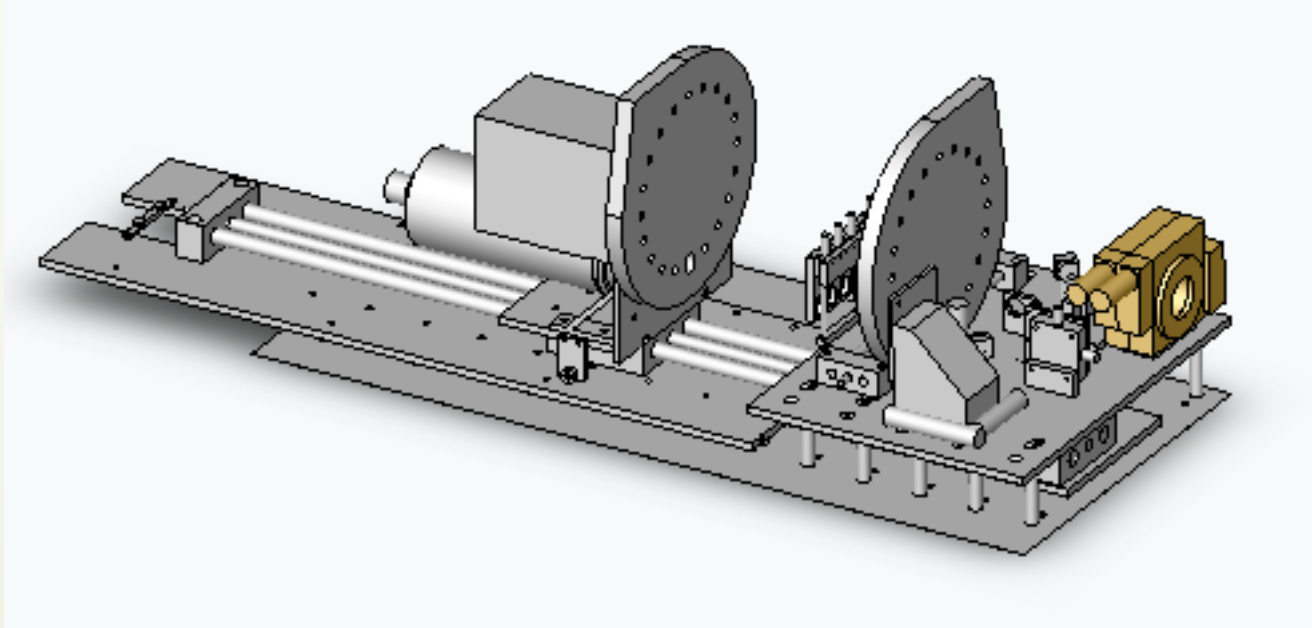


# AO Assisted Observing in the Visible

## LuckyCam, Aperture Masking and Polarization @ Palomar



**Nicholas Law (Caltech), Craig Mackay (Cambridge),  
Mike Ireland (Caltech), Peter Tuthill (Sydney), Jamie  
Lloyd (Cornell)**

# Overview

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**Concept: AO-Assisted Observations in the visible**

**Using current AO systems for partial wavefront correction, then further processing to improve final images**

**LAMP, new instrument for Palomar with 3 AO-assisted modes:**

- Direct imaging (L3CCD sensitivity)
- Aperture masking - conventional & Lucky
- High-contrast polarimetry

