

Direct Detection of Exoplanets with Polarimetry

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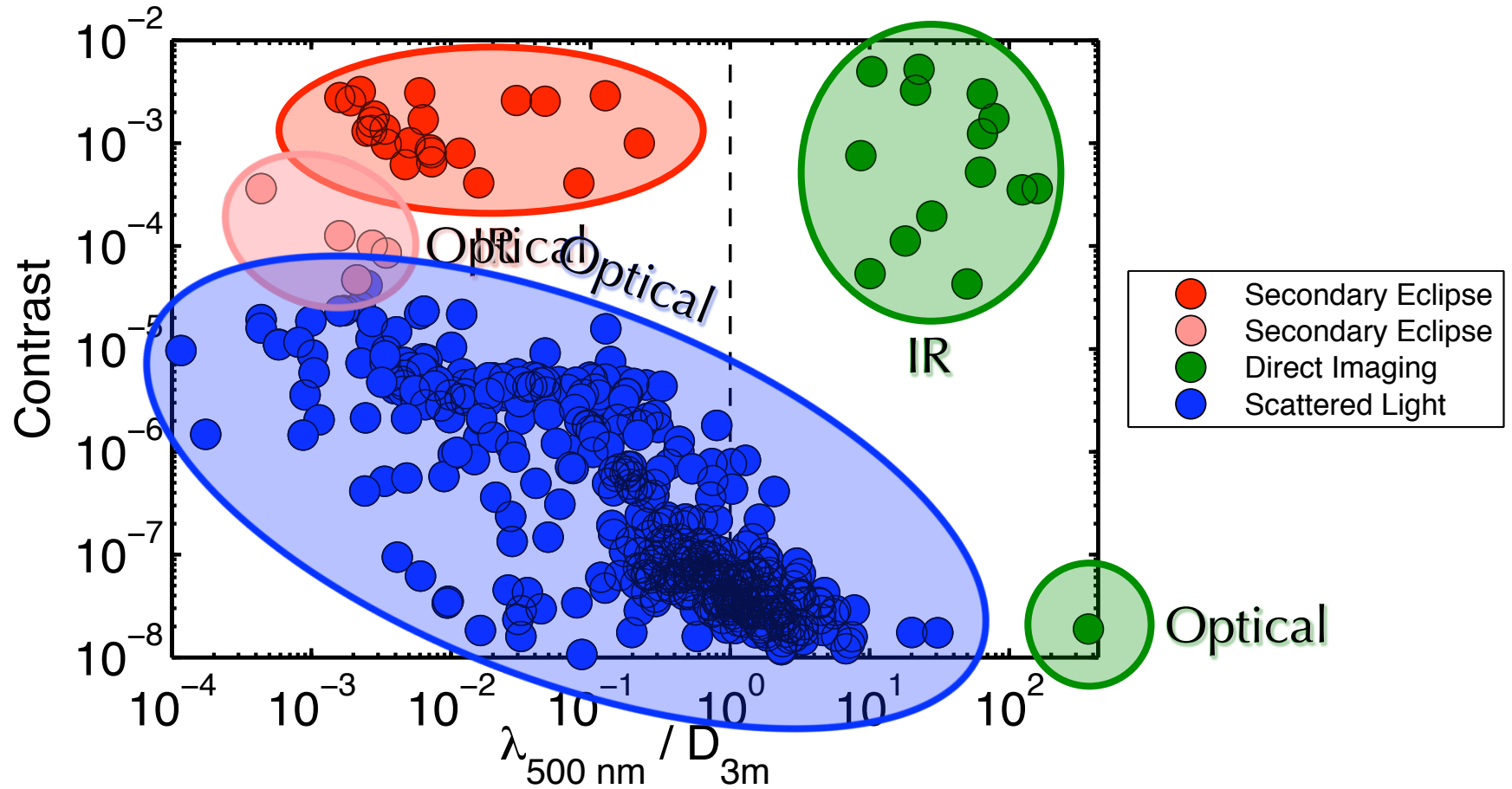
Sagan Fellow, UC Santa Cruz

