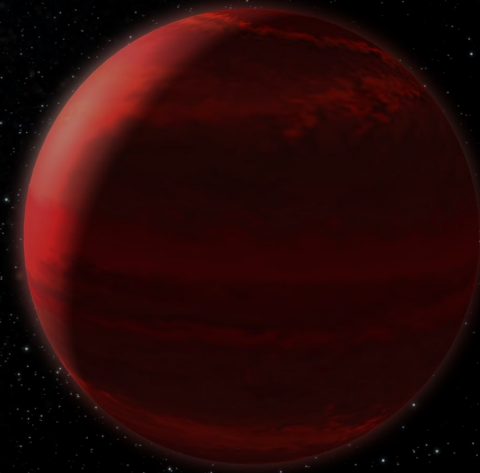


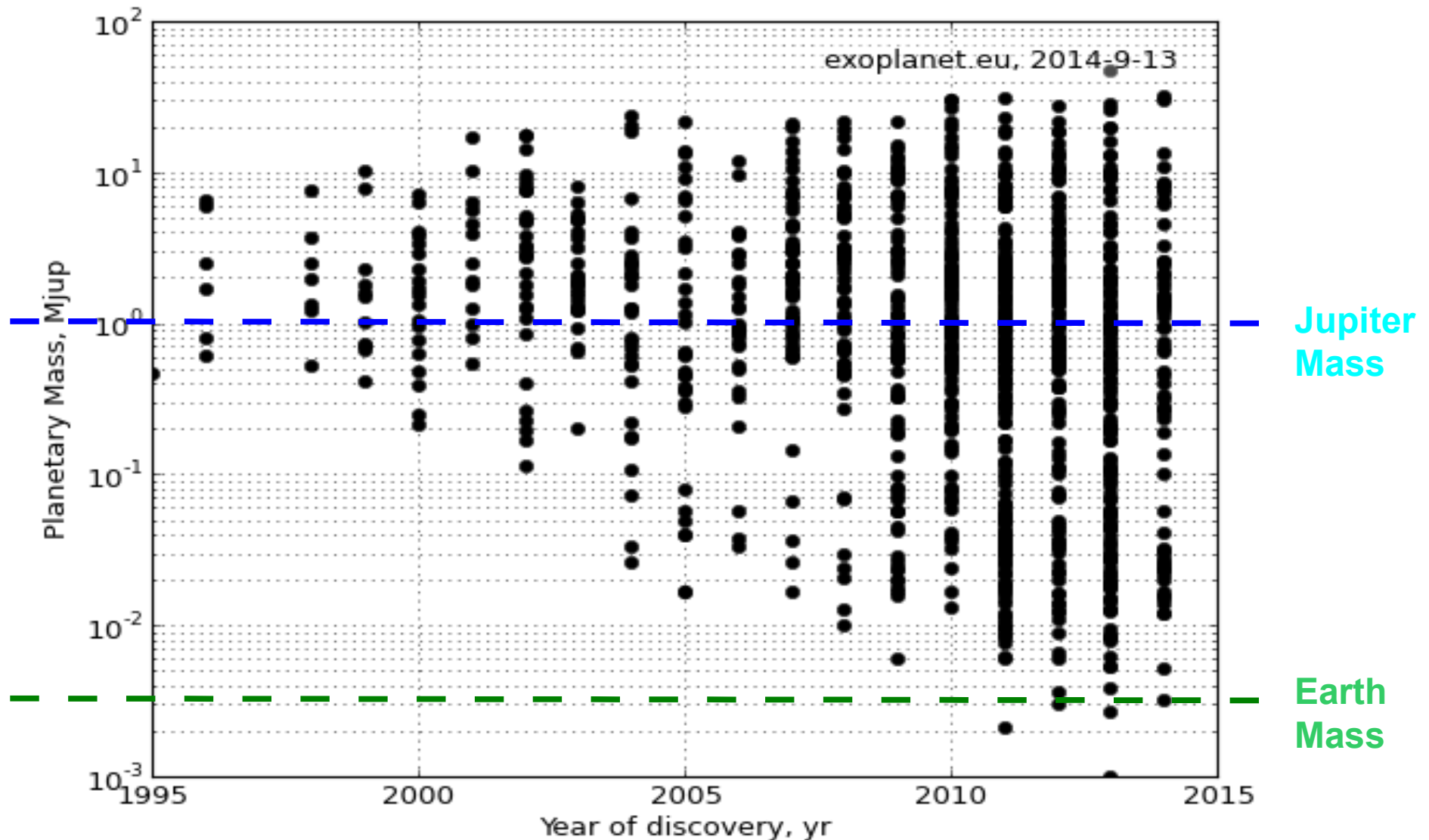
Anybody out there ?

