CHARA

Meeting
Meudon 2018

Speckle interferometry at
NASA ARC

nic scott
NASA ARC
Speckle...
the once and future interferometry?

- Speckle Imaging Group
- Instruments
  - Past
    - DSSI
  - Present
    - NESSI
    - `Alopeke
  - Future
    - Zorro
    - QWISSI, SEXSI (Gerard)
- Techniques
  - Wide Field
  - Extended objects
- Projects
2018 Speckle retreat, following the "Know thy Stars. Know thy Planet" meeting
Author network
Speckle
- 10mas/pixel
- mag limit ~17
- contrast limit ~8

Wide Field
- 73mas/pixel

Speckle
- 18mas/pixel
- mag limit ~14
- contrast limit ~6

Wide Field
- 81mas/pixel
Twin instruments in the North and South.

- TESS follow-up
- whole sky surveys
QWSSI

- Quad-channel
- Wave-front sensing
- Possible near-IR channel?
- DSSI heritage at the DCT+NPOI
K2 binaries detectable with DSSI-

Gemini

- 99%
- 87%
- 59%
- 34%
- 19%
- 11%

- observed
- bound (simulated)
- line-of-sight (simulated)

Matson et al. 2018 (submitted)
Companions of Kepler false positives

Furlan et al. 2017
\[
\frac{f_{\text{total}} - f_{\text{transit}}}{f_{\text{total}}} = \delta_{\text{obs}} = \left( \frac{f_{\text{transit}}}{f_{\text{total}}} \right) \left( \frac{R_{\text{planet}}}{R_{\text{transited\star}}} \right)^2
\]
When a planet transits its star, scientists can measure its **size** from the fraction of the star’s light that it blocks.

If it were actually a binary system with two equally-bright stars, the planet has to be **bigger** to block the same total fraction of light.

And if the planet orbits the fainter of two stars, to have the same effect it must be **even larger**!

But this assumes that there is only **one star** in the system.

In actuality, half of the stars with planets are probably **binaries**!

This is important because even modern space telescopes like Kepler have limited resolution and can’t always distinguish between **one star** and a binary system of **two close stars**.
Models from Zeng et al. (2016) for $M < 0.1 \ M_J$
Models from Fortney et al. (2007) for $M > 0.1 \ M_J$

- 100% Fe
- 50% Fe
- Rock
- 50% H$_2$O
- 100% H$_2$O
- Cold H$_2$,He

Giant 1 Gyr-old planet at 0.1 AU
with core mass of:
- 10 $M_\oplus$
- 25 $M_\oplus$
- 50 $M_\oplus$
Shift from $1.8$ to $2.2 \ R_E$ implies increased water/ice content vs pure Si rock

- Large radius errors originally hid distribution features
- Fulton gap revealed after CKS (10% stellar radius errors)
- Accounting for binarity shifts gap in the distribution

Teske et al. (in prep.)
Two-color wide-field speckle reconstruction

- 0.25" resolution from 500 frames (20s)
- compromise b/t angres and contrast
- Seeing ~ 0.85"

(a) Seeing-limited
(b) Reconstructed
Abs astrometry residuals
~6-7 mas    4.2 mas

Further improvement possible to obtain
~0.02 pix (~0.4mas)

- optics, dither, deeper obs

0.05 mag accuracy on aperture photometry

M13
- astrometry of clusters
- very early results and little calibration or modelling over the FoV
NEAs

- sizes
  - radar typically quotes 40% uncertainties
  - albedo/radar size mismatch
- shapes
  - adapt stellar surface modeling tools
  - light curve inversion/illumination model
Asteroid Kleopatra imaged at Gemini. The images are 2.8 x 2.8 arcsec and show 550 nm (left) and 880nm (right).

H310008 = 216 Kleopatra

a~2.8AU
d~270km x 80km
(neck~50-65km)

model: Franck Marchis
Phaethon
Dec 2017 ~ 0.07AU
d~6km

Phaethon power spectrum (resolved)

Point source PS
Exozodis

- Flux limited to 1.6% at 0.1"
- Any companion $T \geq 2500K$ (M8V/M9V) is eliminated.
Open to the community

- NOAO proposal process
- NESSI - WIYN@KPNO
- `Alopeke - Gemini-N
- DSSI - Gemini-S
- Transitioning from block queue operation to Facility Instrument status

NPP & internship opportunities: see me for details
Some other proposals so far:

- Constrain NEA diameters. Image SS objects.
- Determine multiplicity of nearby K and M-dwarfs, does it vary across spectral type?
- Imaging of brown dwarfs and distant large planets, particularly around M dwarfs.
- Investigate differences in planetary system architectures between multiple vs not (known) multiple host stars.
- Examine long term RV trends/determine binarity of RV planet hosts.
- K2, TESS follow-up
- Provide and unbiased sample for TESS, so statistical determinations of planet occurrence rates can be made.
- Occultations, Transit photometry, Pulsar time scales, observe pulsating WDs at high cadence....
References

- Scott, Howell, Horch, & Everett. PASP 2018 (accepted)
- Horch et al. AJ 2012
- Furlan et al. AJ 2017
- Furlan & Howell AJ 2017
- Horch & Casetti-Dinescu 2018 (in prep.)
- Matson et al. 2018 (submitted)
- Teske et al. 2018 (in prep.)
- Fulton et al. AJ 2017