September 2, 2011

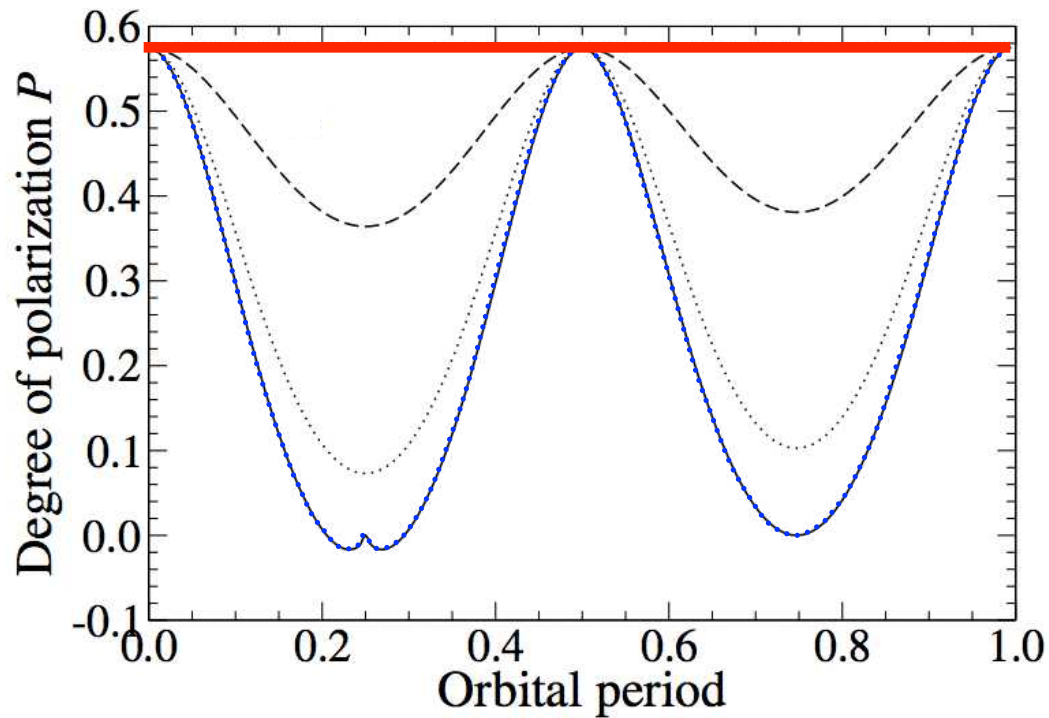




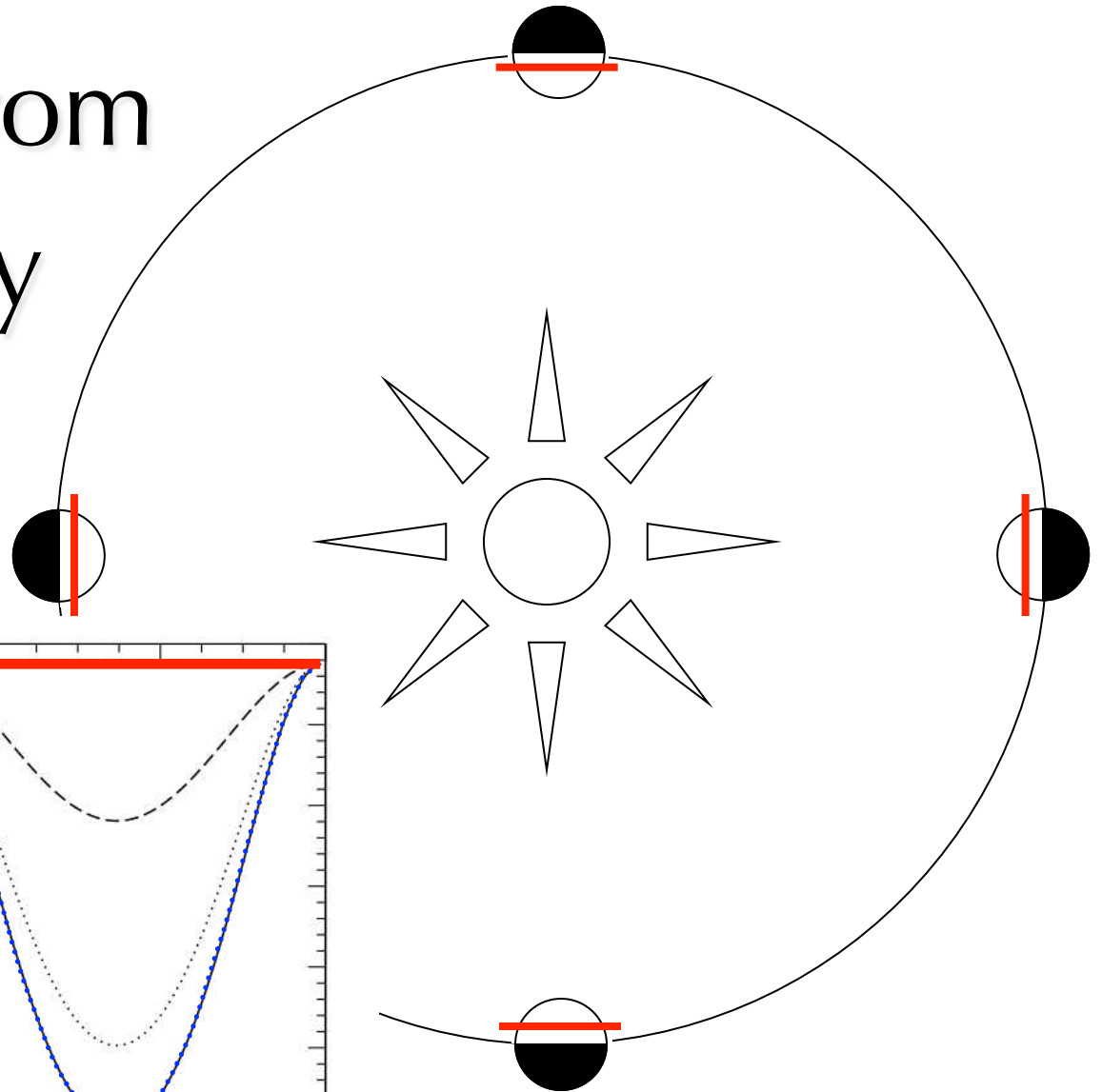
Exoplanet Contrast



Inclination from Polarimetry