Imaging exoplanets

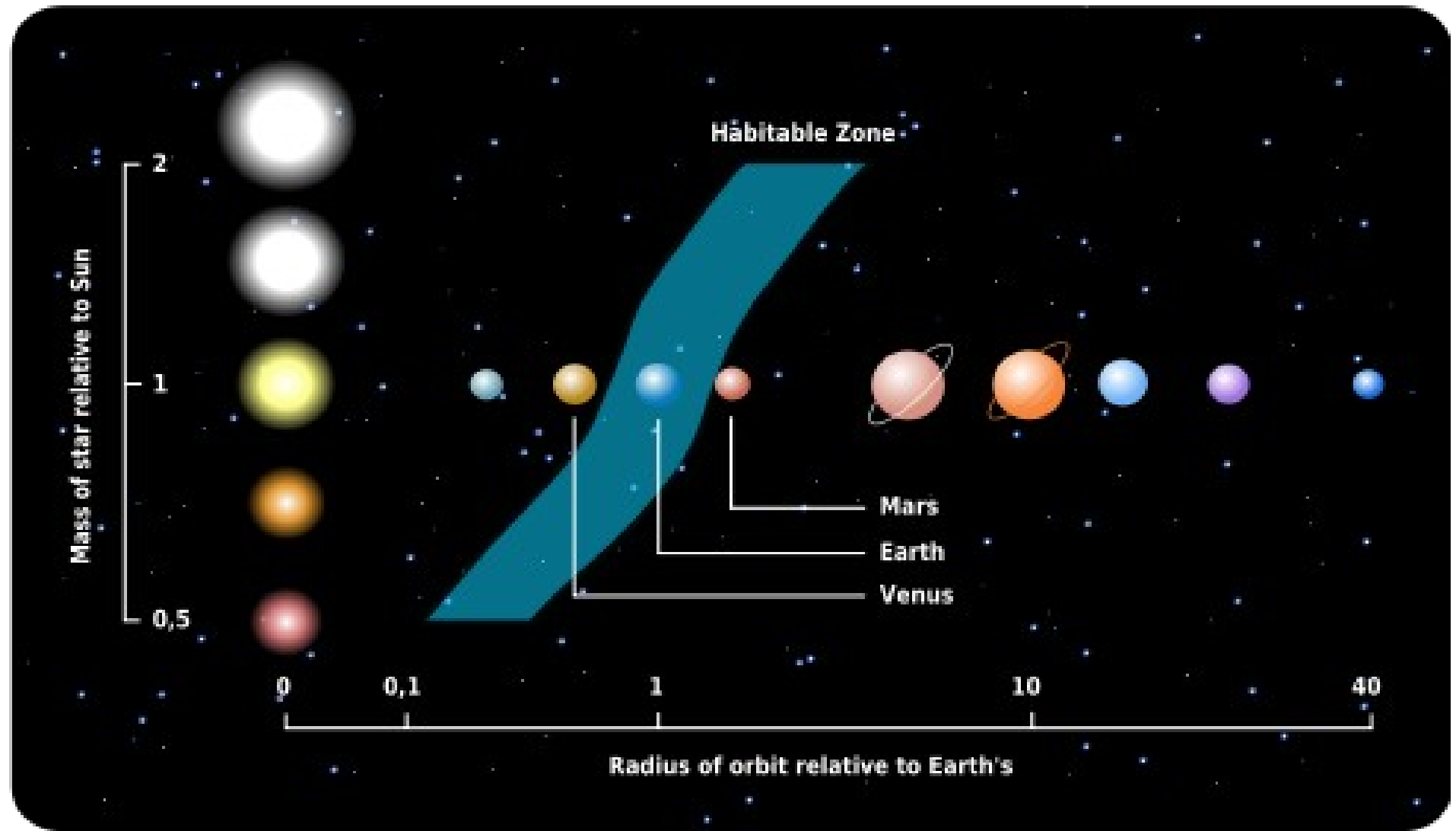


Contact: oliv.guyon@gmail.com

Planets identified – we are now starting to identify Earth-size planets



Habitable zone of a star

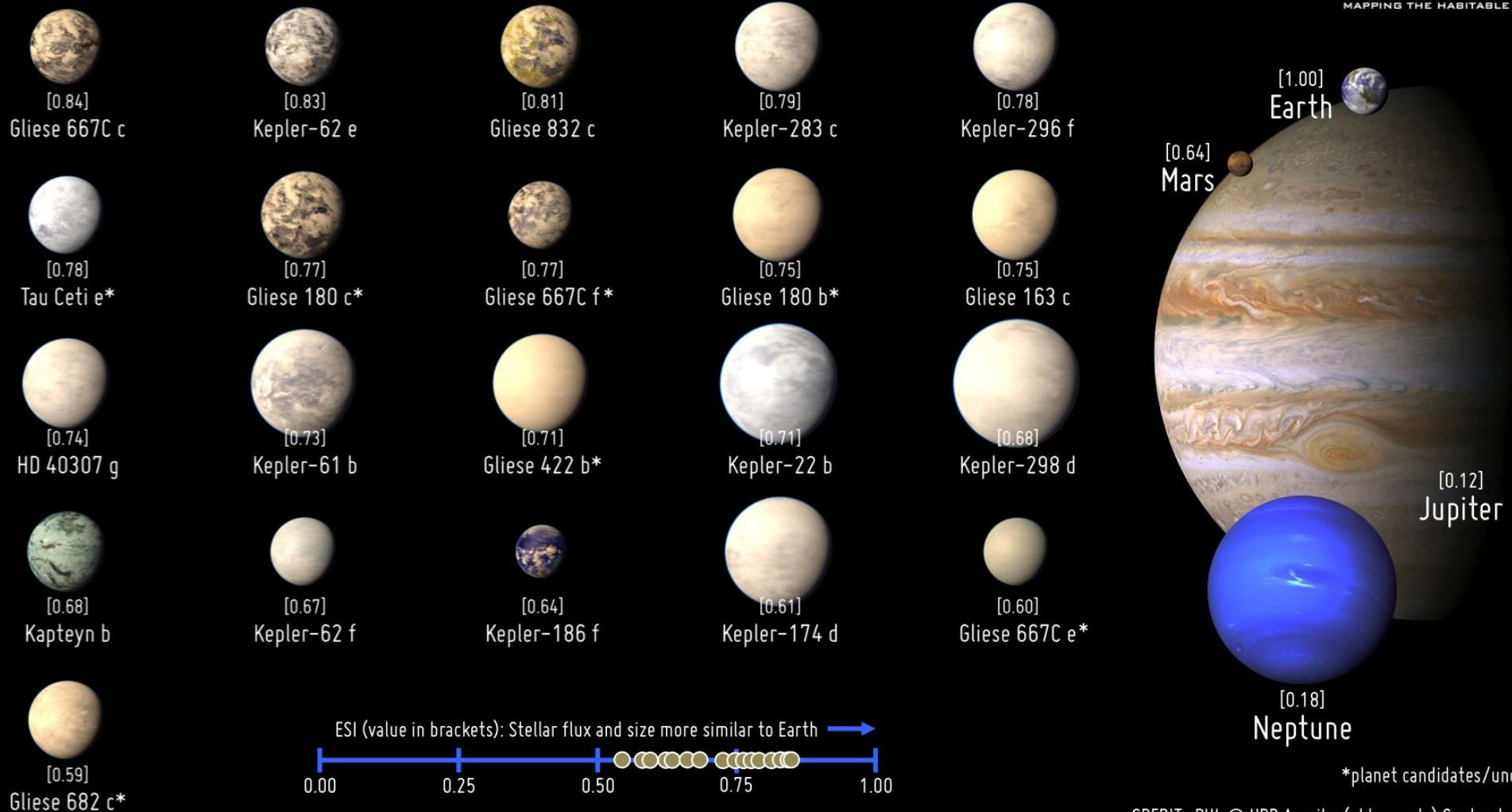


