

Big planets, little stars: Directly imaged companions to young M-stars

Henry Ngo (@AstroDino)

Plaskett Fellow at NRC-Herzberg

DAO, Victoria, BC, Canada

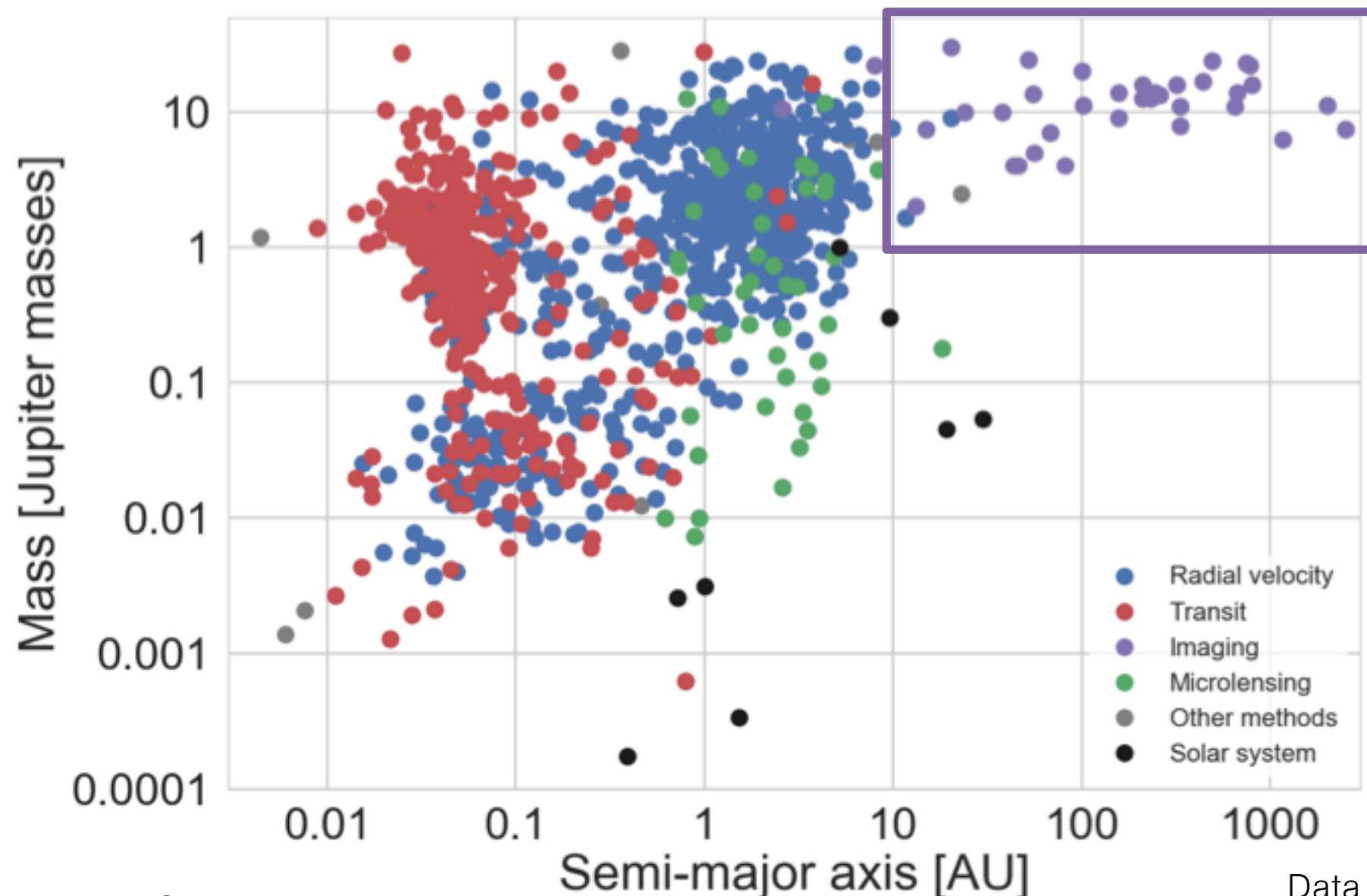
with D. Mawet, G. Ruane, W. Xuan, B. Bowler, E. Choquet, T. Cook, Z. Zawol



National Research
Council Canada

Conseil national de
recherches Canada

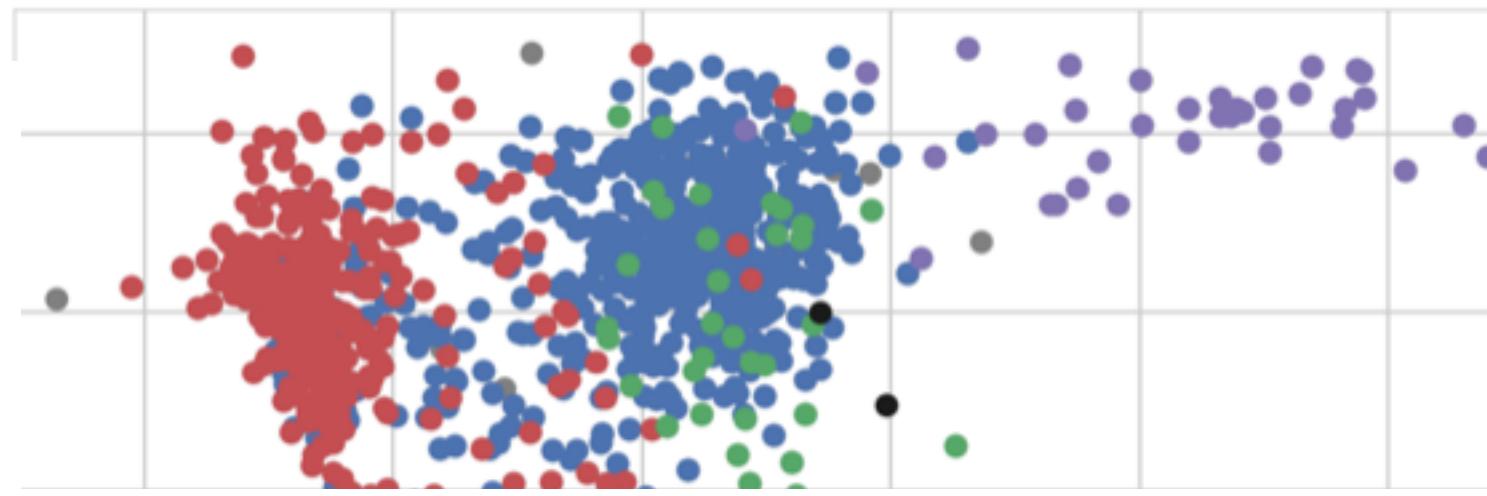
Imaging giant planets < 10 AU



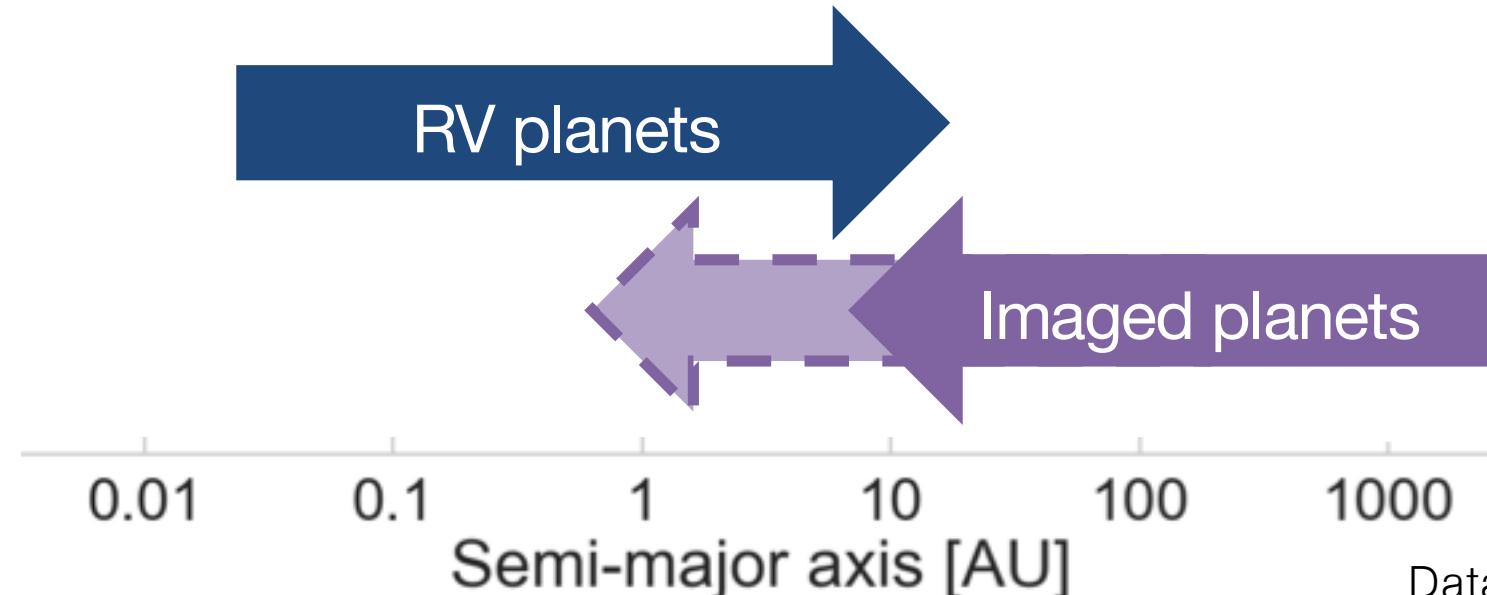
Are these the
biggest planets or
smallest stars?