## **Direct AO imaging in the visible with current systems**

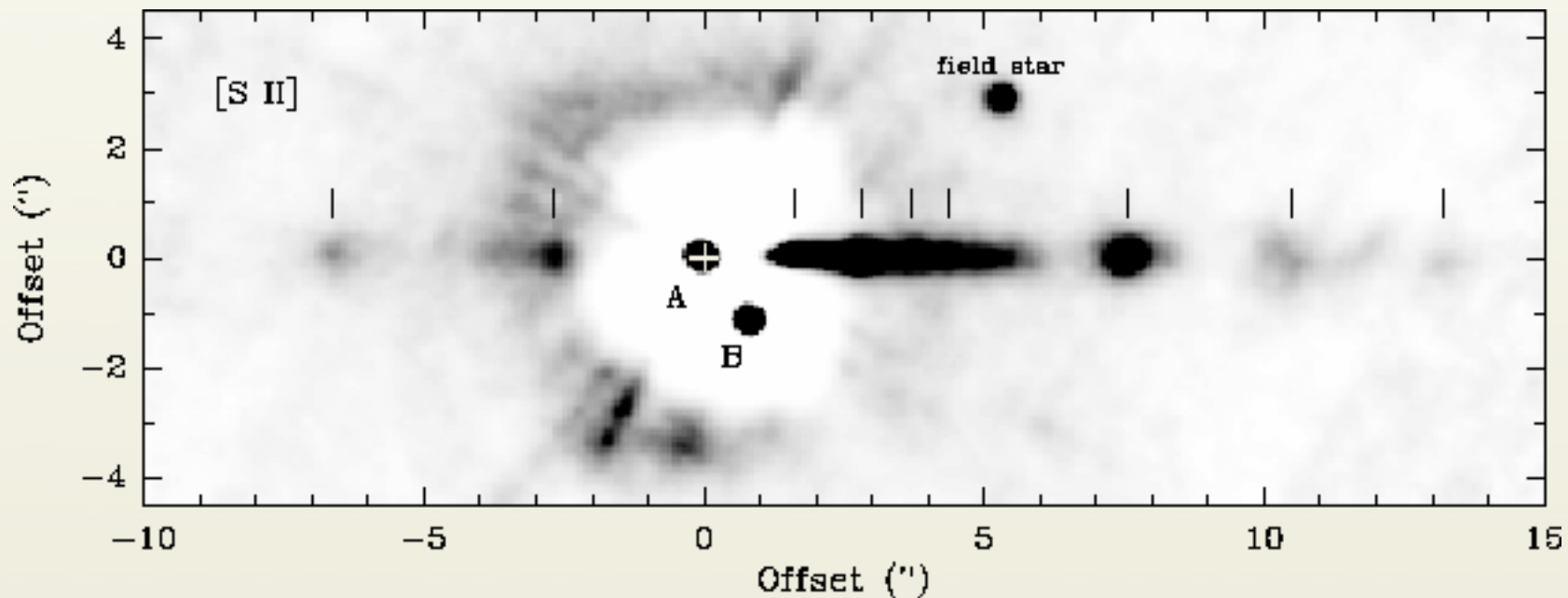
# AO In the Visible with Current Systems

*Low-resolution* AO correction at 600-900nm has already been used for several science programmes.

For example, T-Tauris in H-alpha using CFHT in 1997(!).