~10% of stars have potentially habitable planet

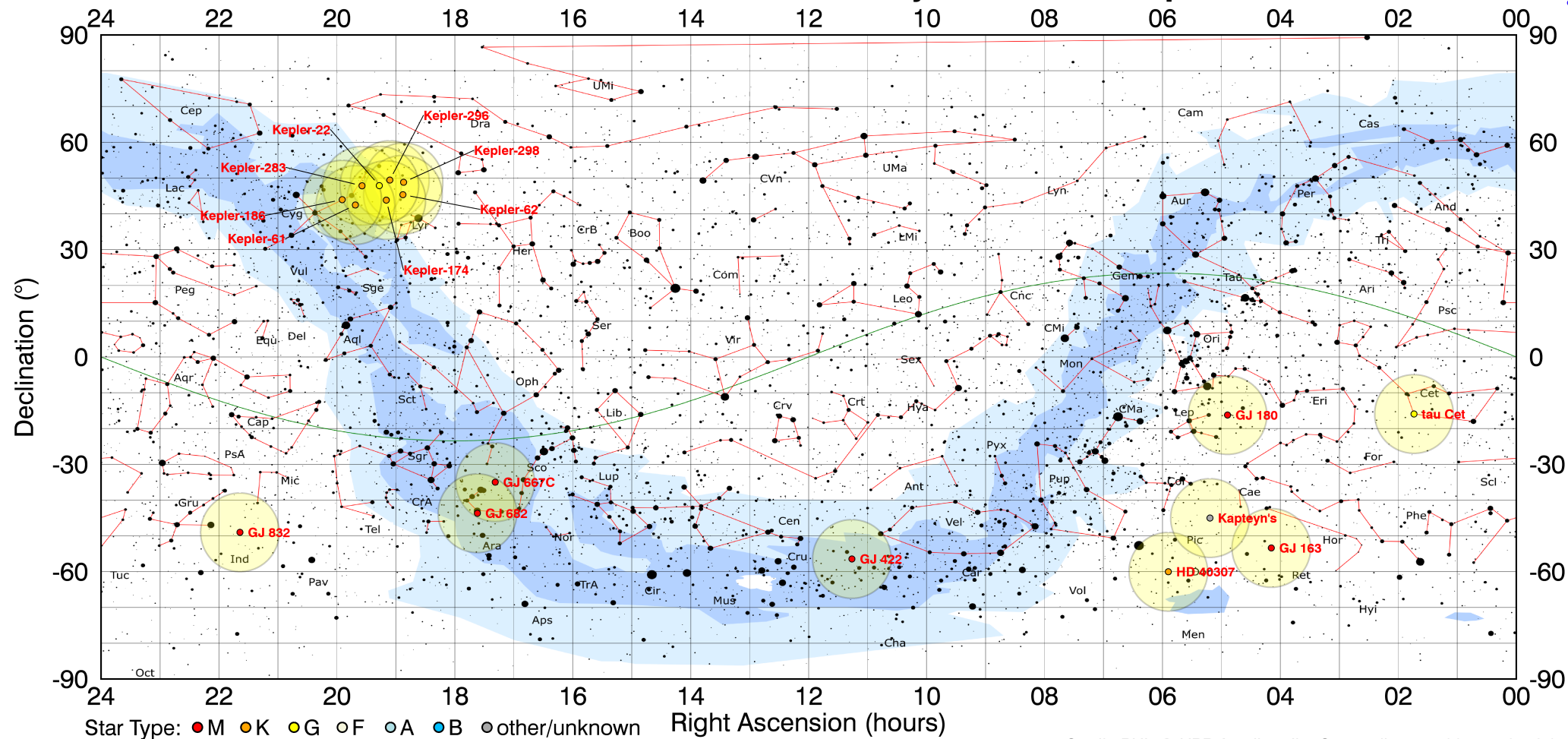
First potentially habitable planets now identified

Current Potentially Habitable Exoplanets

Ranked by the Earth Similarity Index (ESI)