Data from NASA Exoplanet Archive

Imaging giant planets < 10 AU



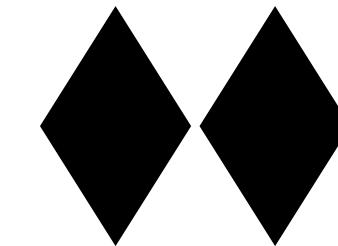
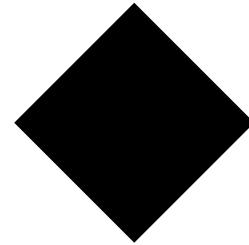
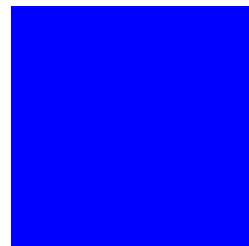
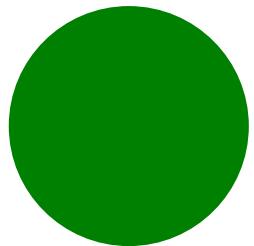
Are these the
biggest planets or
smallest stars?



Search for the
“missing link” of
giant planet
formation

Data from NASA Exoplanet Archive

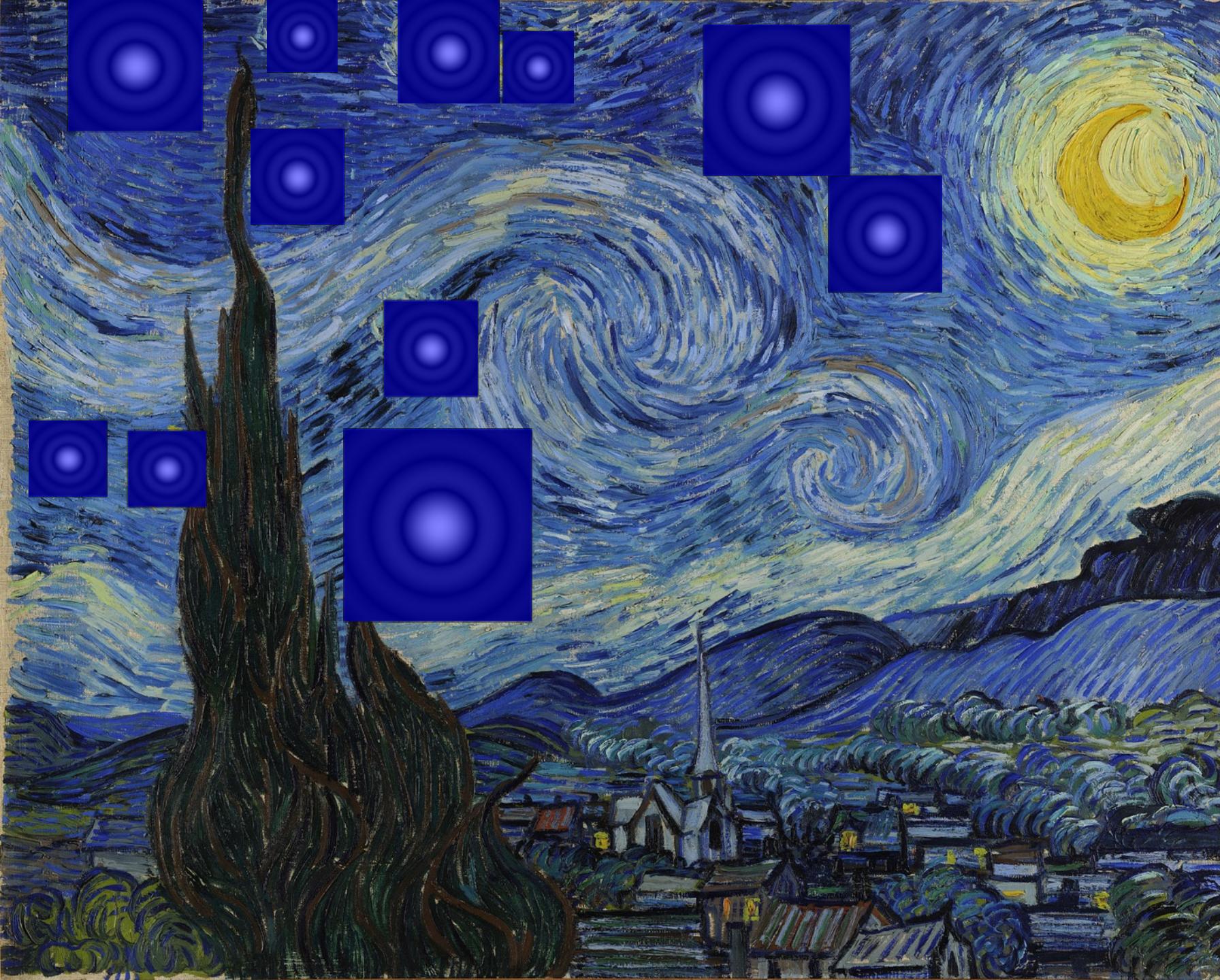
Imaging planets is really hard



- Need the right ~~equipment~~ instrumentation
- Need smart ~~slope~~ target selection



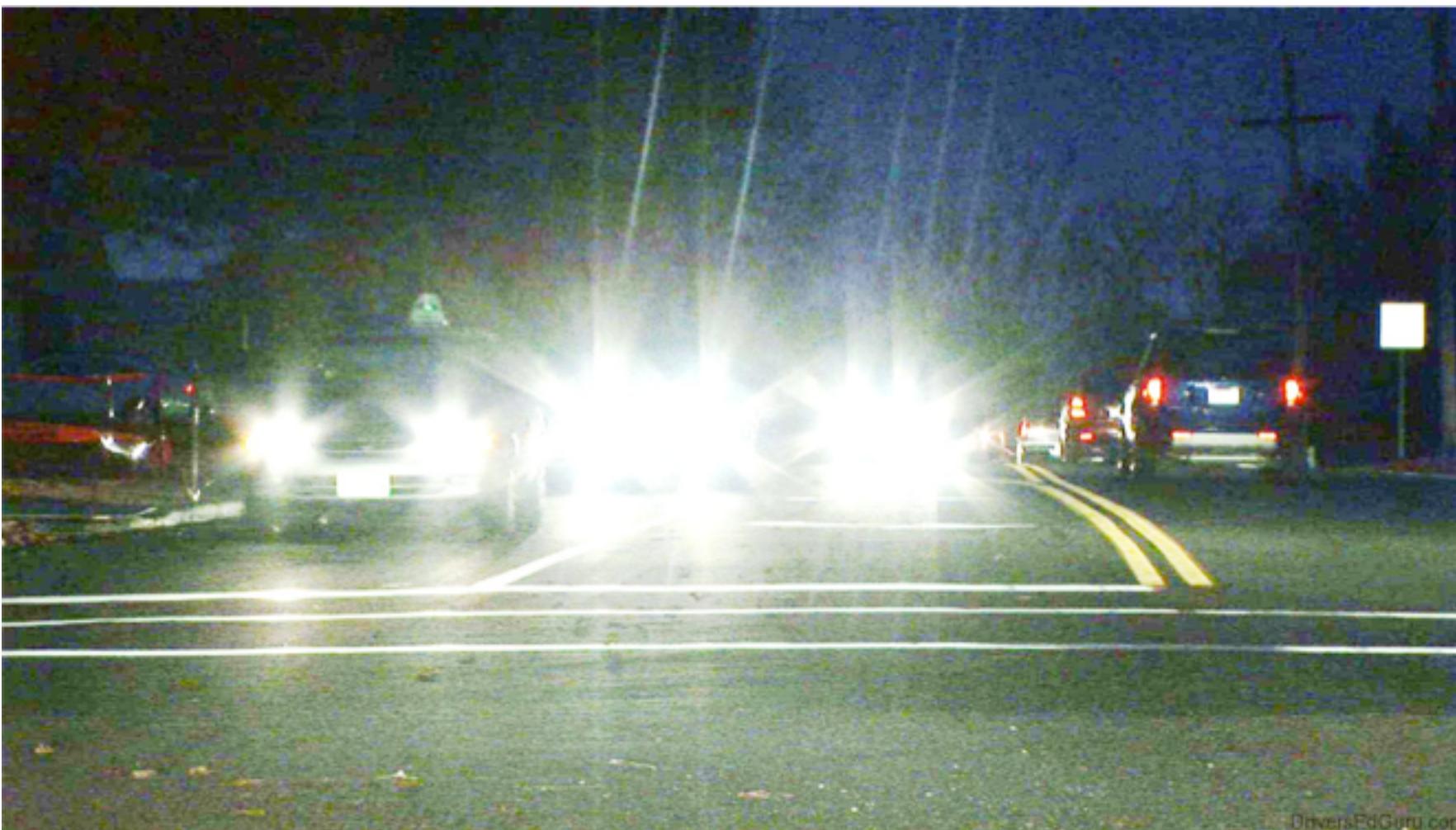
Cannot block out
bright starlight
when it's smeared
out by atmosphere



