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Is there another Earth out there?
Is there life on it?
Requirements for habitability

1. Planet size:
   ~ 0.5 – 2 Earth size

2. Temperature:
   0-100 C

3. Biomarkers:
   water and oxygen

H₂O (Water)  O₂ (Oxygen)

(Schematic representation only)

Credit: Petigura/UC Berkeley, Howard/UH-Manoa, Marcy/UC Berkeley
Detecting atmospheric oxygen and water likely indicates life (because very few non-biological processes can sustain an oxygen atmosphere).
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Beyond Kepler: Direct imaging missions

2010

Kepler

2020

Small sats
(0.25-0.7m, 
~$10 – 200M)
Earth-size
Habitable zone
Spectroscopy
Two stars: αCen

New Worlds Telescope
($4-8m, $4B+)

Exo-C or AFTA
(1.5m / 2.4m, 
$1B / $2B+)

2030

Earth-size
Habitable zone
Spectroscopy
~2-6 stars

Simulation of an exo-Earth around αCen with a $1B mission (1.5m telescope)

Another Earth?

All these missions also do ground-breaking science on non-habitable planets
The Ames Coronagraph Experiment (ACE)
People and organizations partnering with ACE

NASA ARC
- Ruslan Belikov
- Thomas Greene
- Eugene Pluzhnik
- Sandrine Thomas
- Fred Witteborn
- Dana Lynch
- Paul Davis
- Eduardo Bendek
- Kevin Newman

UofA
- Olivier Guyon
- Glenn Schneider
- Julien Lozi

L3 Tinsley
- Jay Daniel
- Asfaw Bekele
- Lee Dettmann
- Bridget Peters
- Titus Roff
- Clay Sylvester

AXSYS Technologies

Princeton
- Jeremy Kasdin
- Bob Vanderbei
- David Spergel
- Alexis Carlotti

STScI
- Laurent Pueyo

JPL
- Brian Kern
- Andy Kuhnert
- John Trauger
- Wes Traub
- John Krist
- Marie Levine
- Stuart Shaklan
- K. Balasubramanian

Lockheed Martin
- Domenick Tenerelli
- Rick Kendrick
- Alan Duncan
- Wes Irwin
- Troy Hix
Stars are a billion times brighter...
...than the planet

...hidden
in the glare.
Like this firefly.
Blocking the star: the PIAA Coronagraph (phase-induced amplitude apodization)

- PIAA is a powerful technology to block the star in order to reveal planets
- Successful track of technology development at Ames over the past 6 years (as well as at partner institutions)
- One of the potential architectures selected by NASA for the Exo-C and AFTA missions

Mission concepts using PIAA:
- Small Sats (0.25-0.7m)
- Exo-C (1.4m)
- AFTA (2.4m)
- NWO (4m)

PIAA M1
- Shaped pupil Apodizer
- Original uniformly illuminated pupil plane

PIAA M2
- New, apodized pupil plane
- Focal plane

Ruslan Belikov, NASA Ames Coronagraph Laboratory
Testbeds and critical hardware

ACE testbed

Lockheed Martin

JPL

PIAA lenses

PIAA mirrors

Deformable mirror

State of the art performance in the lab

Ruslan Belikov, NASA Ames Coronagraph Laboratory
Highligthed effort: \(\alpha\)Cen imager

- Recently started
- 0.25m telescope
- \(~\$5M\) (rough estimate)
- Theoretically capable of finding biomarkers on habitable planets around \(\alpha\) Centauri (if they exist)
Conclusions

- Technology to find biomarkers and life on other worlds is rapidly maturing

- If there is a habitable planet around the nearest star, we may be able to detect it this decade with a small satellite mission

- In the 2030 decade, we will likely know if there is life in our Galactic neighborhood (~1000 nearest stars)