Location of the Stars with Potentially Habitable Exoplanets



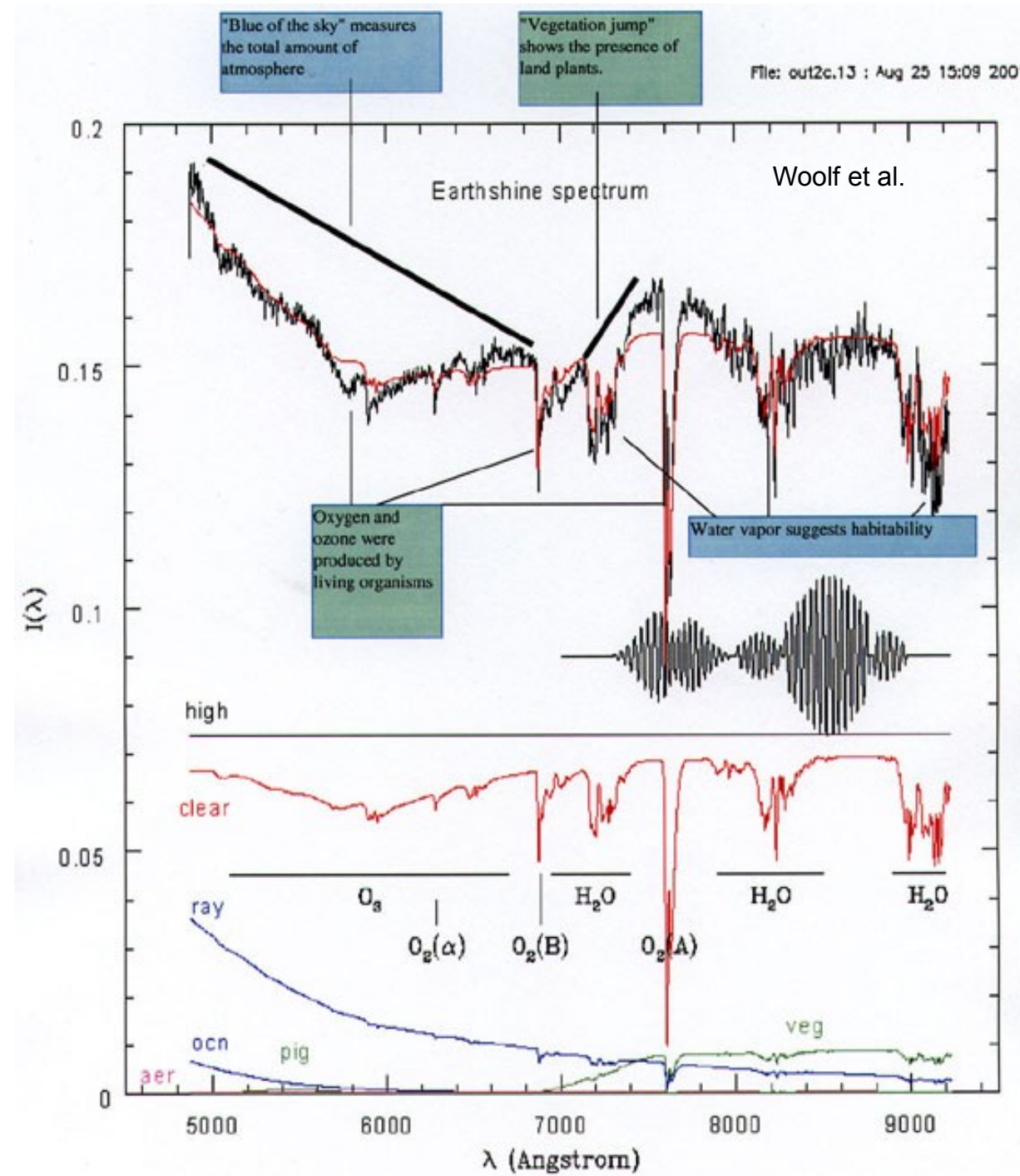
Credit: PHL @ UPR Arcibo, Jim Cornmell

phl.upr.edu, Jul 2014

Directly imaging planet is necessary to find life

We need to take spectra of habitable planets

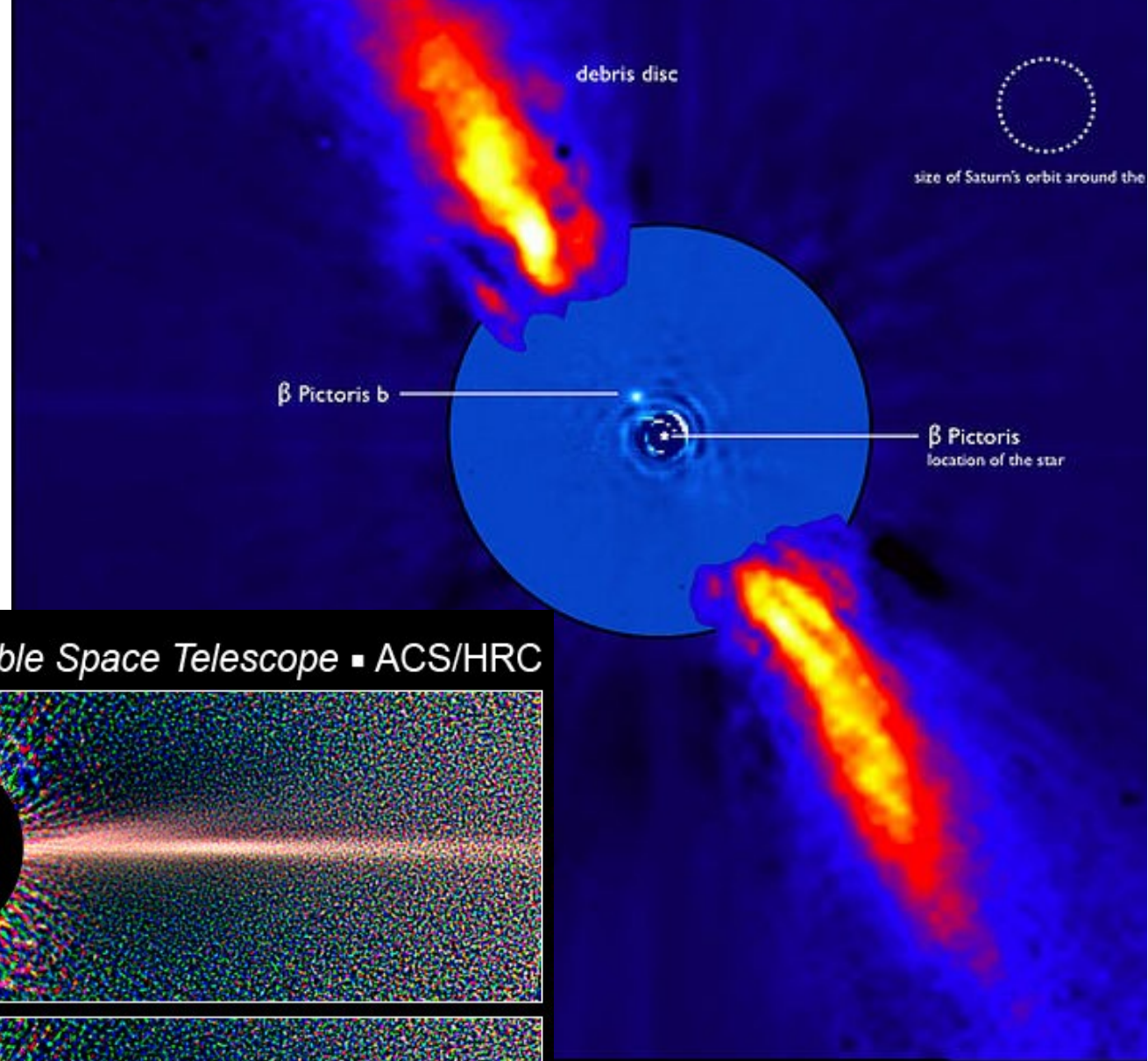
Spectra of Earth (taken by looking at Earthshine) shows evidence for life and plants