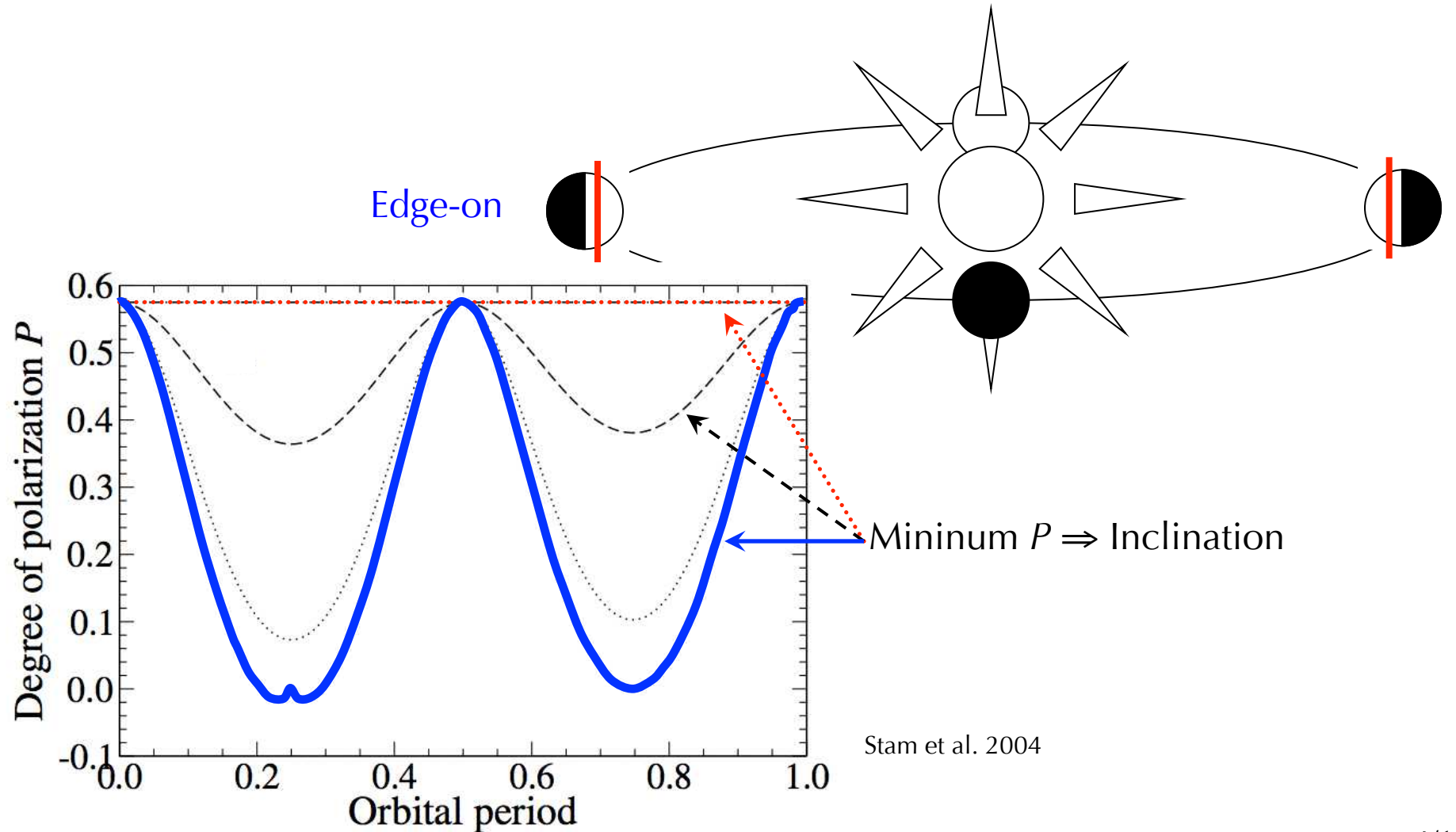
Face-on



Stam et al. 2004

Inclination from Polarimetry

< 10^{-5} precision
(> 10^{10} photons)

