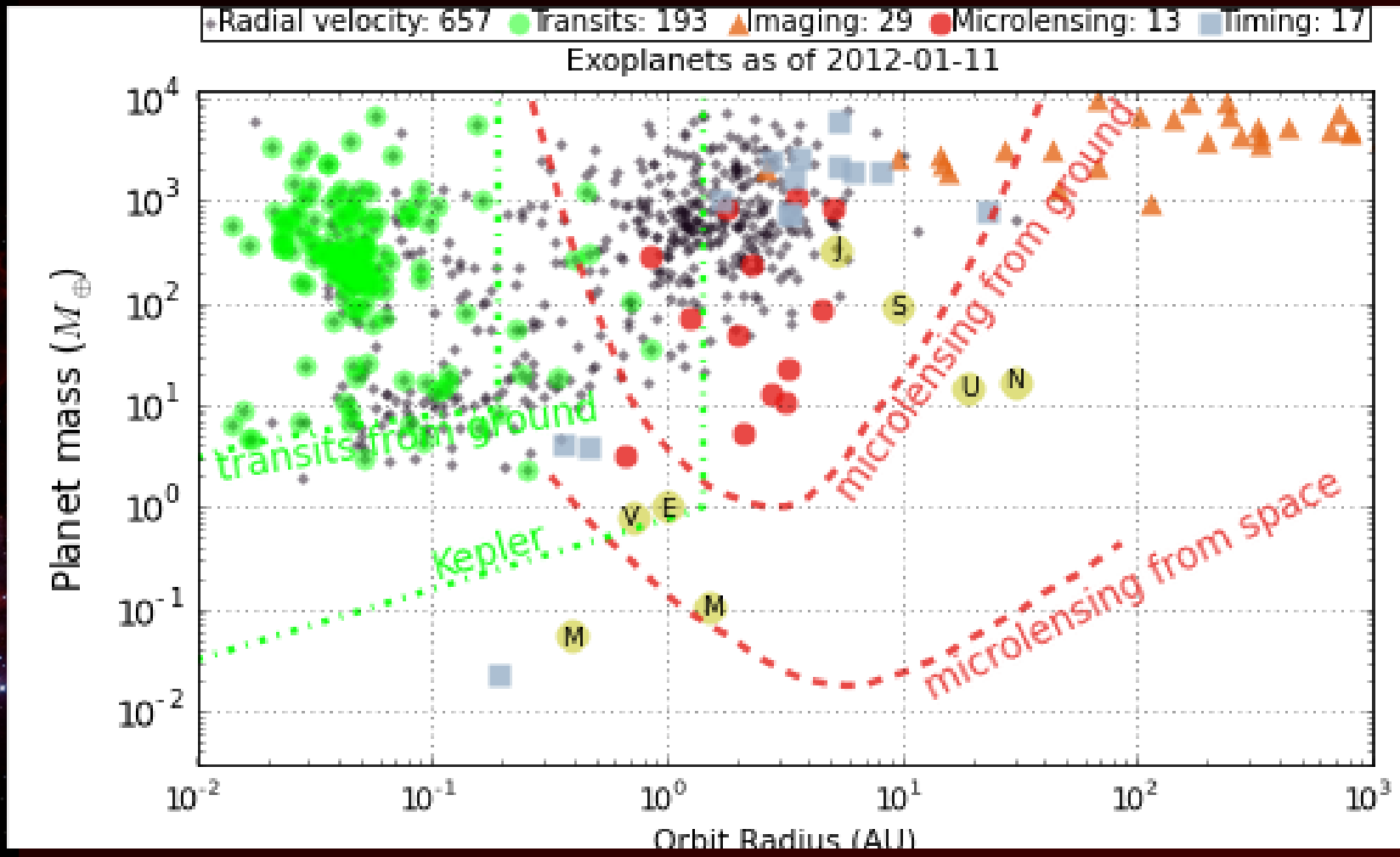


How many planets have we found?