Beta Pictoris

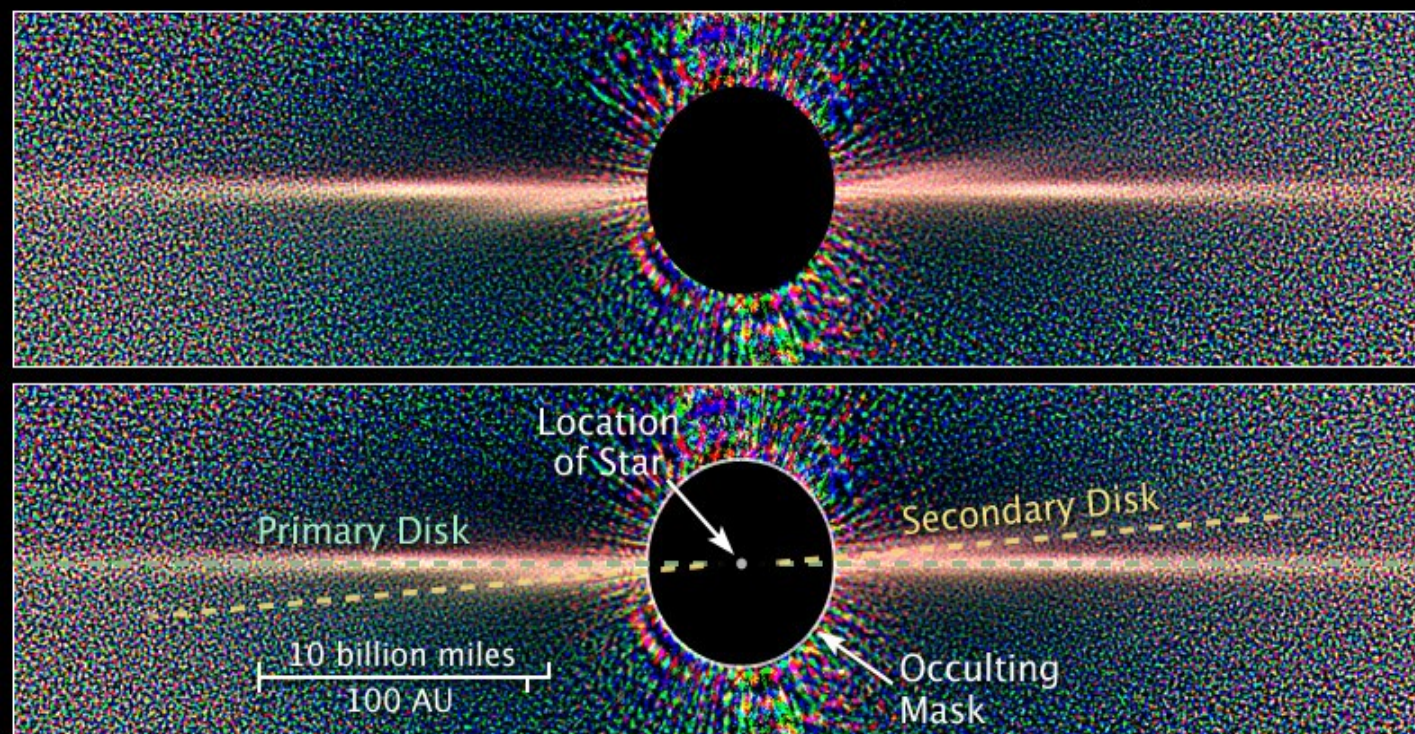
8 Jupiter mass planet

Orbits young massive star in ~20yr



Beta Pictoris

Hubble Space Telescope ■ ACS/HRC

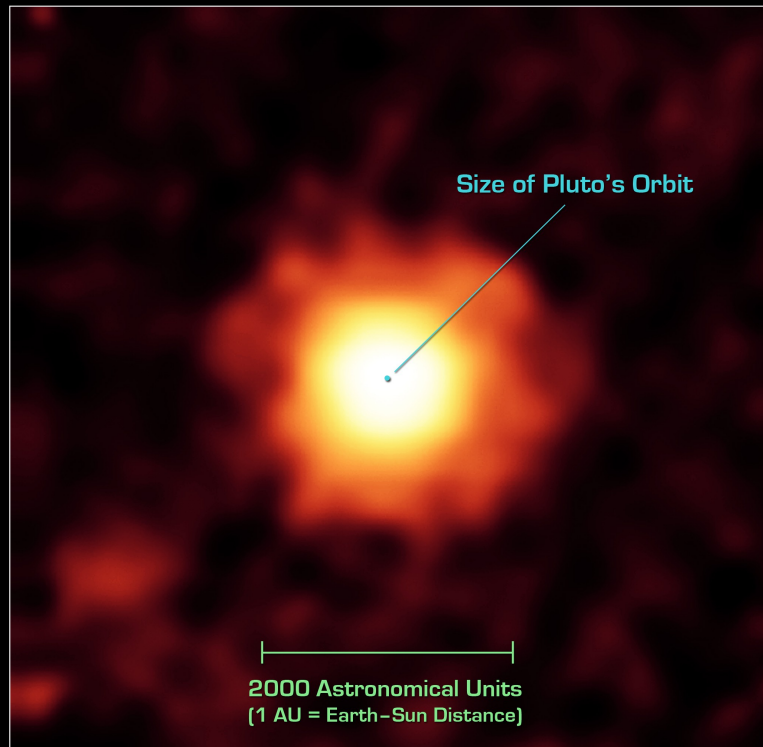


ESO VLT image
(Lagrange et al.)

HR8799

Four planets, orbital periods on the order of 100yr
Each planet 5 to 7 Jupiter Mass

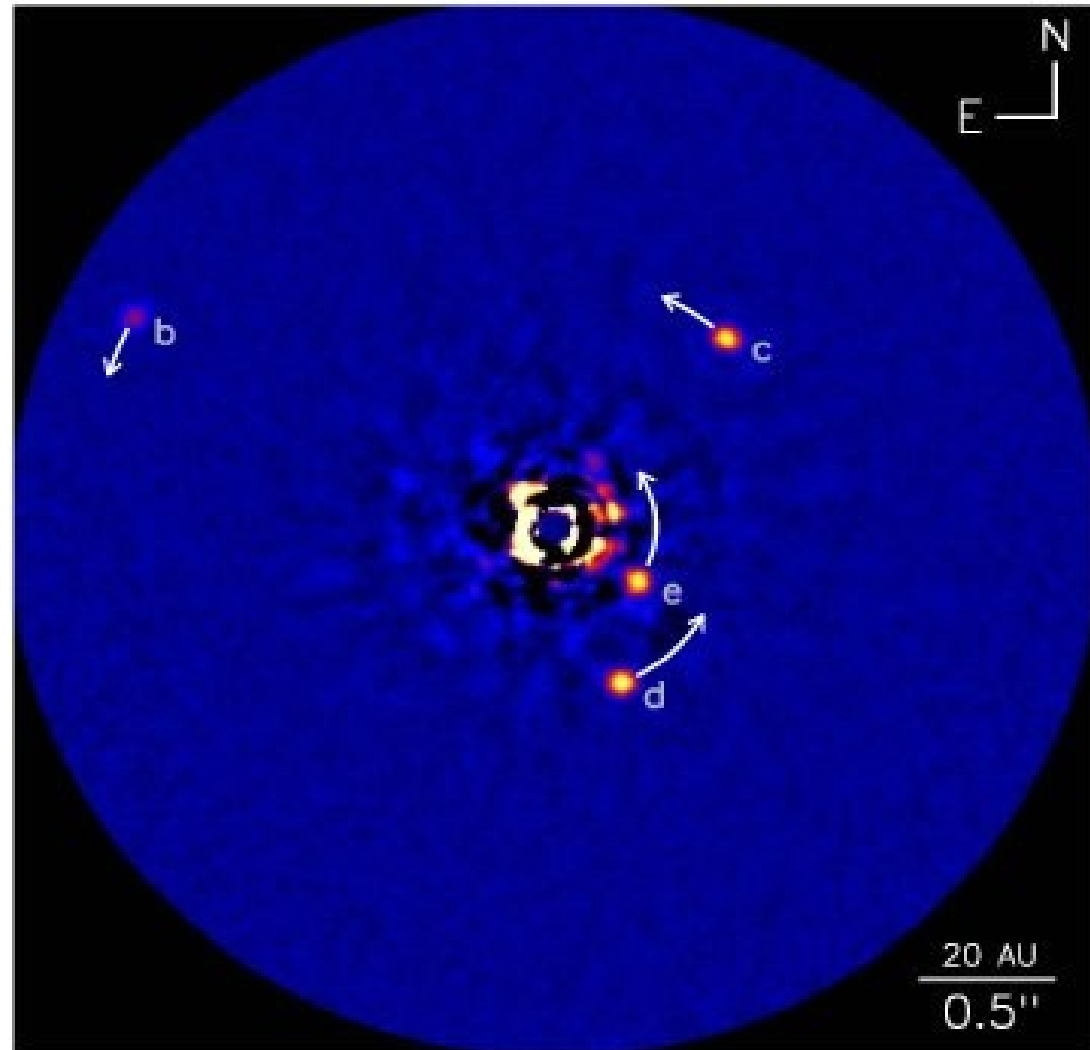
Keck telescope image (Marois et. al)