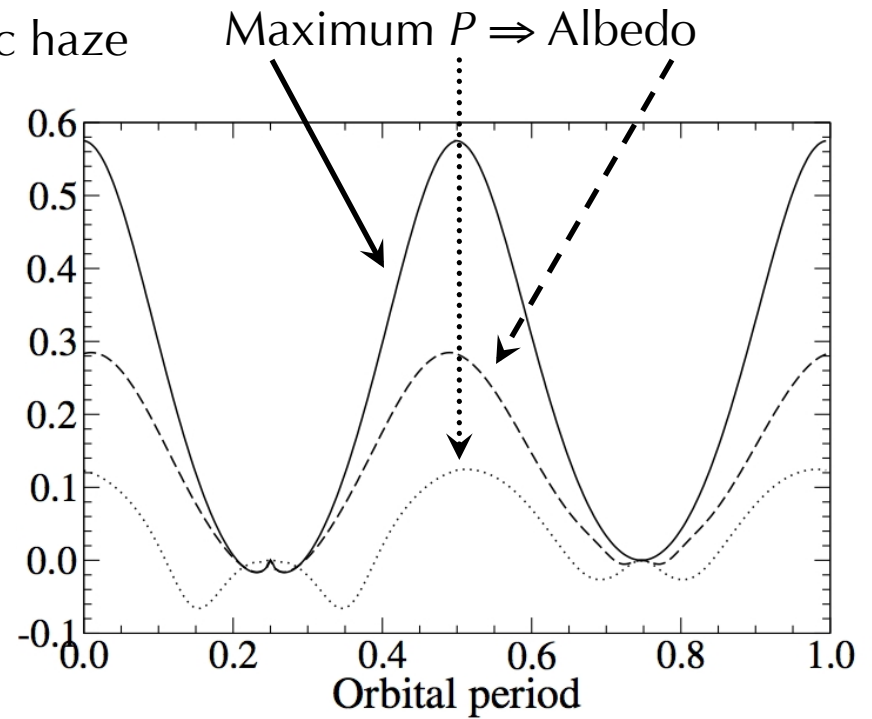
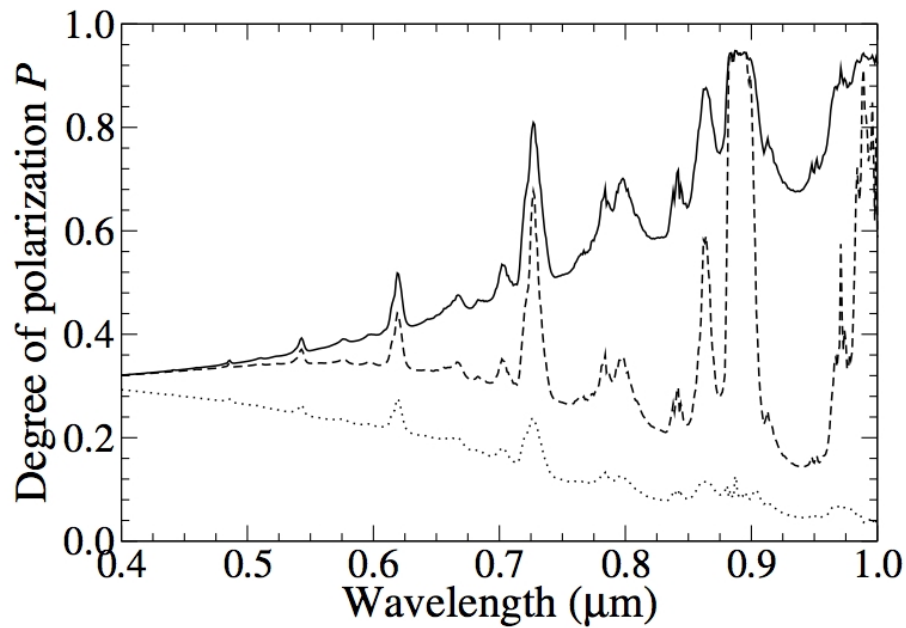




Atmospheric Structure



- Clear
- - - Tropospheric cloud