- Radial velocity: 503 planets in 390 systems
- Planetary transits: 294 planets in 238 systems
- Gravitational microlensing: 18 planets in 16 systems
- Direct imaging: 32 planets in 28 systems

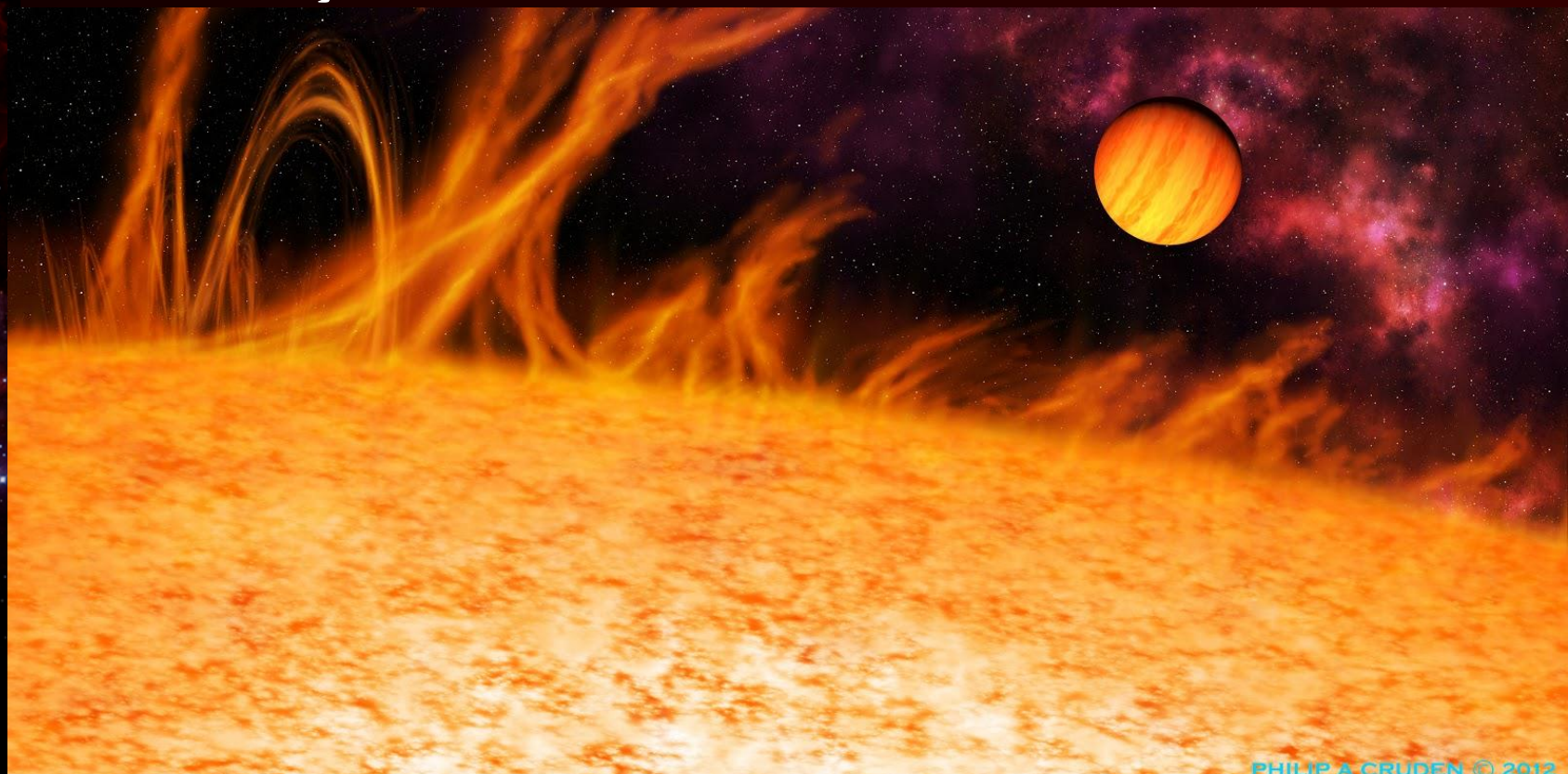
- Total: 847 planets in 672 systems!