Core FWHM: 0.3 arcsec

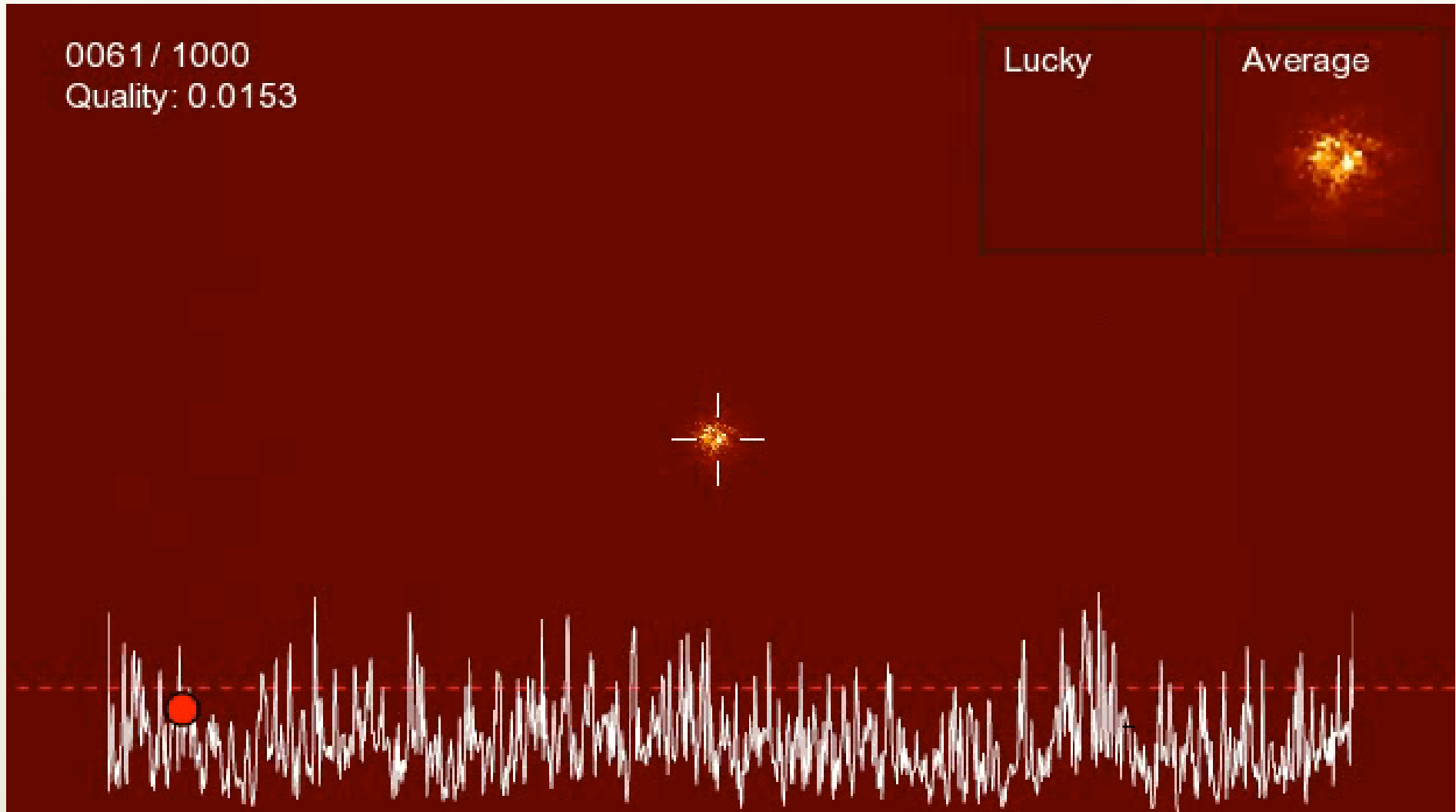
**After Image selection: 0.16-0.22 arcsec**