- Tropospheric cloud + stratospheric haze

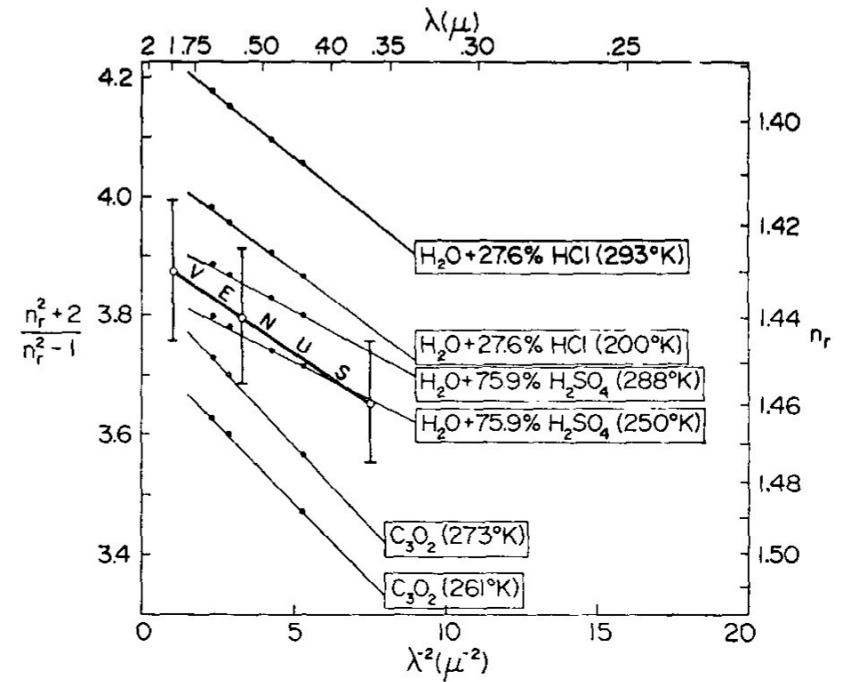
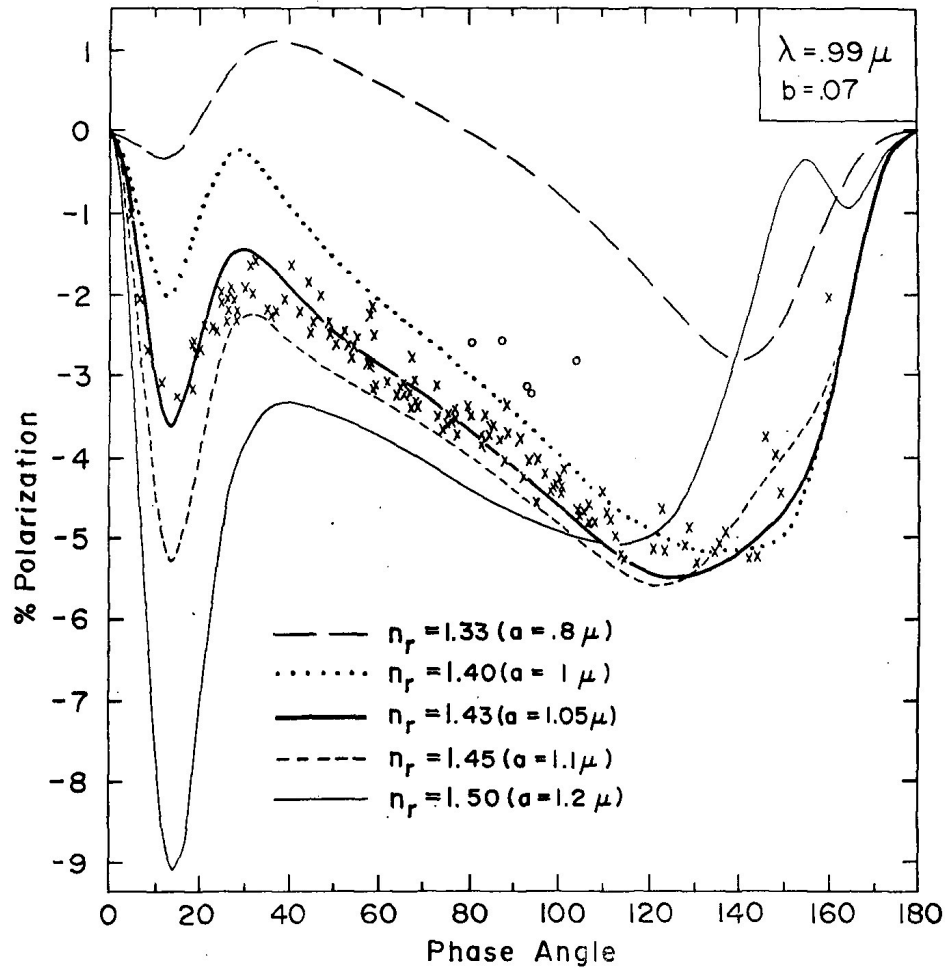