Sensitivity of different techniques



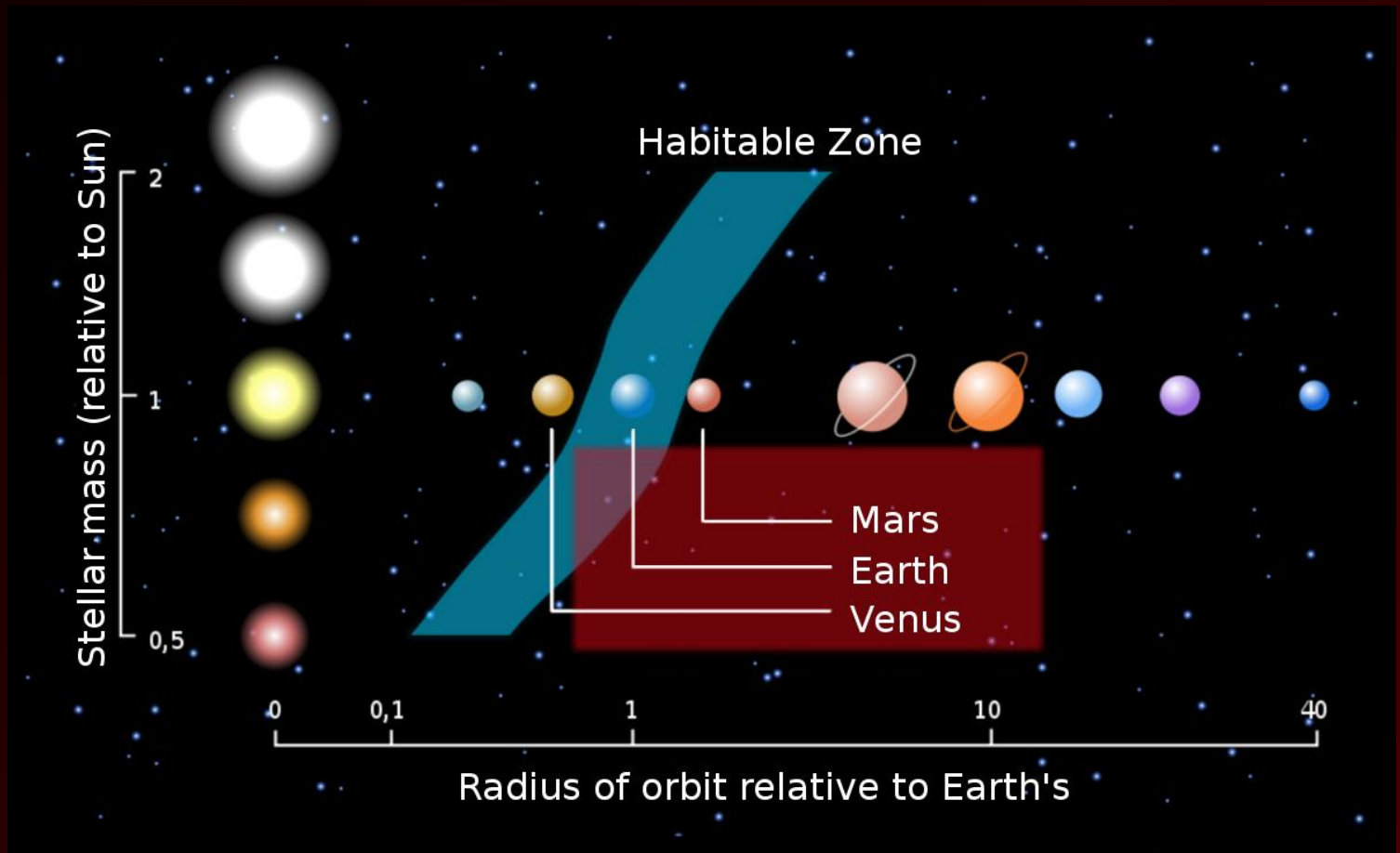
Hot Jupiters

- Orbits very close to host star
- Easy to find with radial velocity method
- Not likely to harbor life