**Cannot block out
bright starlight
when it's smeared
out by atmosphere**

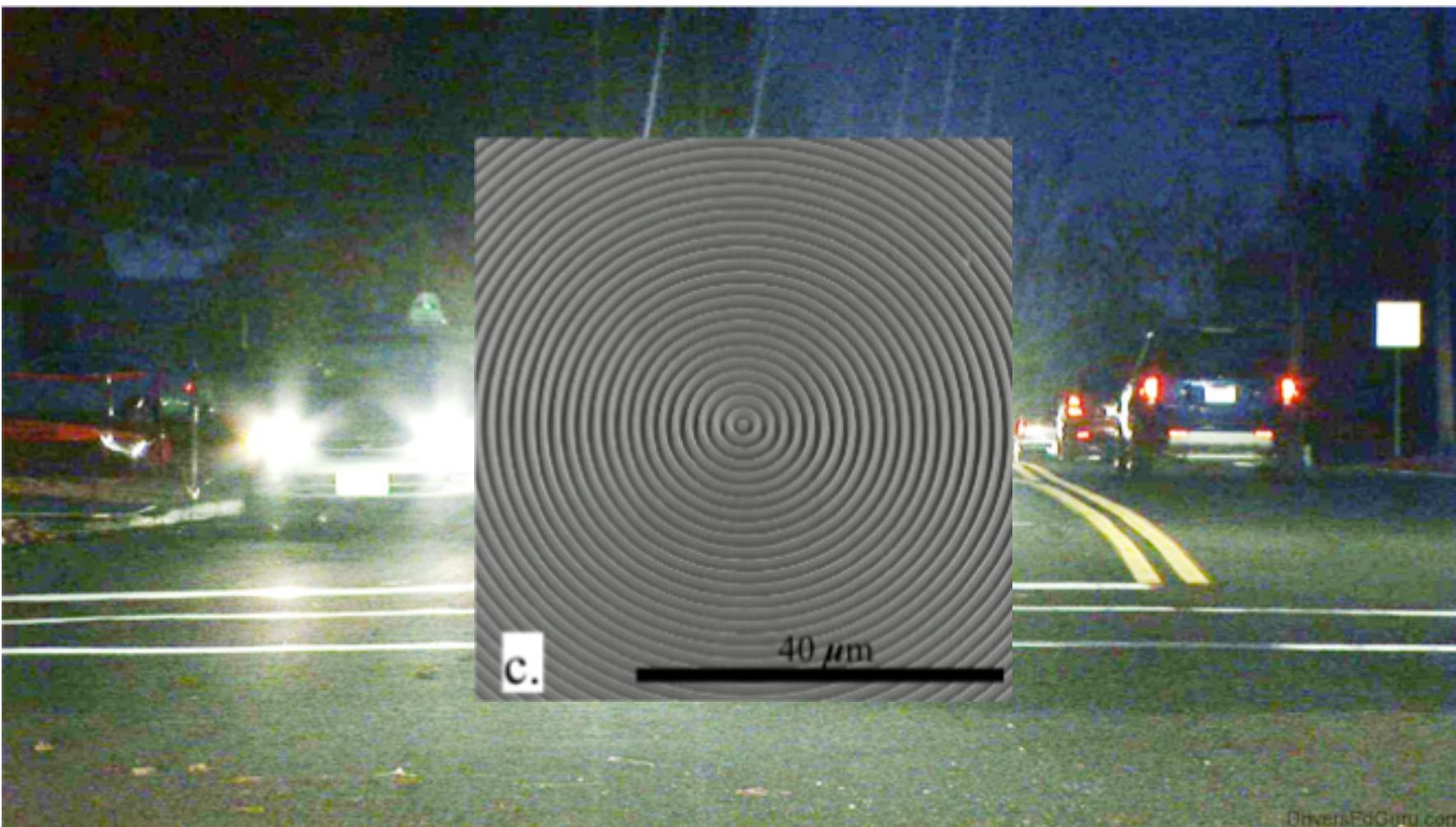
**Solution: Use an
adaptive optics
system to “fix” the
messy image**