Stam et al. 2004



polish2

Sulfuric Acid in Venus



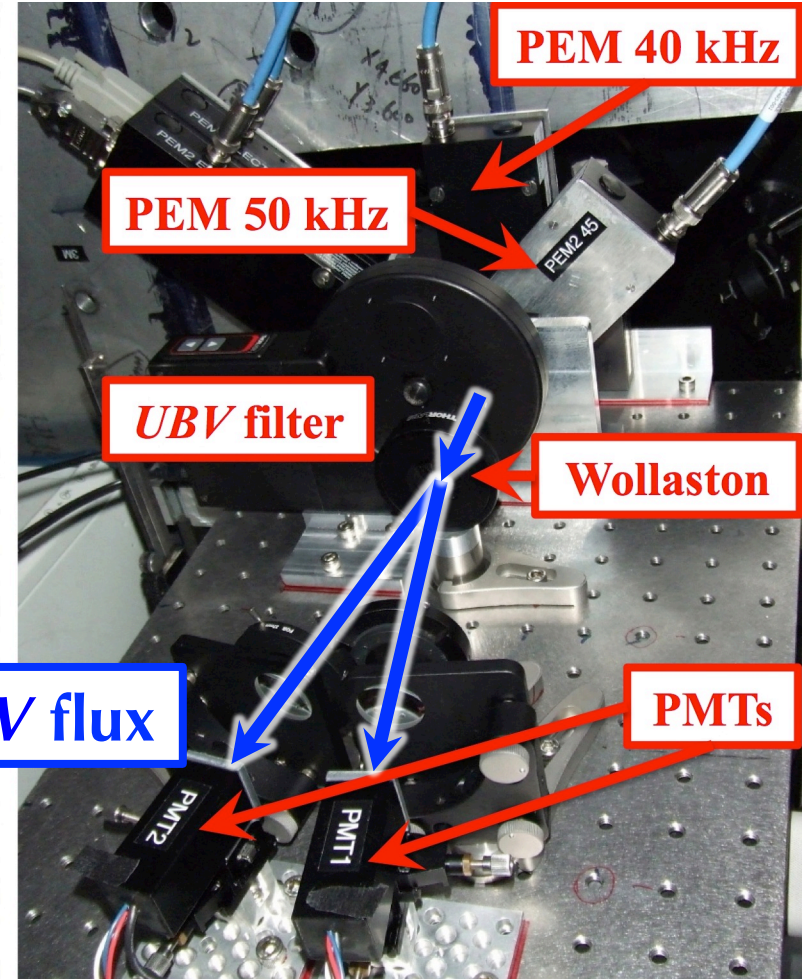
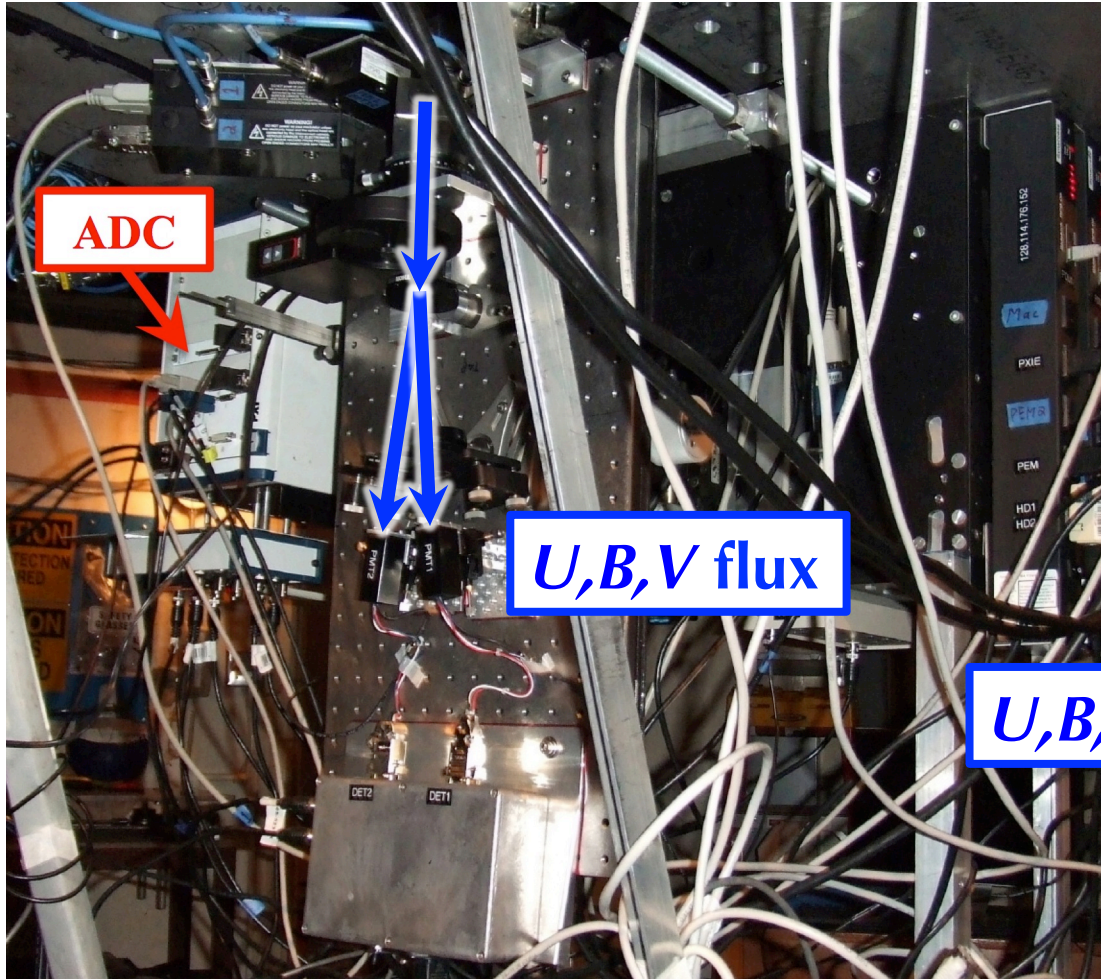
Coffeen & Gehrels 1969
Hansen & Hovenier 1974