Earth analogs

- Probably have characteristics similar to Earth
- More likely to harbor life



Life on extrasolar planets

- Astrobiology is a relatively new field with the goal of studying life outside of the Earth
- No life found in Solar System or on extrasolar planets (yet)
- Moons in SS (e.g., Titan and Enceladus) may have potential to harbor life
- Requirements: water, habitable zone

Future of extrasolar planet studies

- Kepler will continue to find large numbers of transiting planet candidates
- Planned next generation telescopes will be able to image extrasolar planets

E-ELT

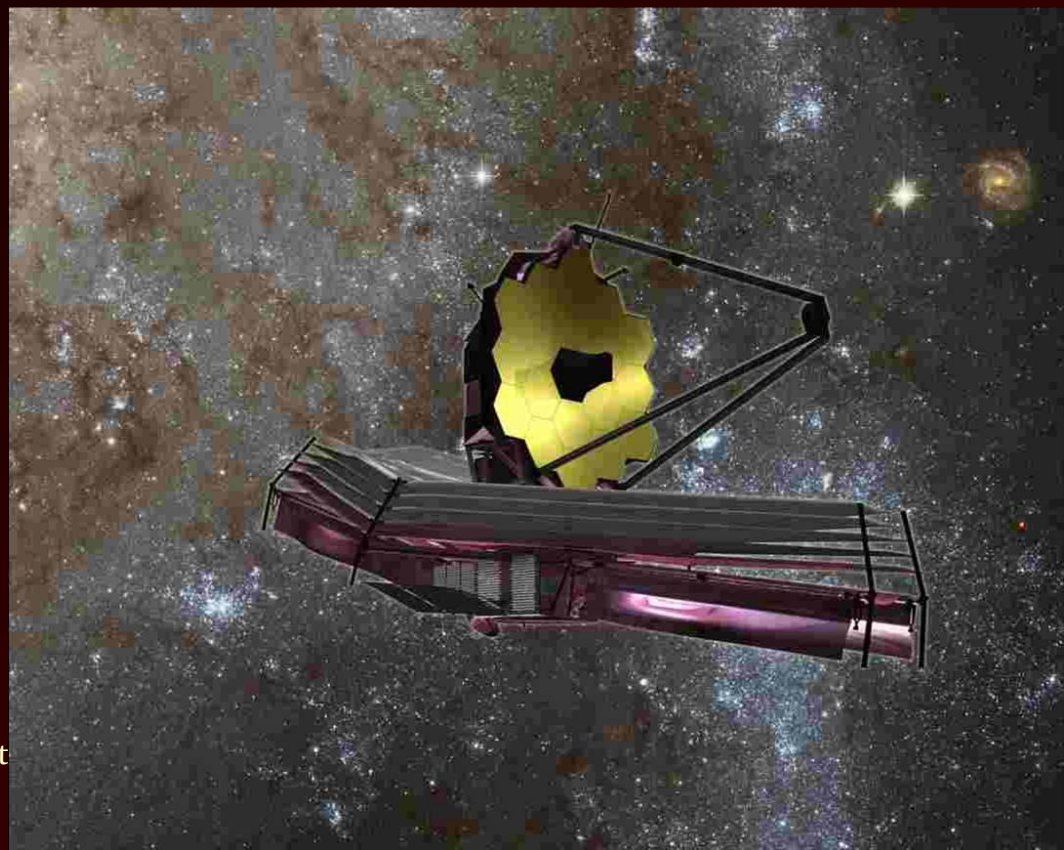
- 39 meter telescope with main goal of imaging extrasolar planets
- Planned first light early 2020s

Future of extrasolar planet studies

- Kepler will continue to find large numbers of planet candidates
- Planned next generation telescopes will be able to image extrasolar planets
- Ground- and space-based spectrographs will study the atmospheres of extrasolar planets to search for signs of water