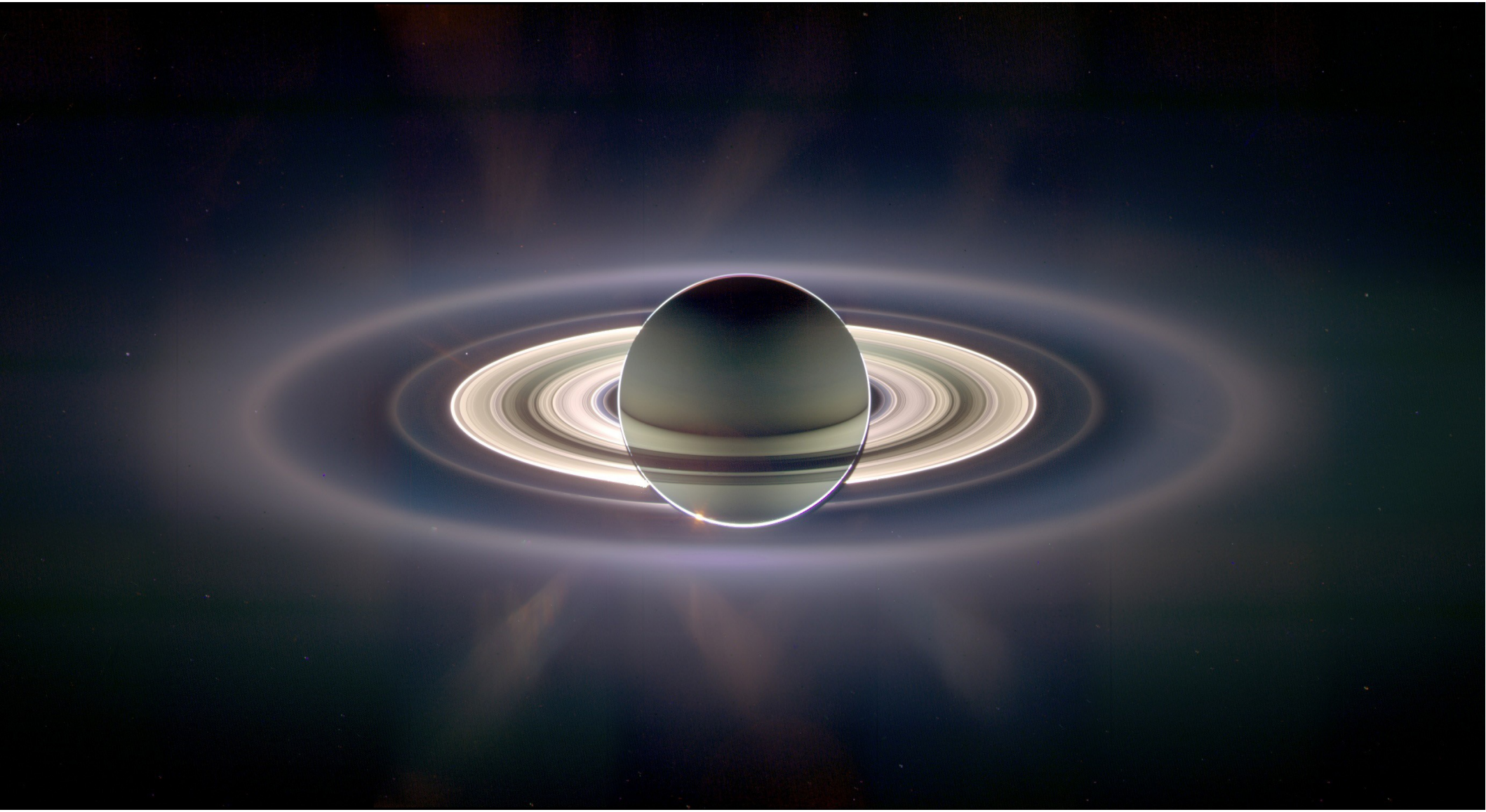
Debris Disk around Star HR 8799
Spitzer Space Telescope • MIPS

NASA / JPL-Caltech / K. Su (Univ. of Arizona)

sig09-008



Taking images of exoplanets: Why is it hard ?



Earth





Coronagraphy ... Using optics tricks to remove starlight (without removing planet light)



← Olivier's thumb...
the easiest coronagraph
Doesn't work well enough to
see planets around other stars

We need a better coronagraph... and a larger eye (telescope)

What is light: particle or wave ?



1807: Thomas Young publishes his double-slit experiment result ... cannot be explained by Newton's corpuscular theory of light

1818: French academy of science committee launches a competition to explain nature of light