Finding planets with a coronagraph



DriversEdGuru.com

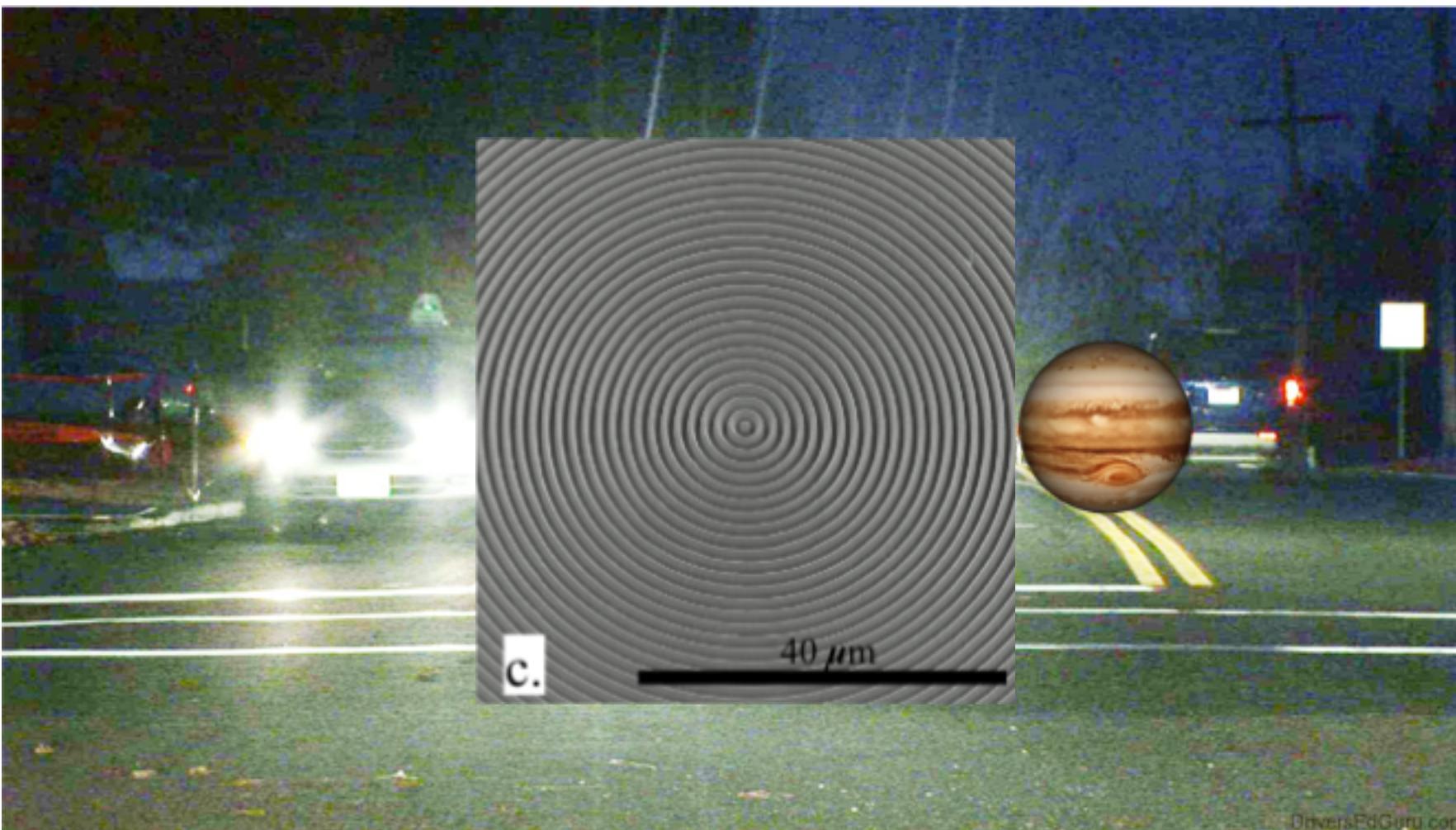
Finding planets with a coronagraph



Keck/NIRC2 L-band
vector vortex
coronagraph



Finding planets with a coronagraph



Keck/NIRC2 L-band
vector vortex
coronagraph



Target Selection (200 stars)

Choose
smaller stars

to improve star/planet contrast

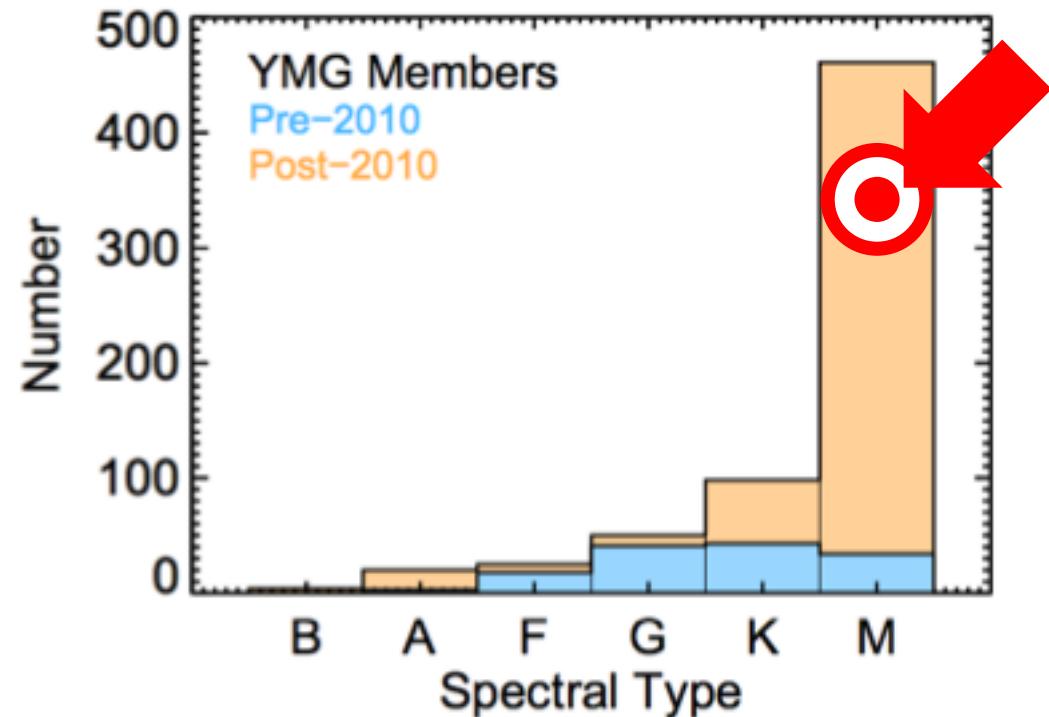
Choose
younger stars

to catch planets still hot and bright

Choose
closer stars

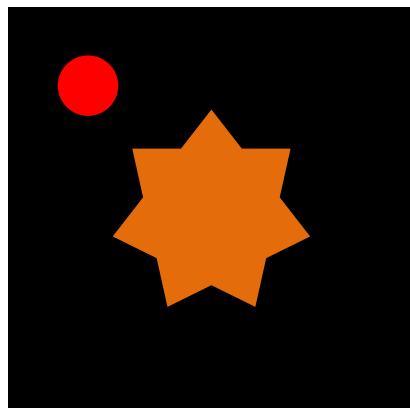
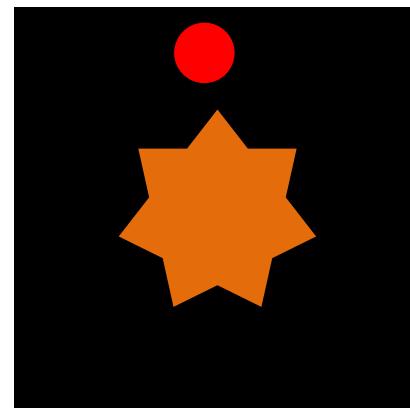
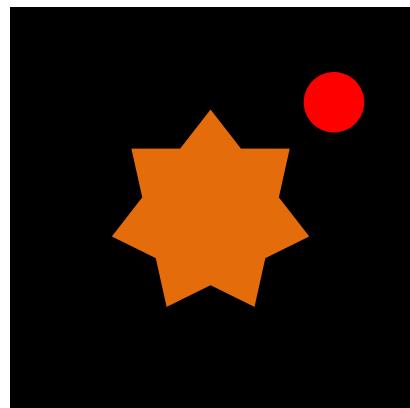
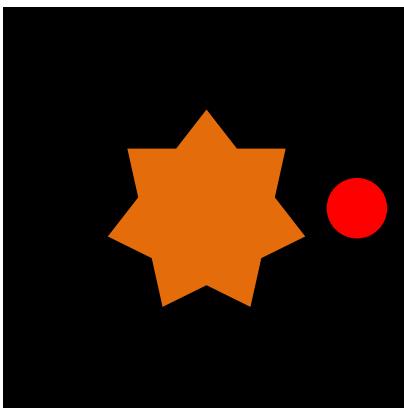
to probe closer projected separations

Young Moving Group
stars are ideal

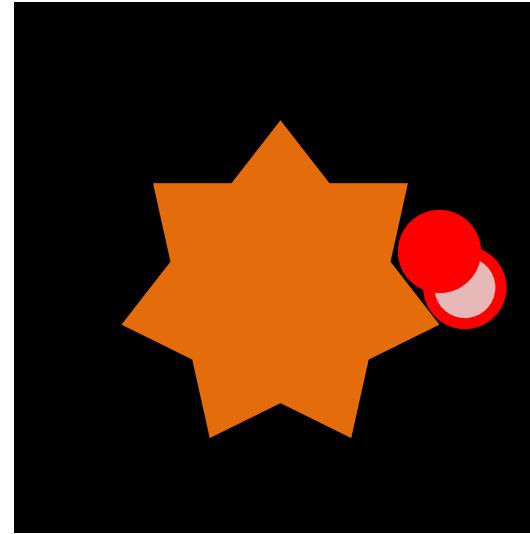
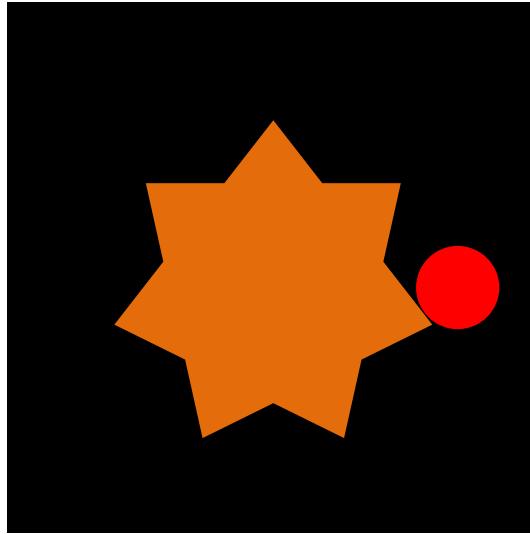


Bowler (2016)