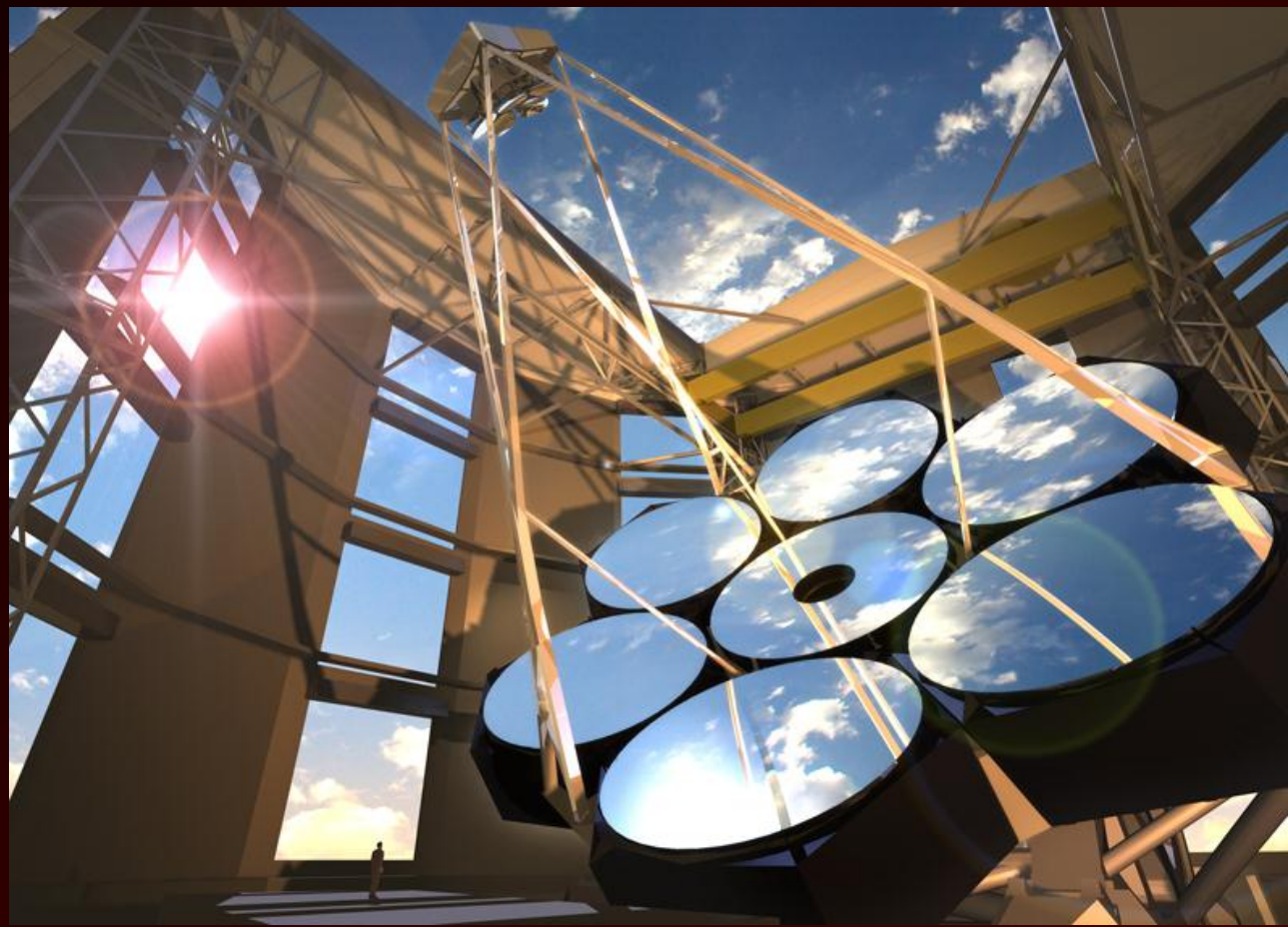
James Webb Space Telescope

- Planned next generation space telescope will image planets and study their atmospheres
- Planned launch in 2018