polish2

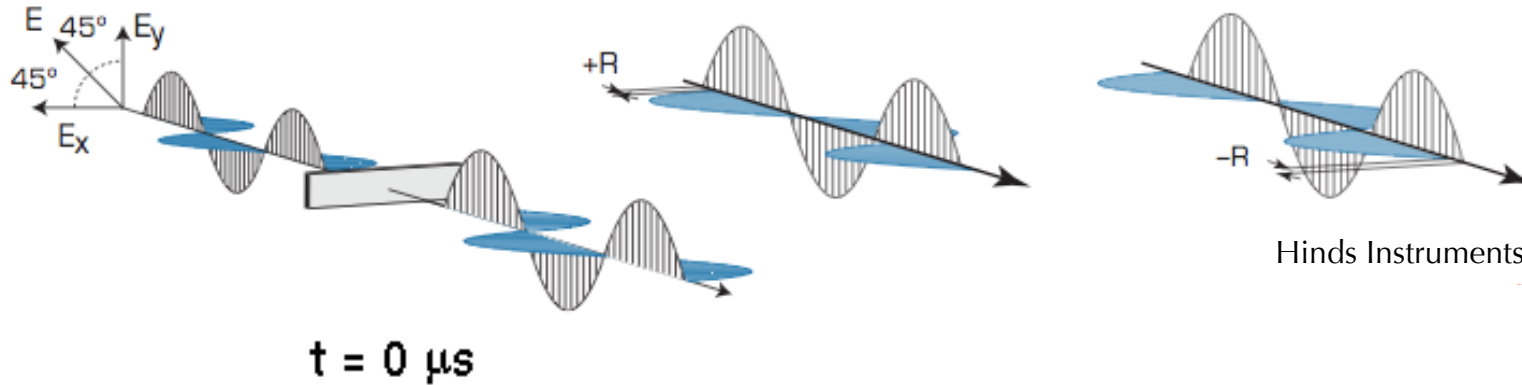
POLISH2

Wiktorowicz & Matthews, 2008, PASP, 120, 1282

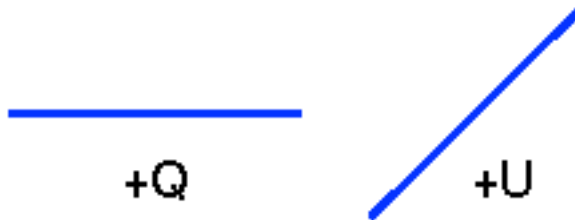




Photoelastic Modulator

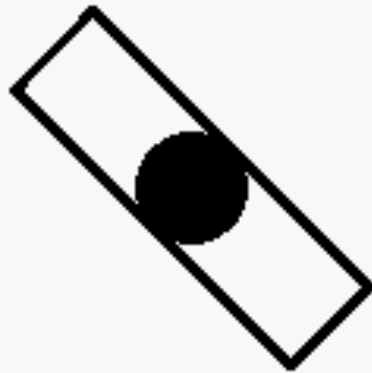


Hinds Instruments

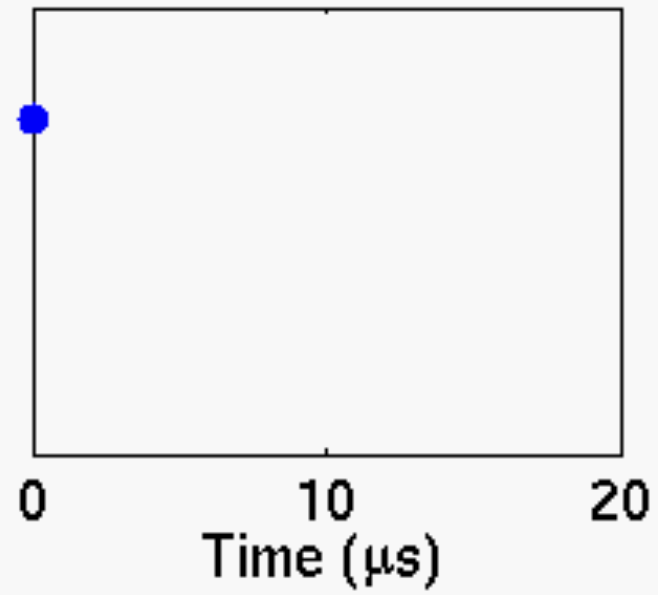
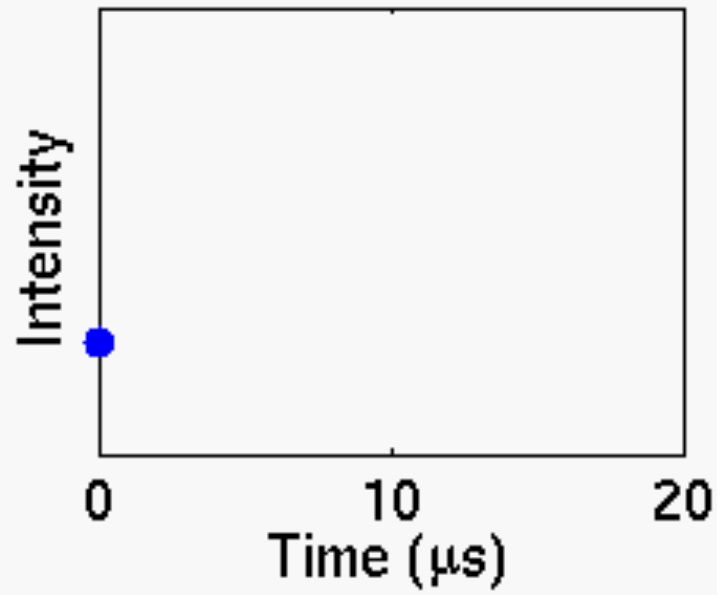
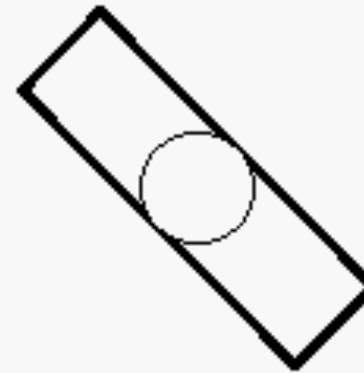


- Birefringence:
horizontal E field
lags/leads vertical
- Non-birefringent
material stressed \Rightarrow
birefringence