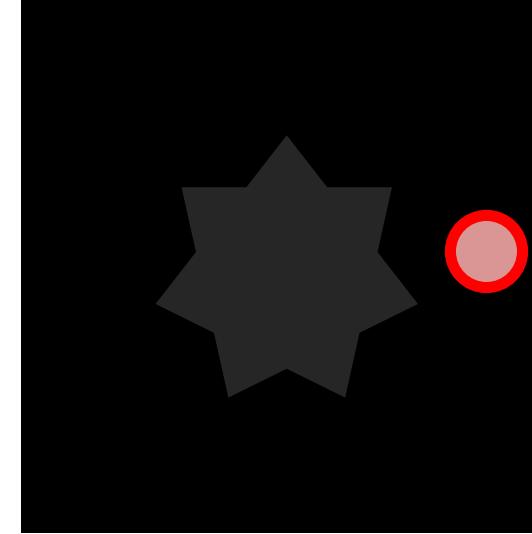
Angular differential imaging



Self-subtraction issue for ADI at low rotation & close-in separations

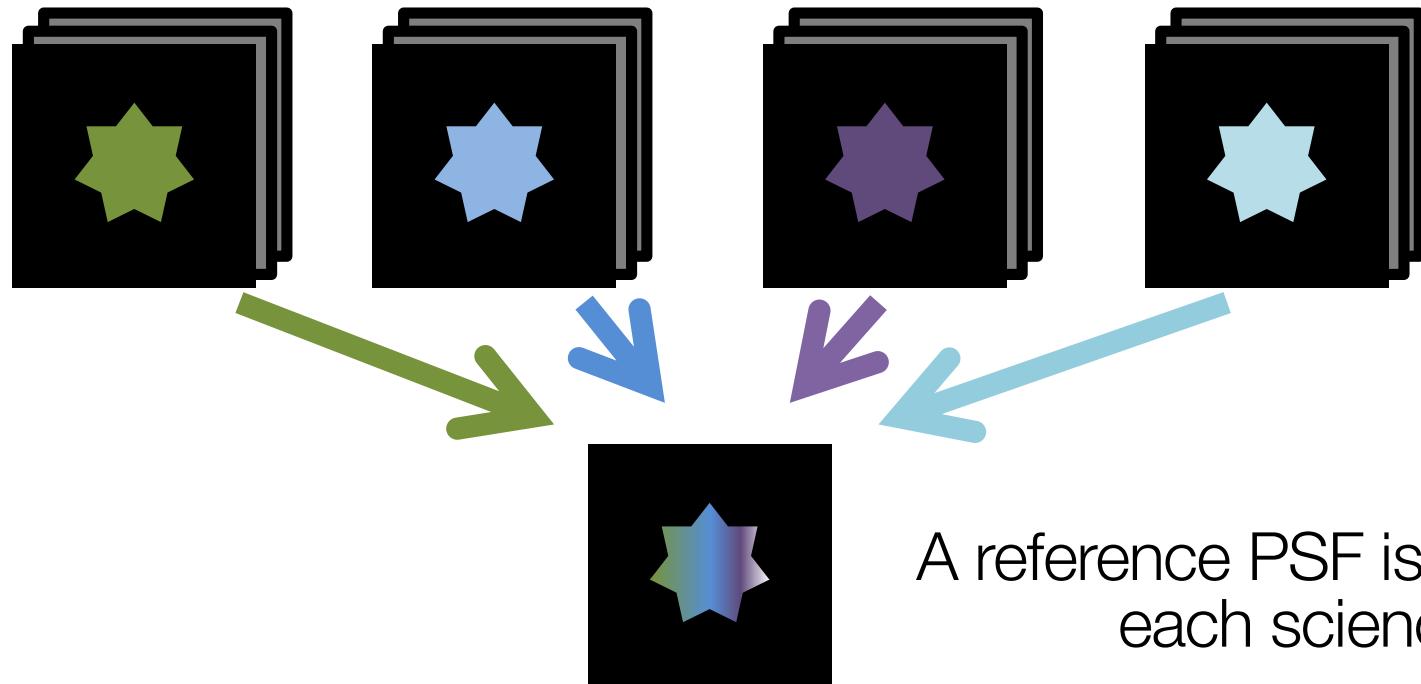


Planet overlaps
with previous
position



Planet sensitivity
reduced by self-
subtraction

Reference star differential imaging



Use library of science targets to create a reference PSF

A reference PSF is constructed for each science target

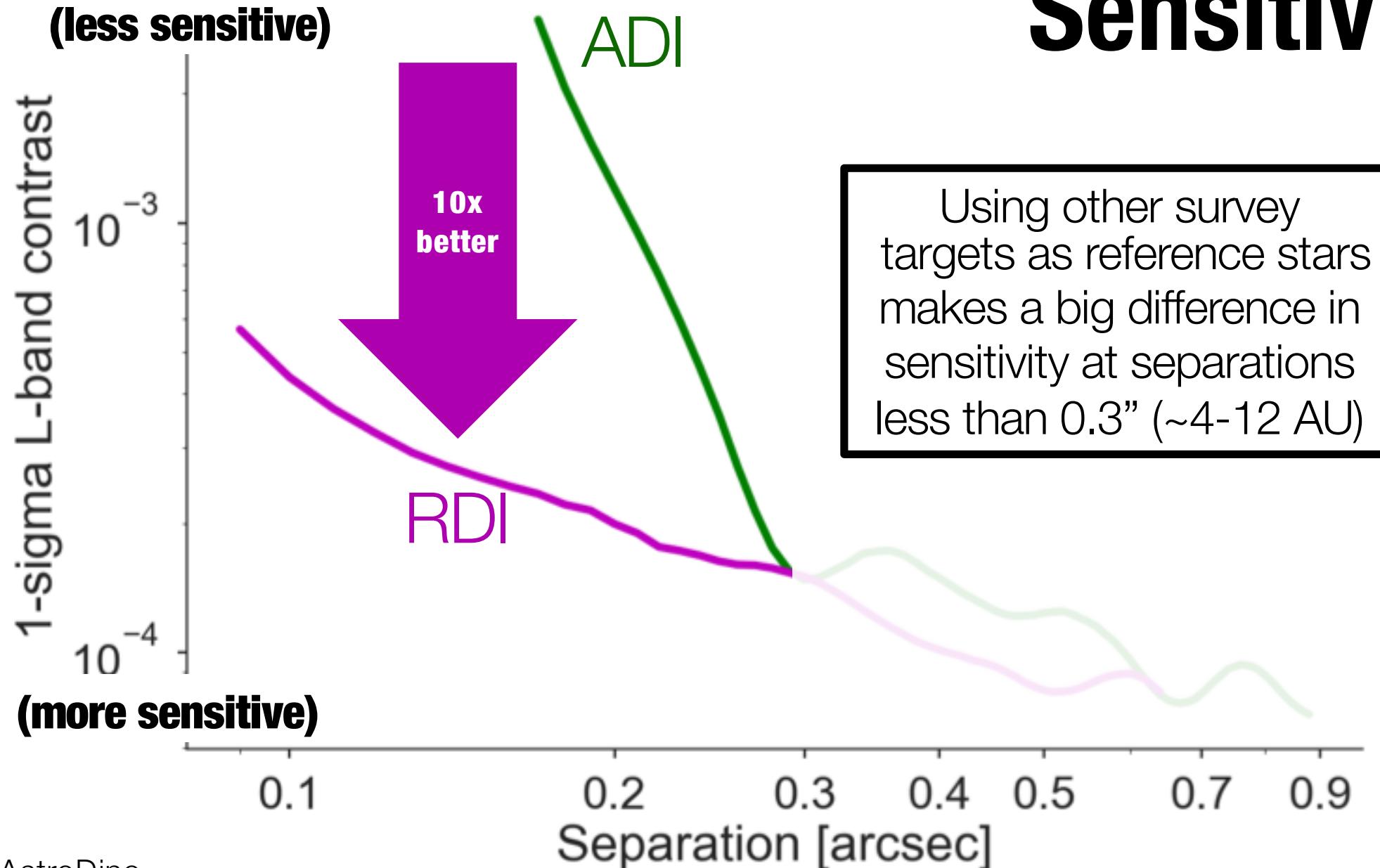
Challenge: Need an automatic pipeline + database to choose best reference stars



**Wenhao Jerry
Xuan**

Pomona College
Applying to grad programs!