Dougados et al 2000

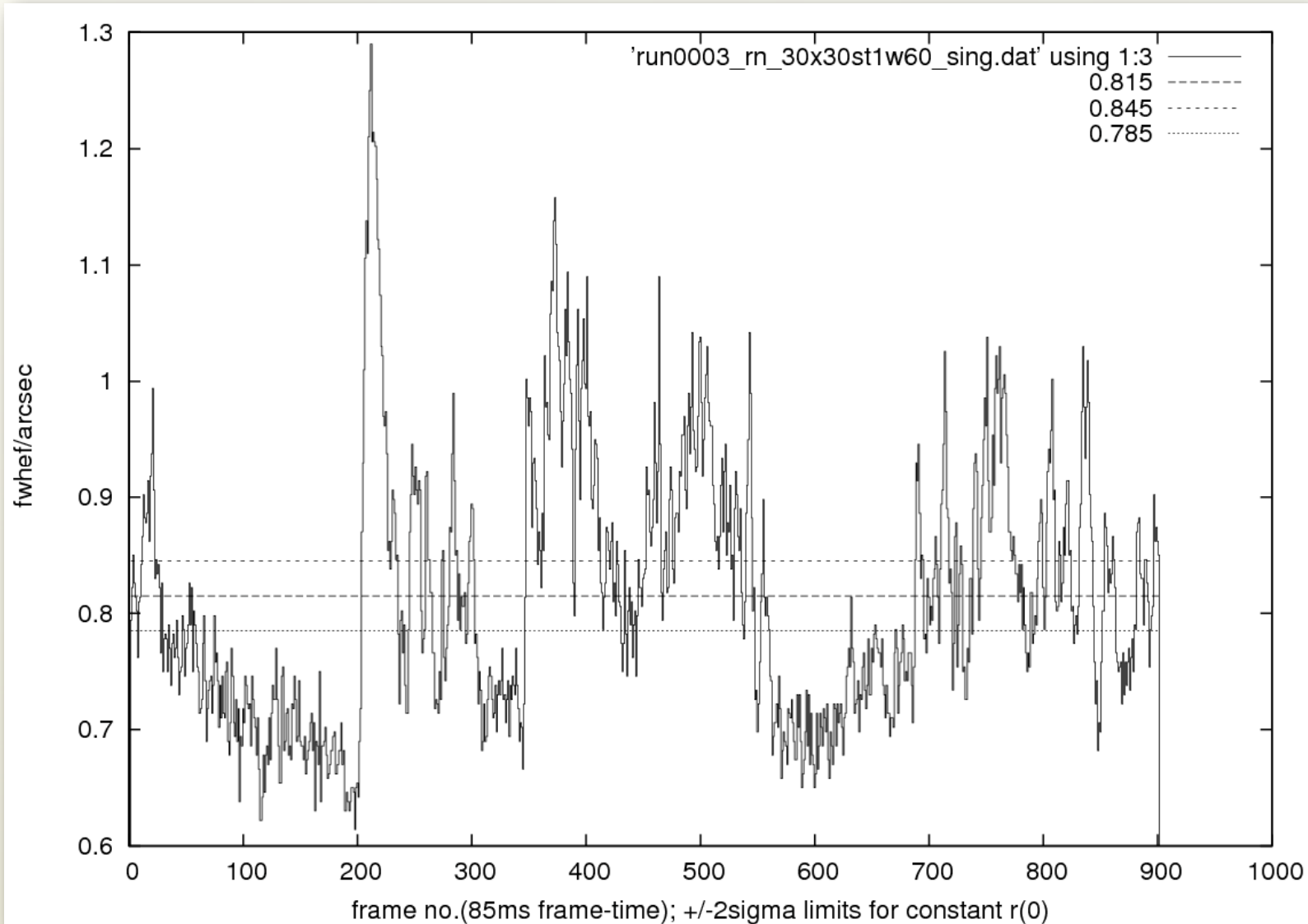
# Lucky Imaging

- Frame selection @ 30 FPS
- Noiseless L3CCD allows faint guide stars ( $I=16$ ) and deep imaging
- Strehl ratios of 0.2 **without an AO system** on 2.5m telescopes at 700nm



# Lucky Imaging + AO

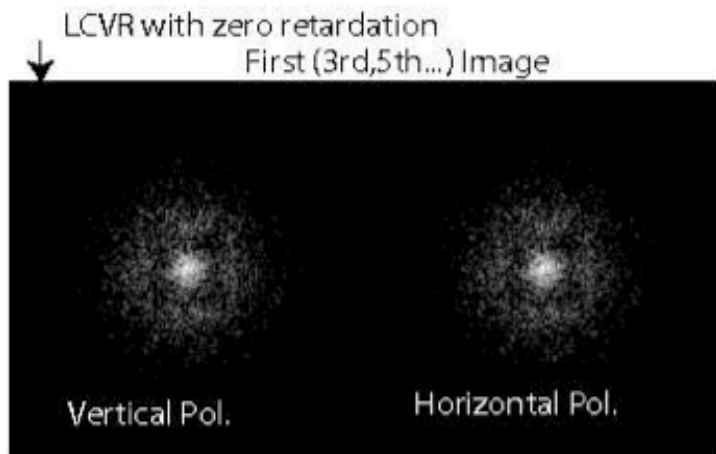
- Fast frame selection allows us to reach Strehls of 0.2 in I-band on 2.5m telescopes **without any AO system**
- Behind an AO system, we're picking the times where the AO system is performing at its very best - for good performance with large telescopes