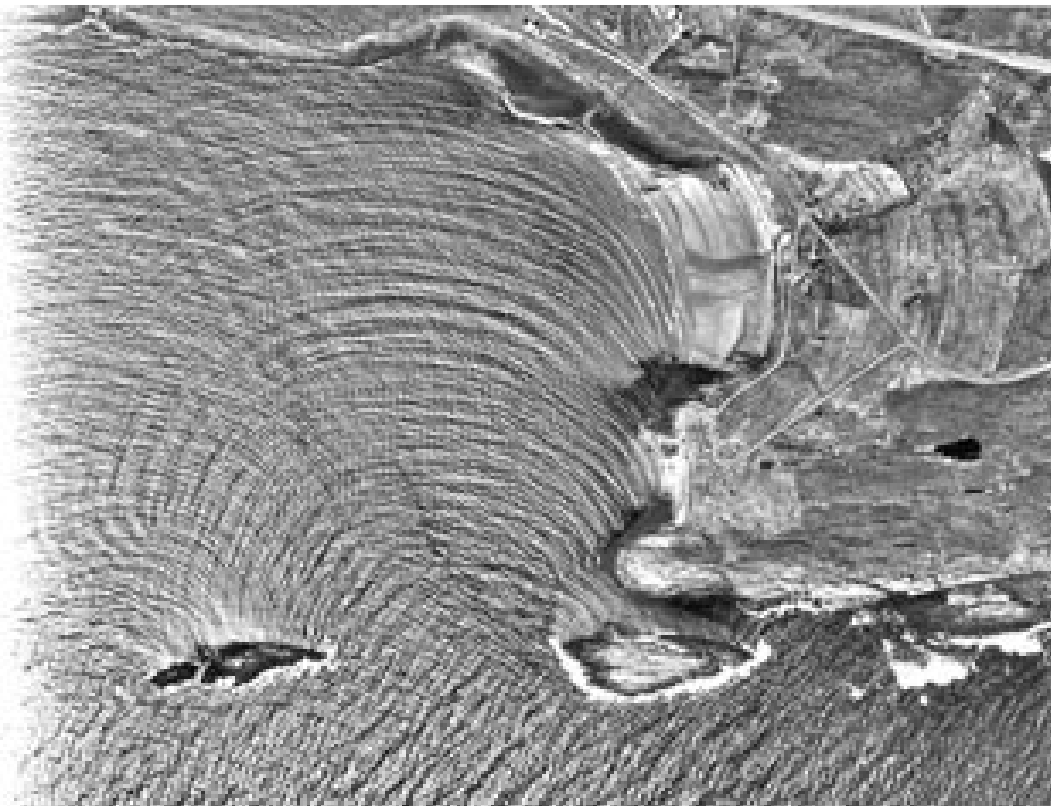


Augustin-Jean Fresnel
submits wave theory of light

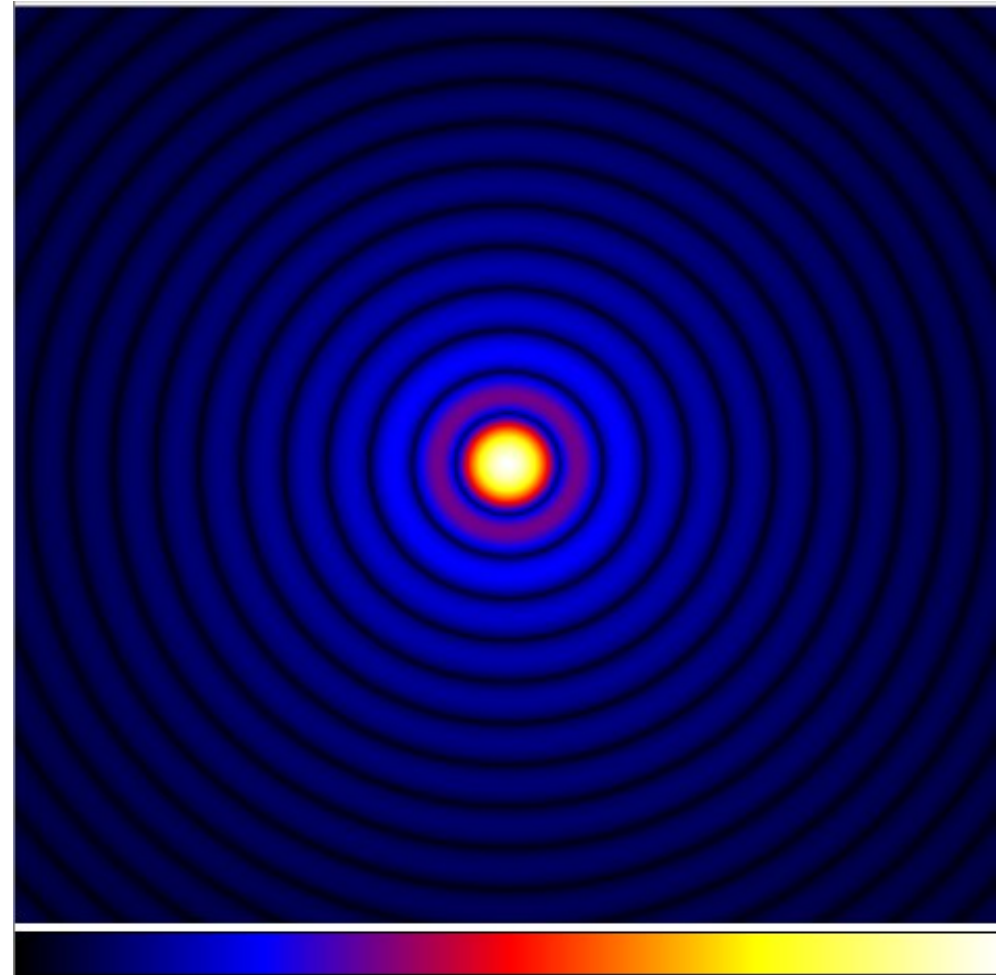
Simeon-Denis Poisson finds a flaw in Fresnel's theory:
According to Fresnel's equations, a bright spot should appear in
the shadow of a circular obstacle → this absurd result disproves Fresnel's theory

Dominique-Francois-Jean Arago, head of the committee, performs the experiment
He finds the predicted spot → Fresnel wins the competition

Water waves diffract around obstacles, edges, and so does light

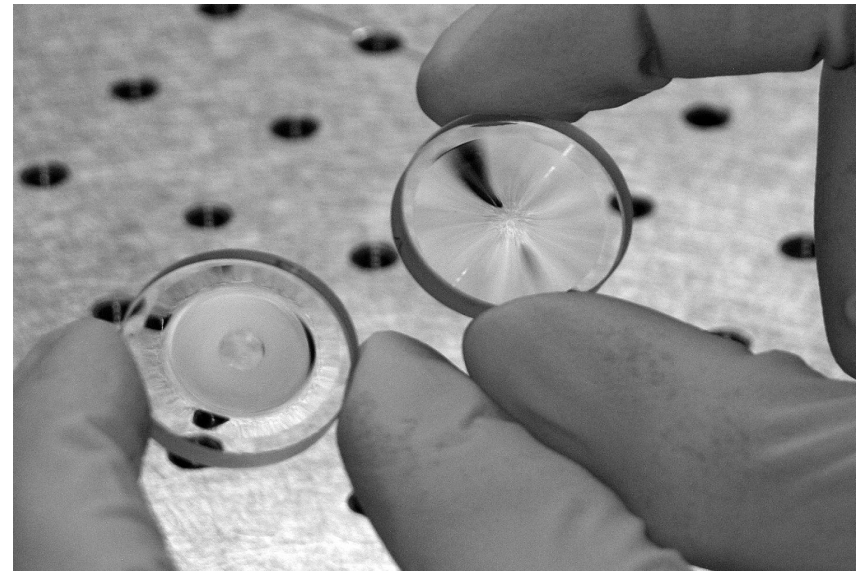
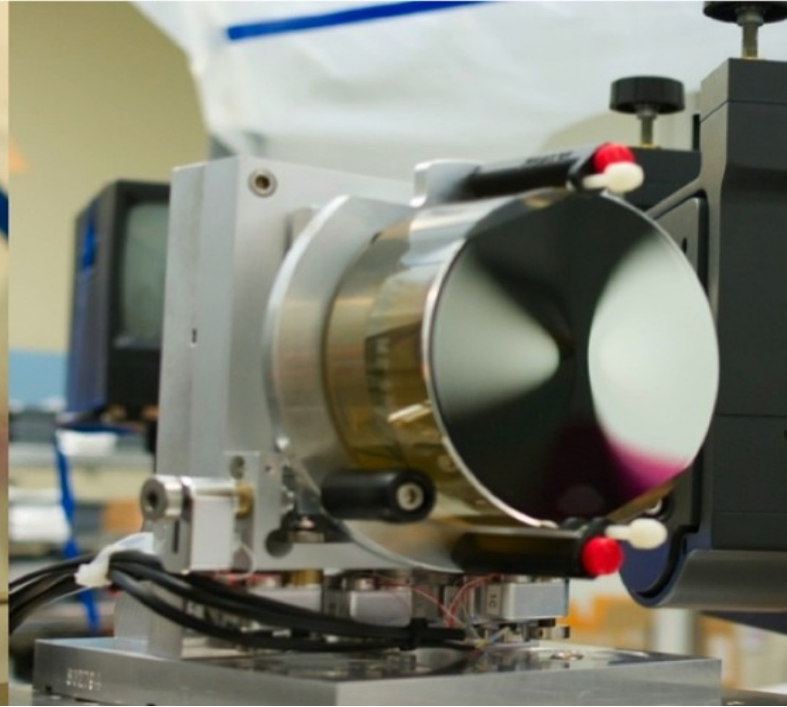
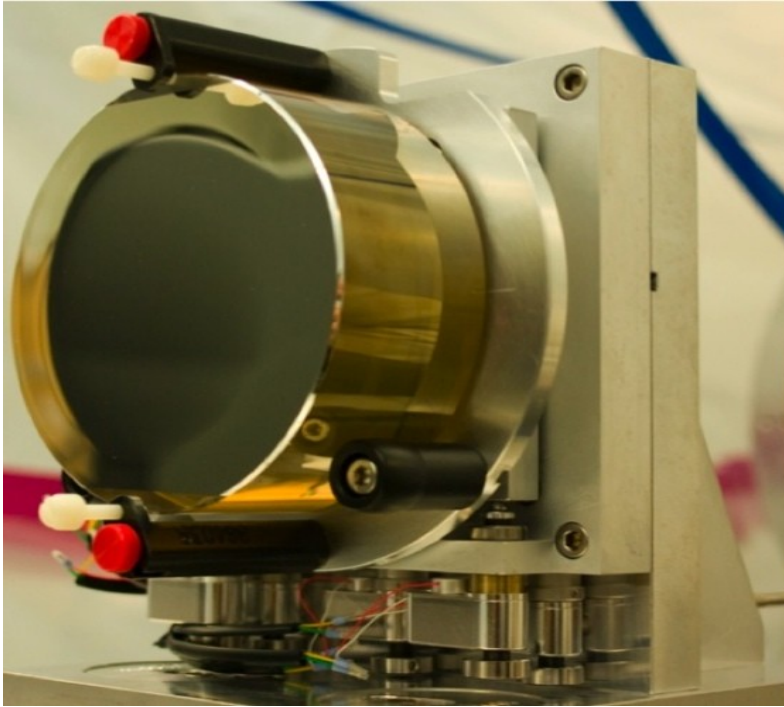