Sensitivity

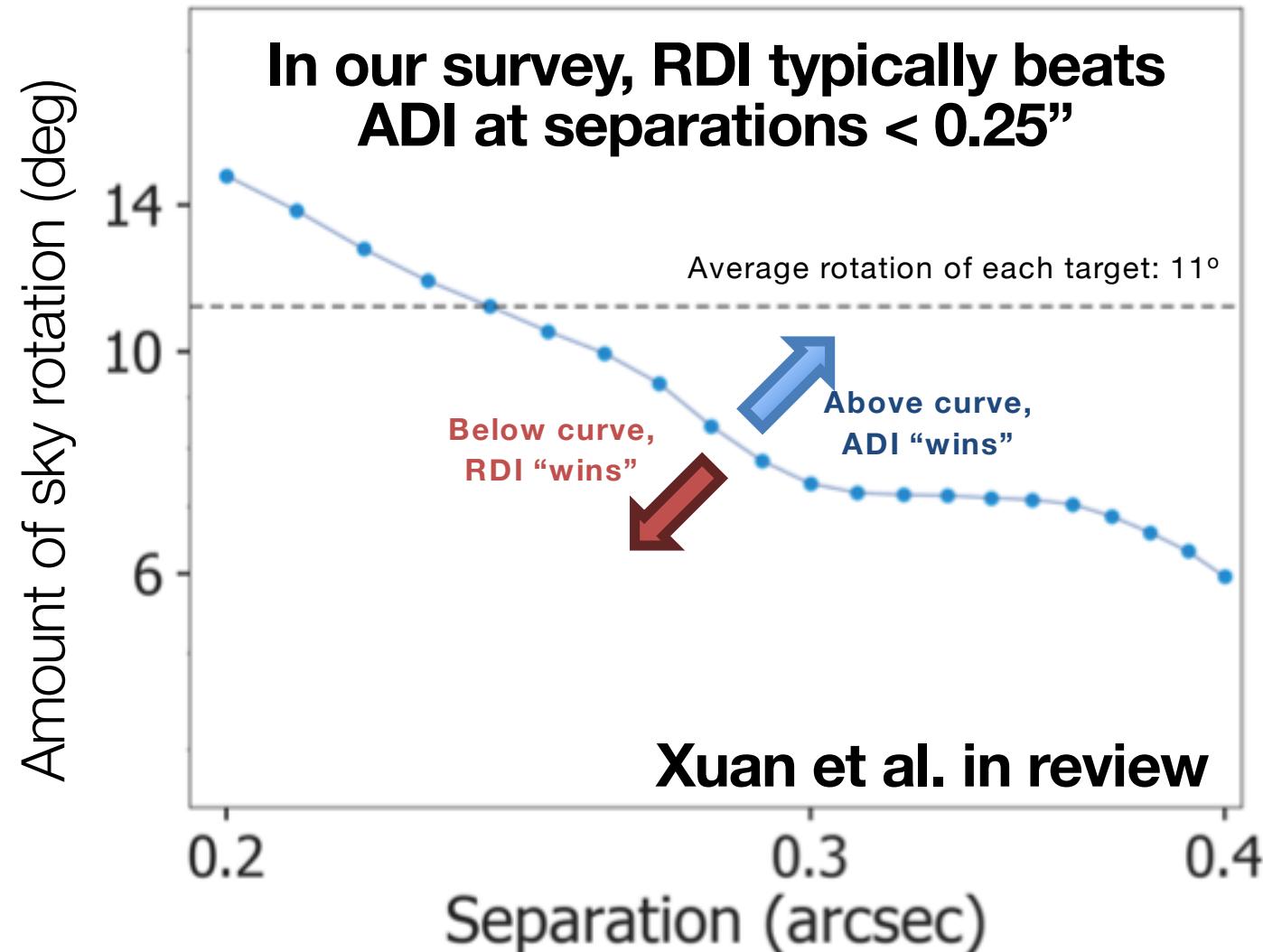


NIRC2 Vortex: RDI vs ADI

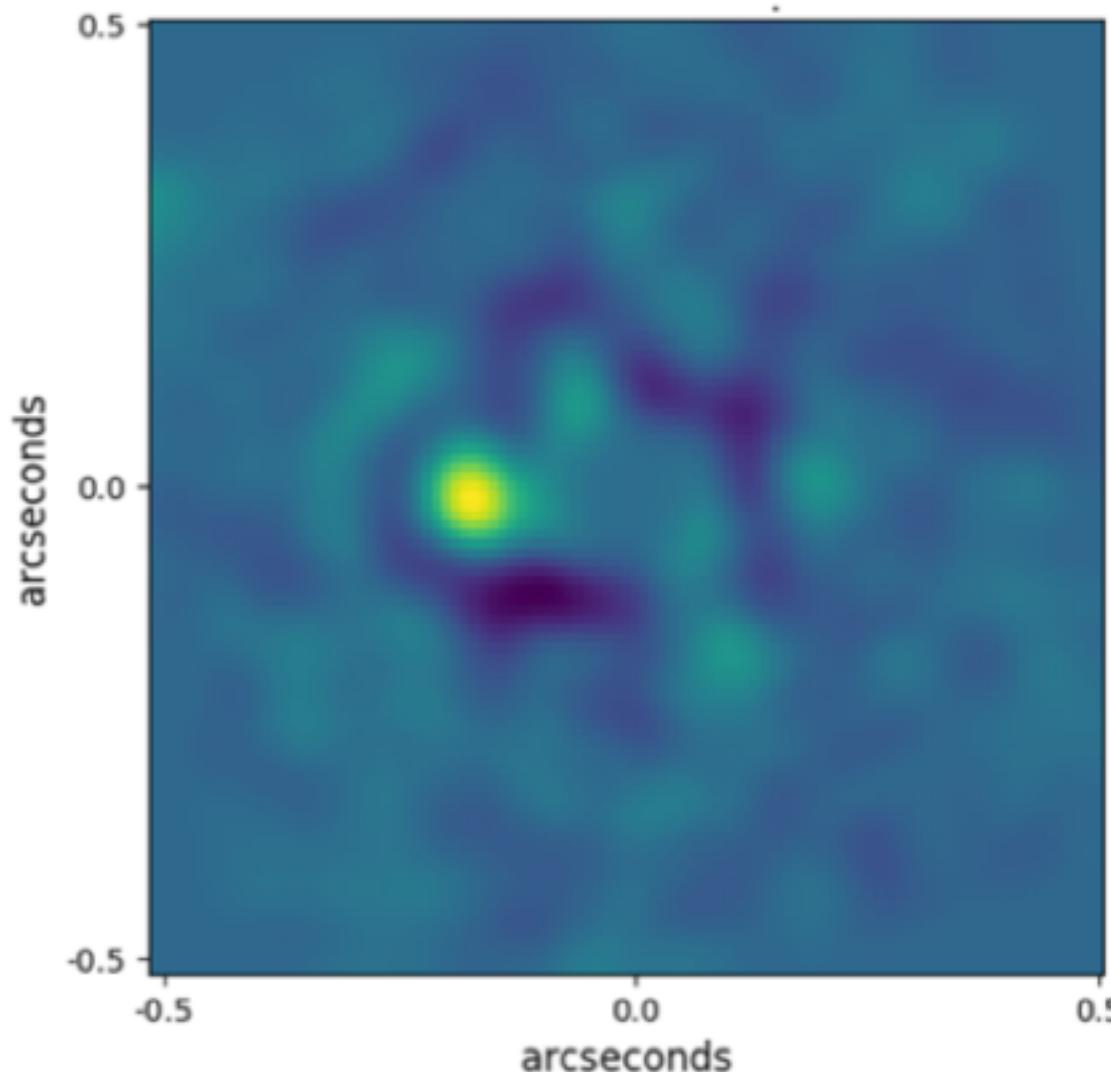


**Wenhao Jerry
Xuan**

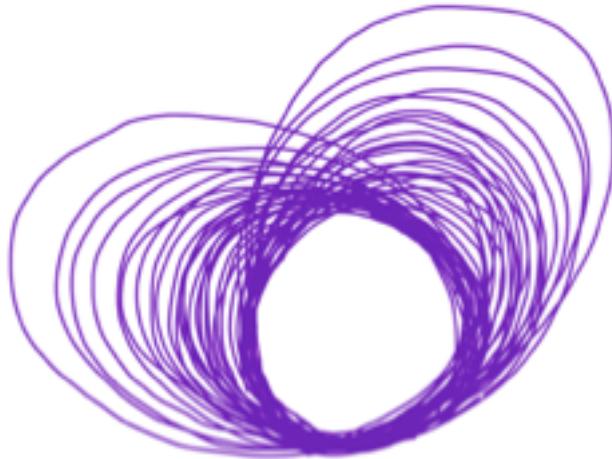
Pomona College
Applying to grad programs!