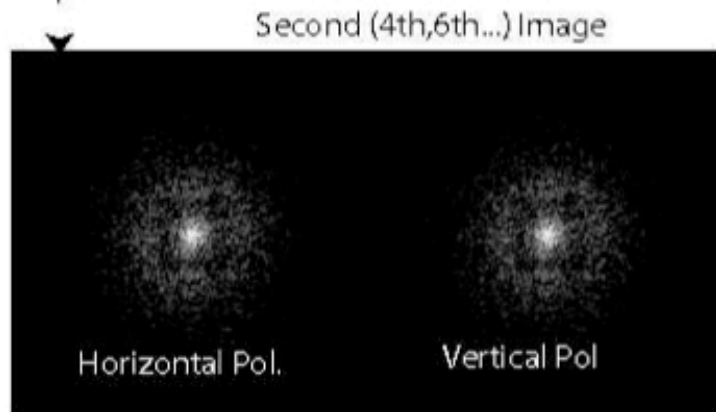
## **AO-assisted observations in the Visible**

# High Contrast Polarimetry (Mike Ireland)

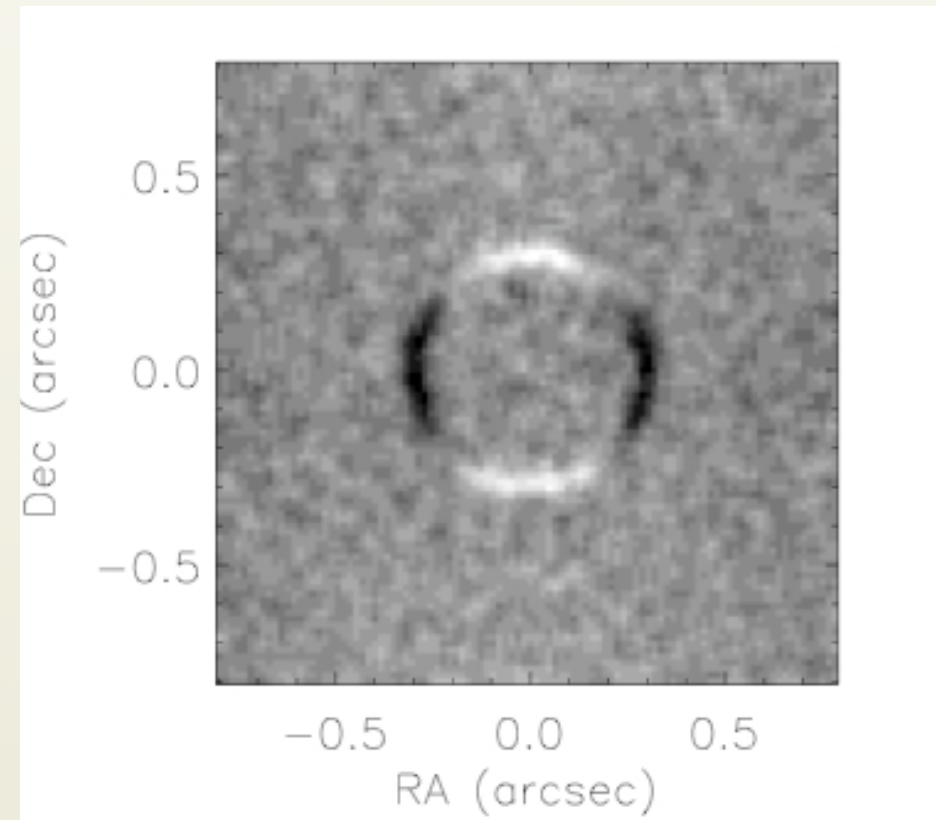
- Wollaston prism to split orthogonal polarizations into side-by-side AO-assisted images
- LCVR switcher rapidly switches the order of the images (faster than turbulence coherence time)
- Gives direct PSF + camera effects calibration and subtraction
- Targeting dust disks
- **Planned to be highest-resolution & speckle suppression to date in imaging polarimetry**



