Exoplanet Science in Reflected Light with ExAO

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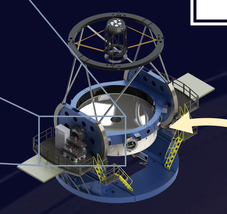
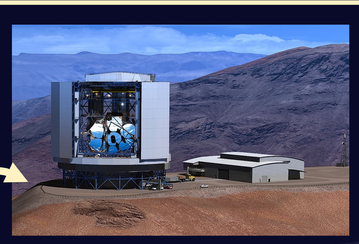
We (The Extreme Wavefront Control Lab at UA) built MagAO-X to directly image Proxima Centauri b in reflected light. We expect to achieve this goal in the next few years!

MagAO-X:
- g' – z', Hα, CH_4
- 3 DMs: Woofer, 2K Tweeter, Non-Common Path DM
- 2 science cameras
- VIS-X IFU

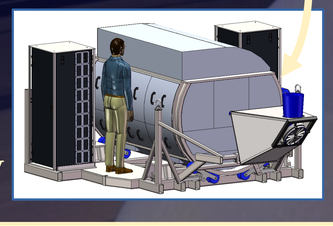


Magellan Clay Telescope:
- 6.5m primary
- Las Campanas Observatory (LCO), Chile
- MagAO-X on Nasmyth



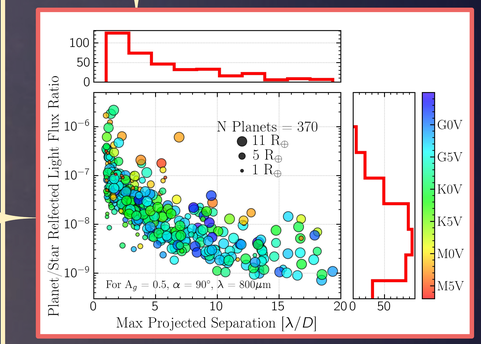
GMT:
- Seven 8.4m mirrors = 24.5m primary
- Also at LCO
- Construction begun, paused by covid

GMagAO-X:
- 21k tweeter DM
- Passed CoDR in 2021



We are currently building GMagAO-X, the extreme adaptive optics instrument for GMT, which will image a lot of exoplanets in reflected light!

Extreme Adaptive Optics (ExAO) will deliver the first images of exoplanets in reflected light. Characterizing exoplanets in reflected light requires careful modeling and preparation



GMagAO-X will target 100s of known exoplanets, requiring planet/star flux contrasts of 10^{-6} – 10^{-9}

We need to understand GMagAO-X ability distinguish characteristics and determine spectrophotometric design that optimizes trade-offs

Water/No Water?
Methane/No Methane?
Terrestrial/Gas Giant?
Biosignatures????

What spectroscopic resolution is needed to resolve features?

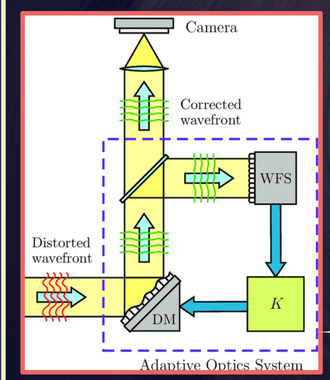
How many planets could we detect for a given atm & inst configuration?

I am doing a GRFP Internship at Ames to work with the radiative transfer code PICASO to try to answer these questions.

PICASO

Wait, What is Adaptive Optics??

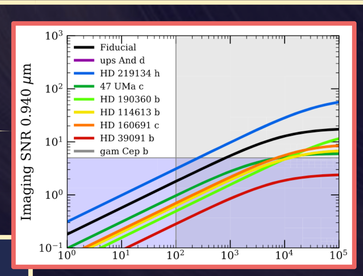
Plane waves from the star are distorted by the Earth's atmosphere. We use a wavefront sensor (WFS) to sense the distortion, send a control signal to a deformable mirror, and distort the mirror's shape to cancel out the wavefront distortion. We can achieve diffraction-limited imaging from the ground. "Extreme" AO systems have faster WFS and more actuators to perform high-fidelity corrections



From: Lessard, Laurent. (2011). Tractability of Complex Control Systems.

Wait, What is Reflected Light Imaging??

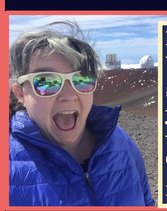
All directly imaged planets to date have been self-luminous in and detectable in thermal emission. To detect older (and cooler), smaller planets we have to detect them in the light they reflect from their host star. This requires extreme contrasts!



Lacy et al. 2019: prediction of observable planets with one Roman CGI band. Purple shows SNR<5; grey show exp time > 100 hrs

Using PICASO and the current GMagAO-X design and noise model, I will explore its ability to detect planets and retrieve atm features of various instr. and obs conditions

The end goal is to be able to input observing conditions and instrument configurations and get out detectable planets/features and a prediction of the data information content.



Logan Pearce is 4th year PhD student at University of Arizona. In addition to this work, she is PI of two science surveys with MagAO-X, you should ask her about those! She is a Navy vet and calls Austin TX home. She lives in Tucson with her 4yo lab Lani. Scan the QR code for more!