~40 candidates to follow up



Delta-L ~ 5 mag
Sep: 0.16 arcsec (< 10 AU)
Likely a brown dwarf



orbitize!

for imaging astrometry orbit fitting

learn more / contribute at:

GitHub.com/sblunt/orbitize

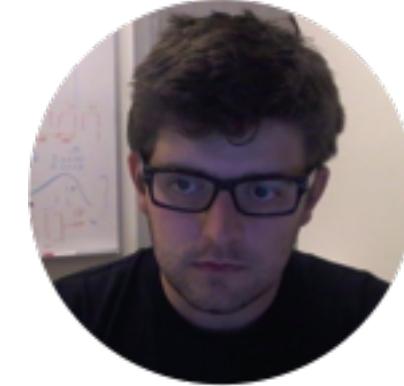
(version 1.0 in August 2018)



Sarah Blunt
Caltech->CfA



Jason Wang
Berkeley->Caltech



Rob de Rosa
Berkeley



Devin Cody
Caltech

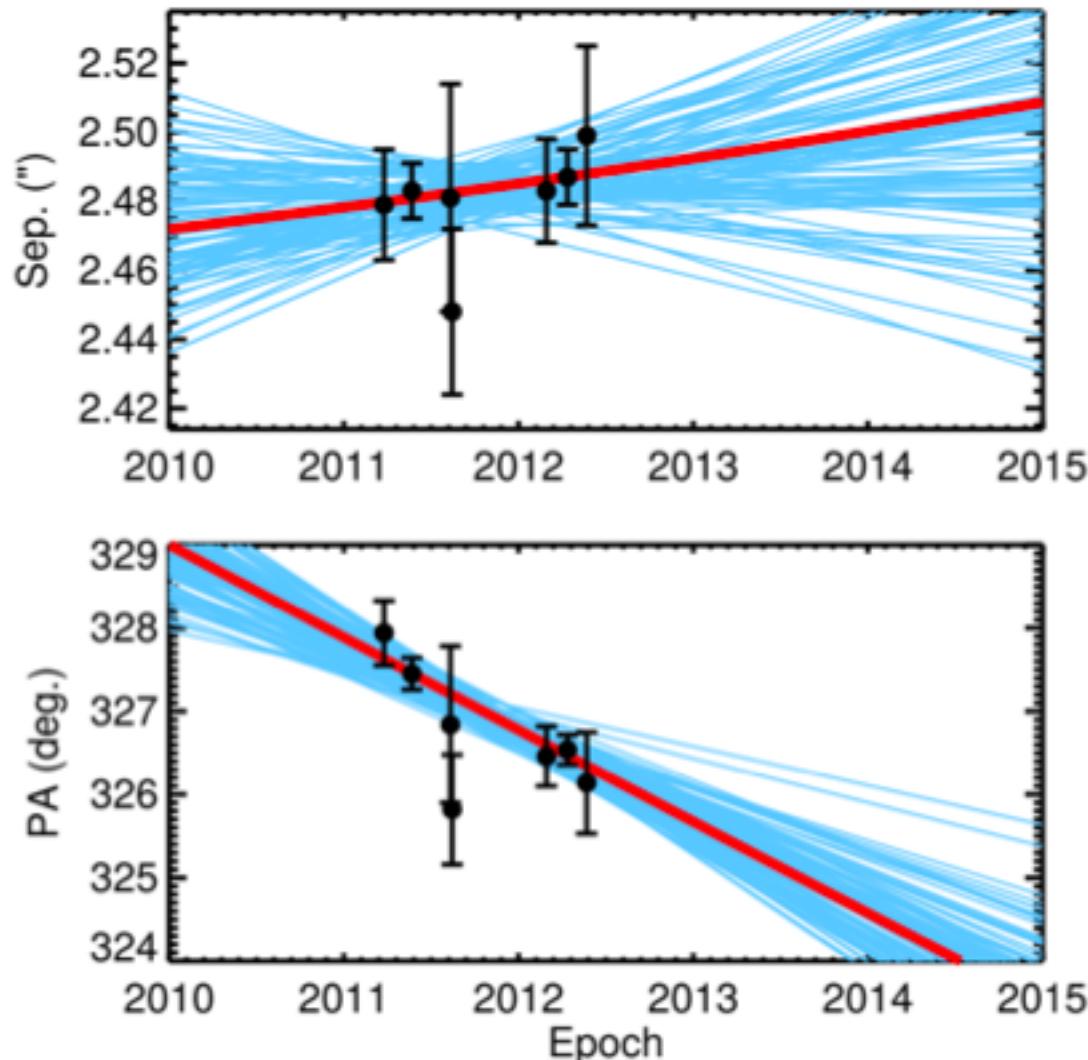
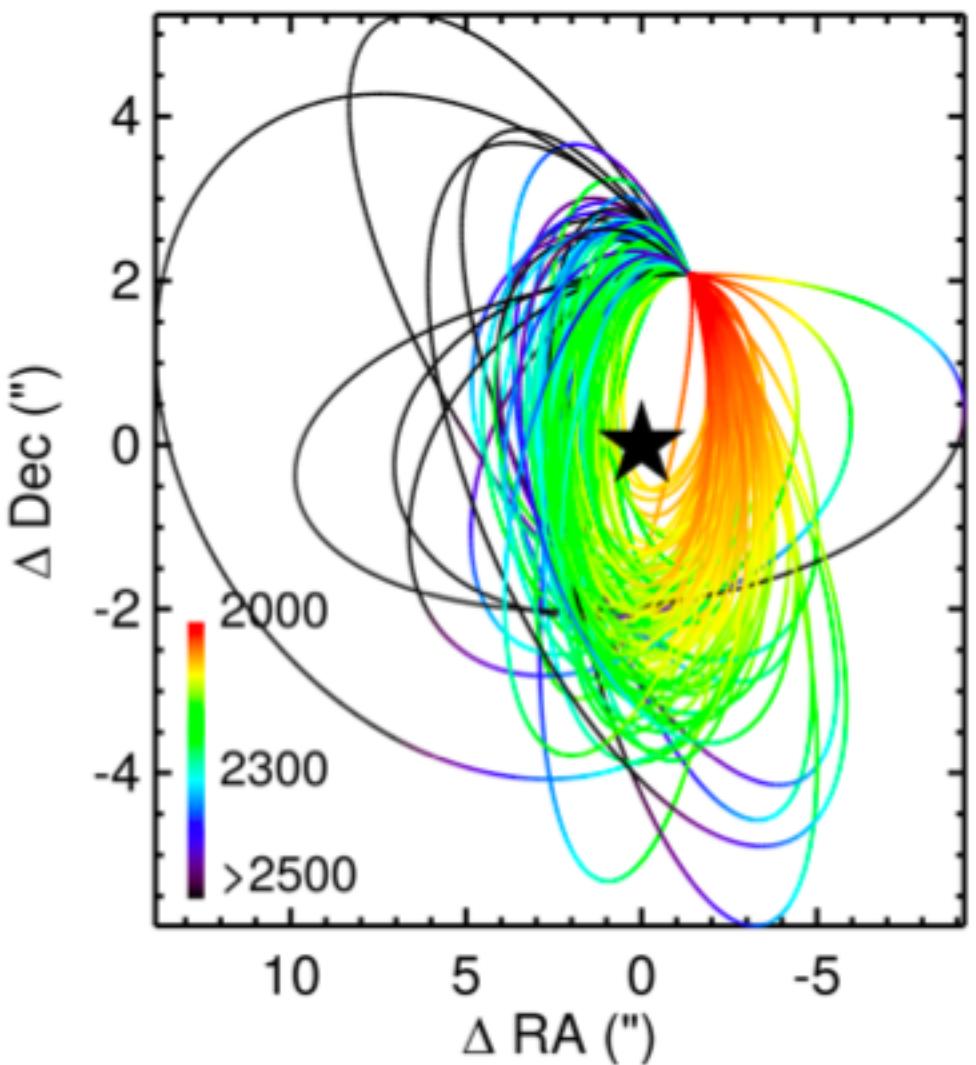


Isabel Angelo
Berkeley->UCLA



Logan Pearce
UT Austin

.... and you?