...LCVR with fast axis oriented  $\diagup$  goes from 0 to half-wave in  $\sim 4$ ms during frame transfer.

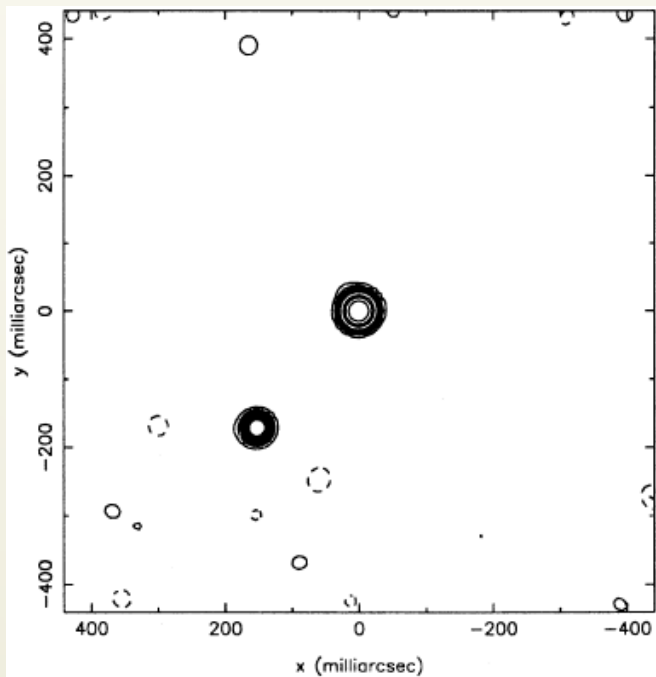


...odd left hand images subtracted from even images. This forms Stokes Q, the same for the right hand images is -Q; then the left hand and right hand sides are registered against each other and subtracted, forming a doubly-differential Q image...

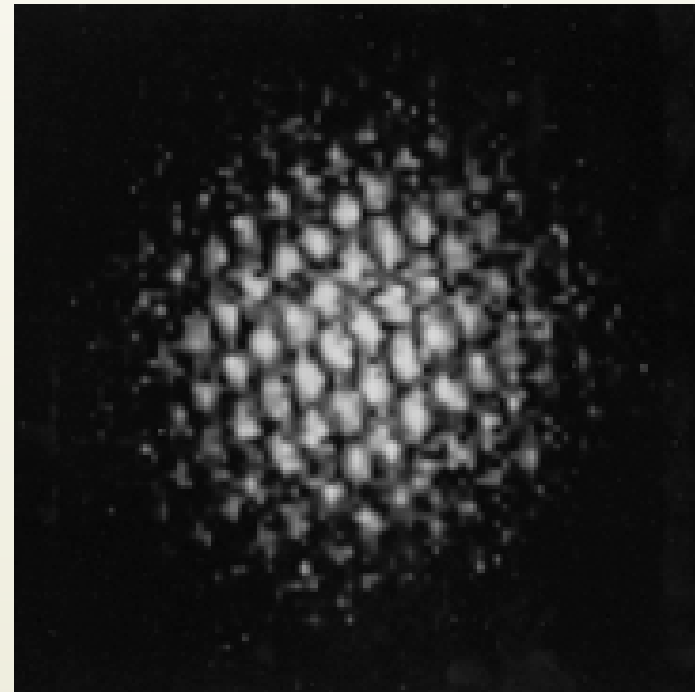


# Aperture Masking (Peter Tuthill)

- Place masks in pupil plane to split aperture into lots of small apertures
- Reconstruct high-angular-resolution image by measuring components along baselines between apertures.
- Target Mira winds
- **Need L3CCD for sensitivity. AO system allows much larger aperture sizes & therefore much fainter targets.**
- **Used very successfully in IR on Keck**