Waves diffracted by coastline and islands



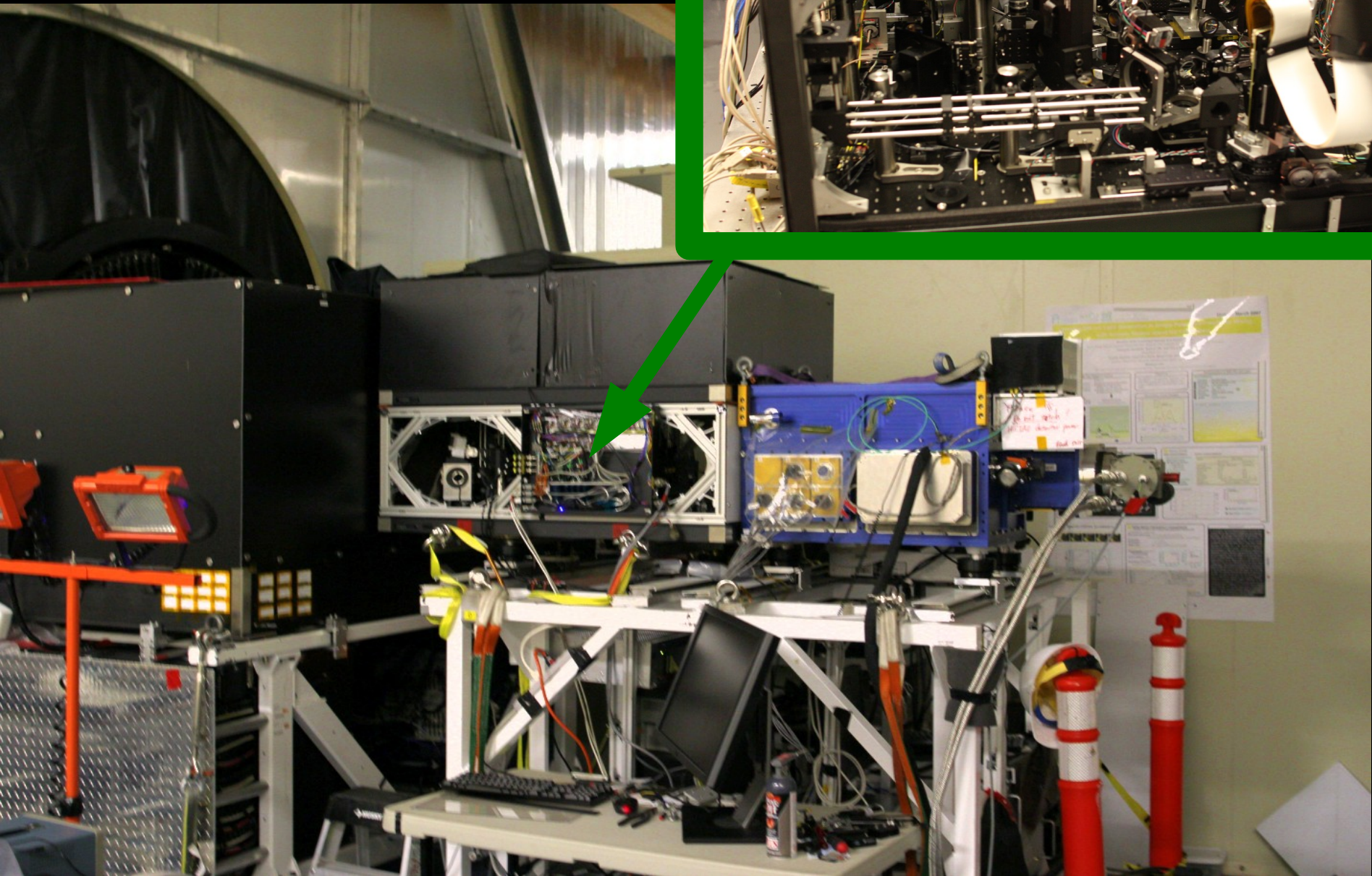
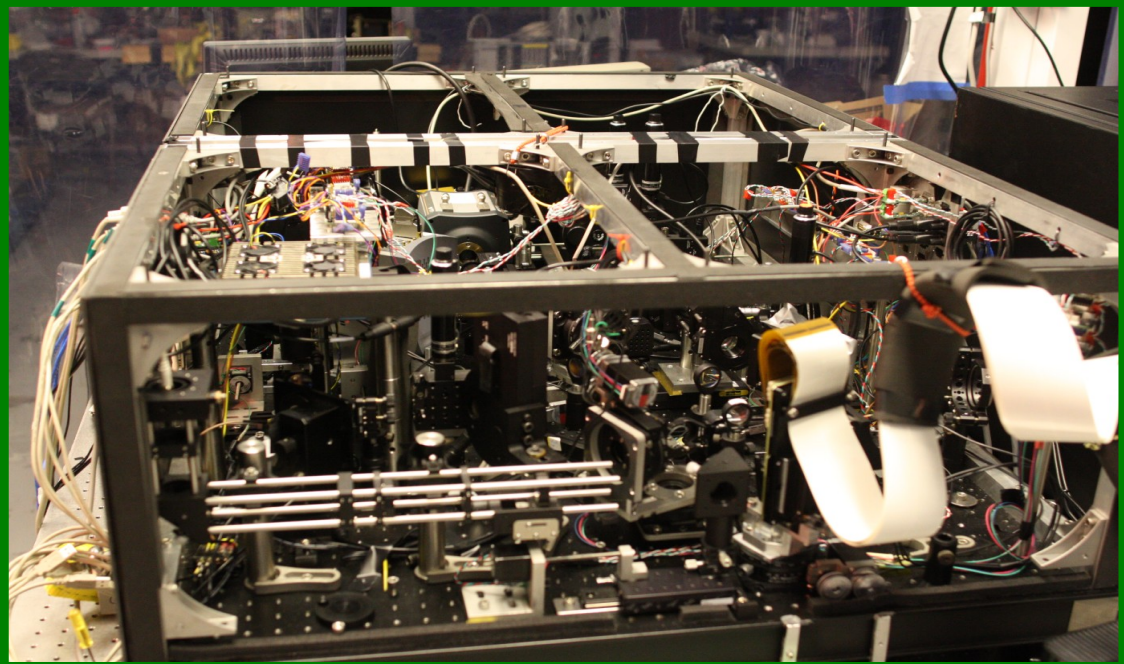
Ideal image of a distant star by a telescope
Diffraction rings around the image core

We use strangely shaped optics to reshape light





The Subaru Coronagraphic Extreme Adaptive Optics (SCExAO) system



Exciting future opportunities

Next generation of large telescopes on the ground will be able to image habitable planets around nearby low mass red stars

3 projects, ~30m diameter

Space telescopes with coronagraphs will be able to image and study Earth-like planets around sun-like stars

