Anybody out there?

Imaging exoplanets

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Planets identified – we are now starting to identify Earth-size planets
Habitable zone of a star

Every star has a habitable zone.
~10% of stars have potentially habitable planet
First potentially habitable planets now identified
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

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)
Taking images of exoplanets: Why is it hard?
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