**$\beta$  CrB imaged by SRK with P200 in 1988 at 630 nm.  
~0.045 arcsec FWHM**



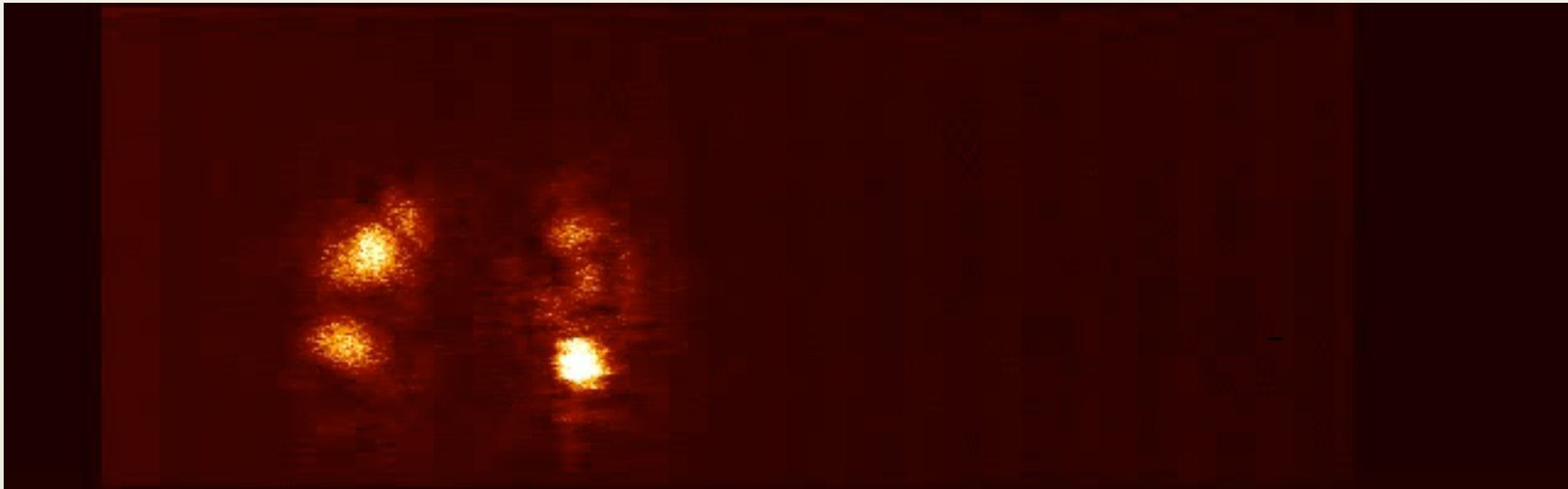
**First optical closure phase image, 1984, Hawaii 2.2m, with slow-scan noisy CCD. (Mackay, Baldwin, Haniff)** 9

# Lucky Aperture Masking (C. Mackay, N. Law)

- Use Lucky Imaging concepts to allow much larger apertures
- Four 1m apertures give **same probability** of getting good wavefront as one 2m aperture
- Tip/tilt must be corrected on a per-aperture basis
- **Use AO system for tip/tilt correction**

Test observations on NTT last July

- **No** AO system (so no tip/tilt correction)
- ~0.7m apertures



# Summary

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- Current AO systems give useful performance in the visible
- Many observations for which an only partially-corrected input wavefront is fine
- LAMP on P200 will offer 3 AO-assisted modes:
  - Direct imaging (L3CCD frame selection and sensitivity)
  - Aperture masking - conventional & Lucky
  - High-contrast polarimetry