Blunt et al. (2017)



Sarah Blunt
Caltech->CfA

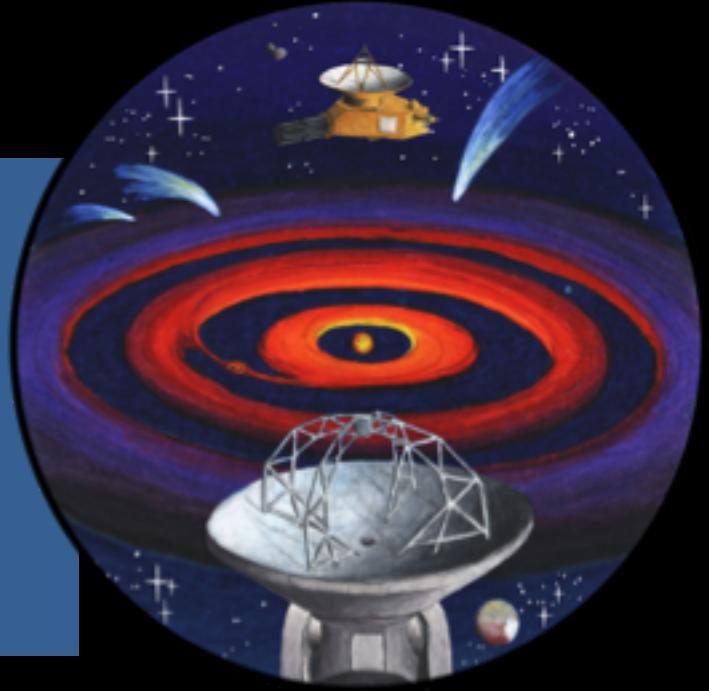
NEW HORIZONS IN PLANETARY SYSTEMS

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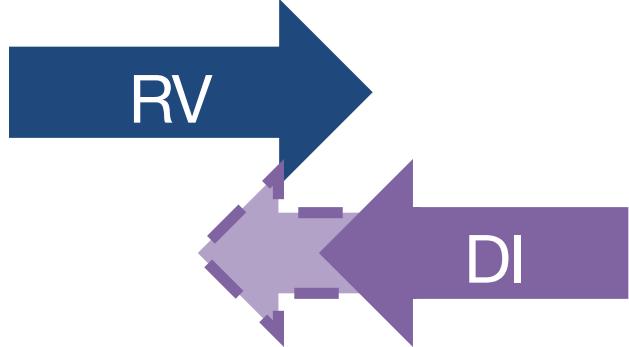


Doug Clement Photography © 2019



Invited speakers:

- **Diana Dragomir:** first results from TESS mission
- **Brett Gladman:** theory of planet formation
- **Grant Kennedy:** debris disk constraints on planet formation
- **Heather Knutson:** exoplanet atmospheric composition
- **Emmanuel Lellouch:** mm observations of solar system objects
- **Karin Öberg:** protoplanetary disk composition and chemistry
- **John Spencer:** New Horizons KBO flyby: first results
- **Zhaohuan Zhu:** protoplanetary disk structure and theory



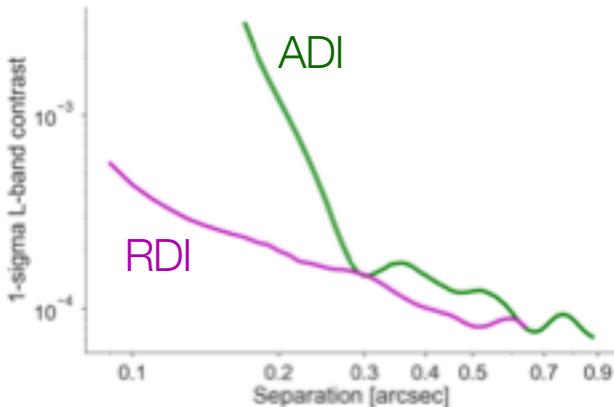
Finding the missing link
planets at 1-10 AU



Automatic Pipeline
by Wenhao Jerry Xuan



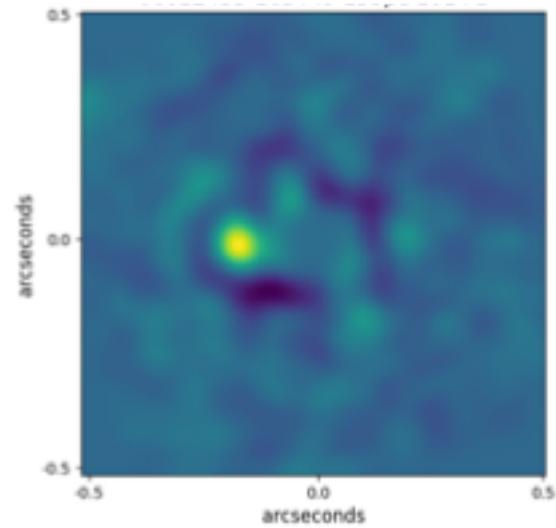
Using the L-band vortex
coronagraph on NIRCam



Reference stars provide
better sensitivity



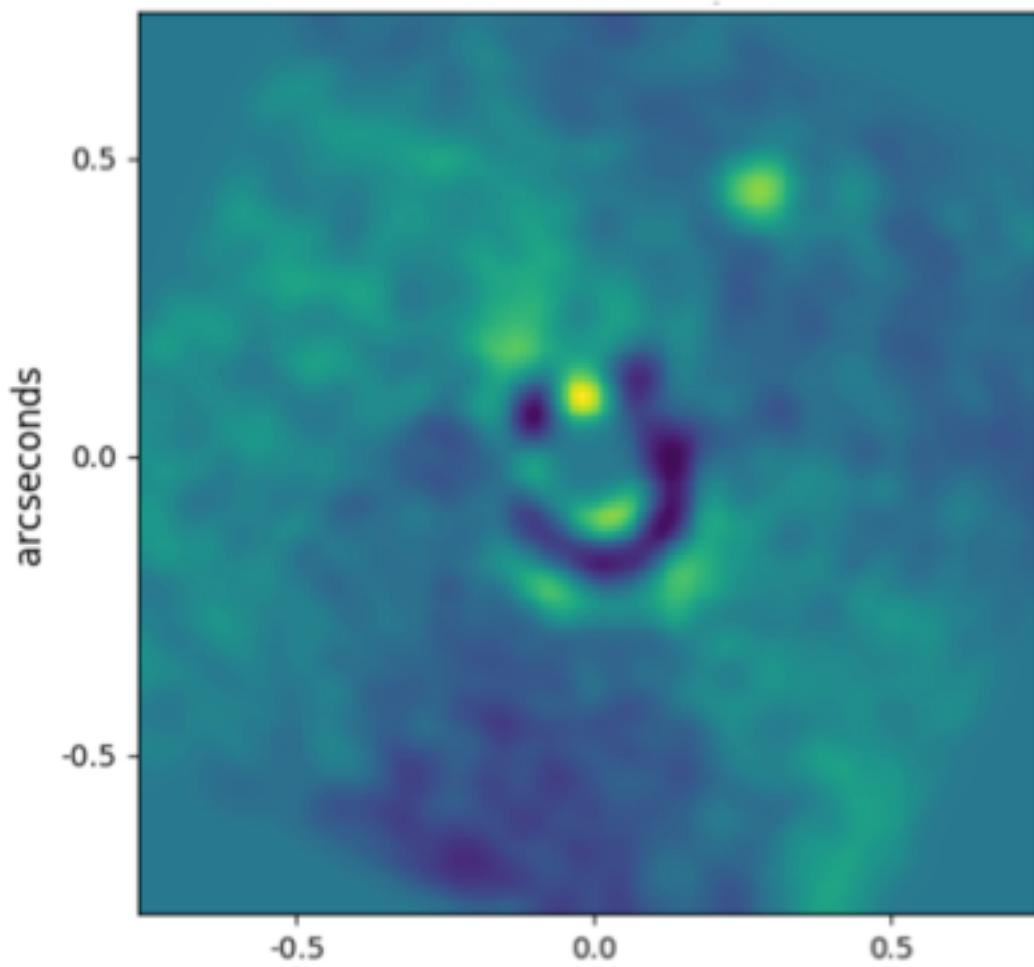
Target 200 young
nearby M-stars



Stay tuned for more!
henry@planetngo.ca
[@AstroDino](https://www.twitter.com/AstroDino)

EXTRA SLIDES

☺ ??



**Reference
off-centre**