Giant Magellan Telescope

- Texas A&M is founding member of 28m telescope
- Planned first light in 2019



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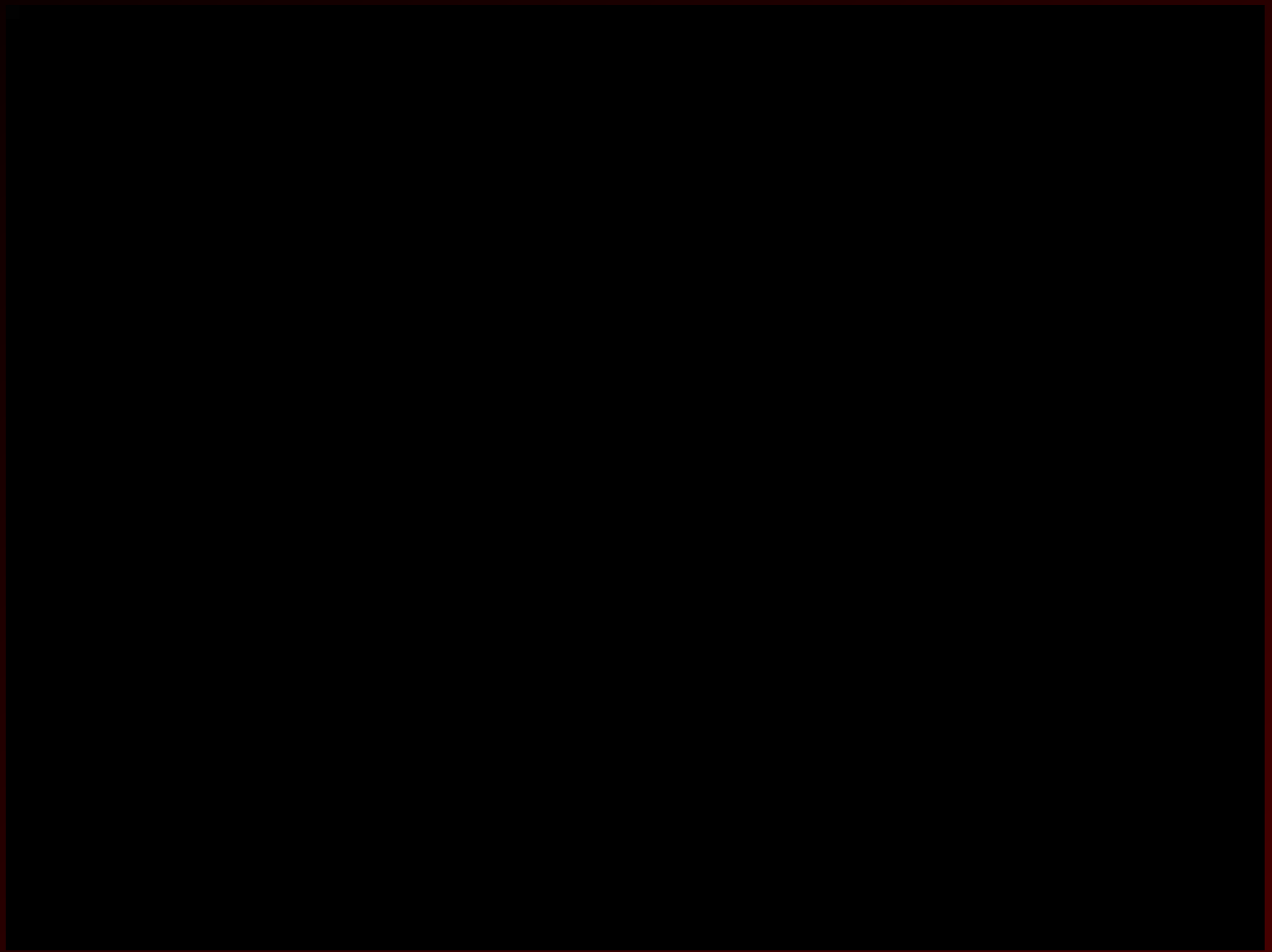
GMACS spectrograph



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The search for extrasolar planets

- Relatively young field has made much progress in the past 18 years
- One of the future "hot topics" in astronomy is astrobiology
- The search for life outside the Solar System is likely to be popular for many years

The search for extrasolar planets

"The nature of life on earth and the quest for life elsewhere are two sides of the same question: the search for who we are."

—Carl Sagan