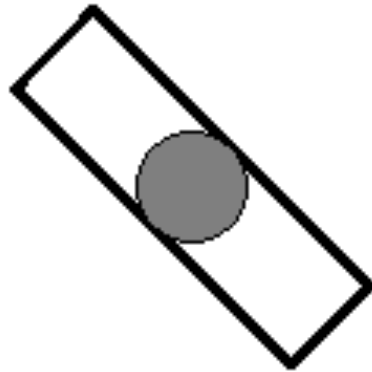
Left Beam



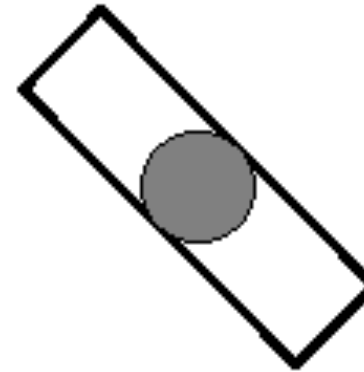
Right Beam



Left Beam

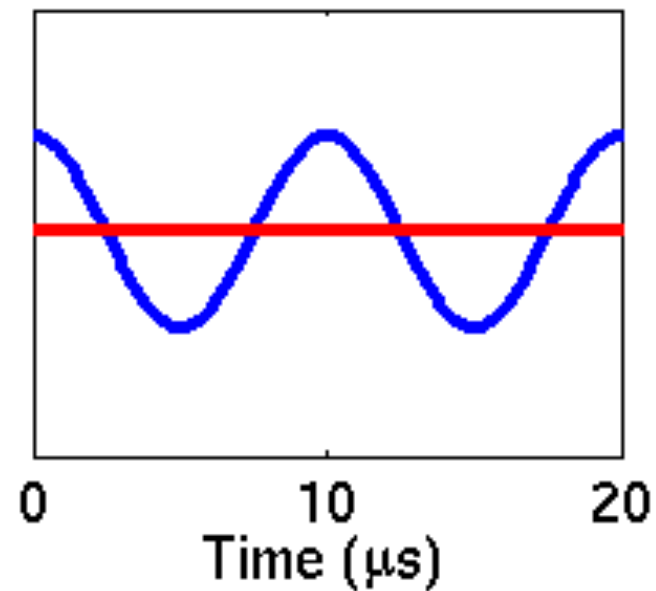
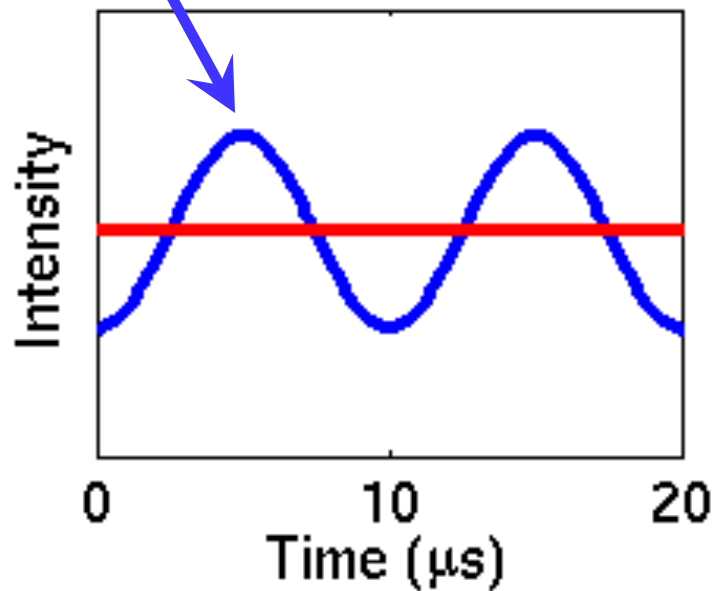


Right Beam

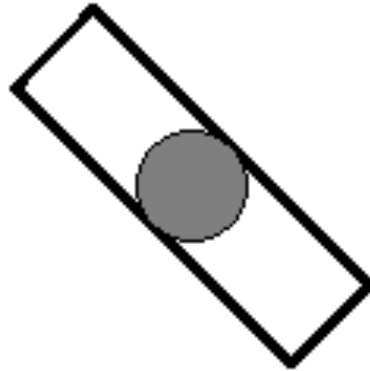


Nearly sinusoidal: $50 + 150 \text{ kHz} + \dots + (2n-1)f = \text{Stokes } V/I$

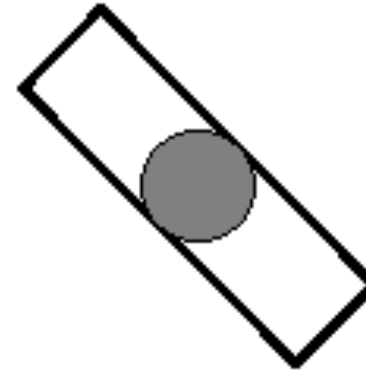
$100 + 200 \text{ kHz} + \dots + (2n)f = \text{Stokes } Q/I, U/I$



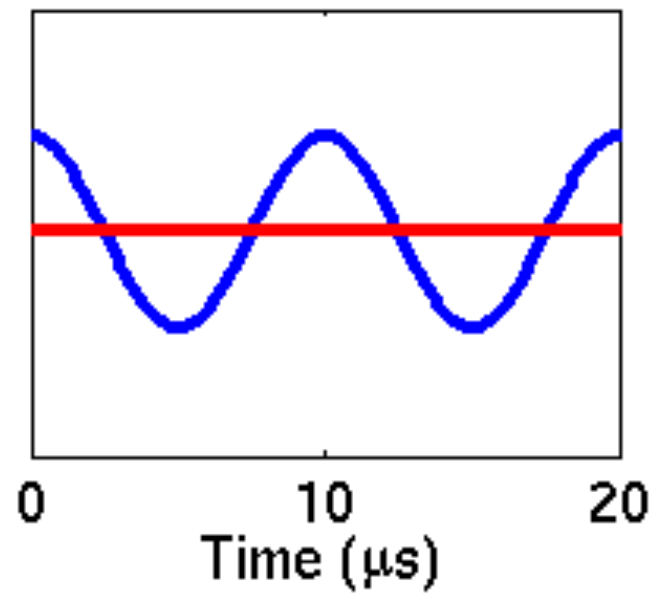
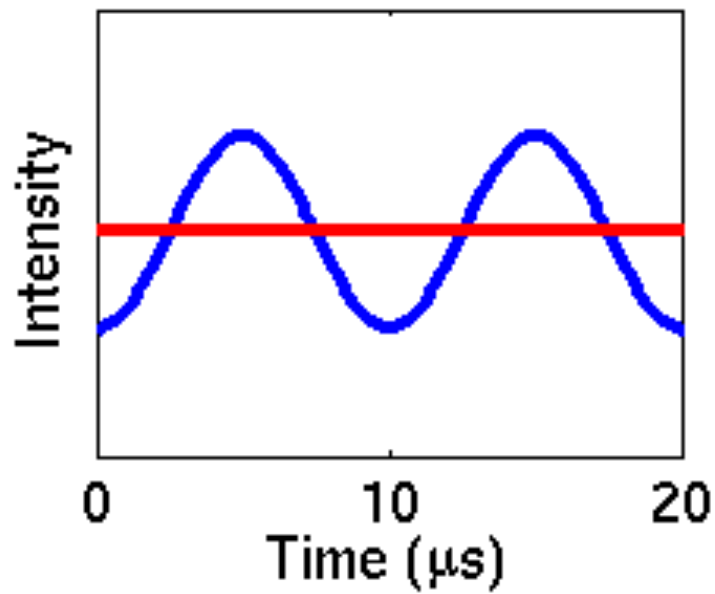
Left Beam



Right Beam



$$P \propto \frac{AC}{DC}$$

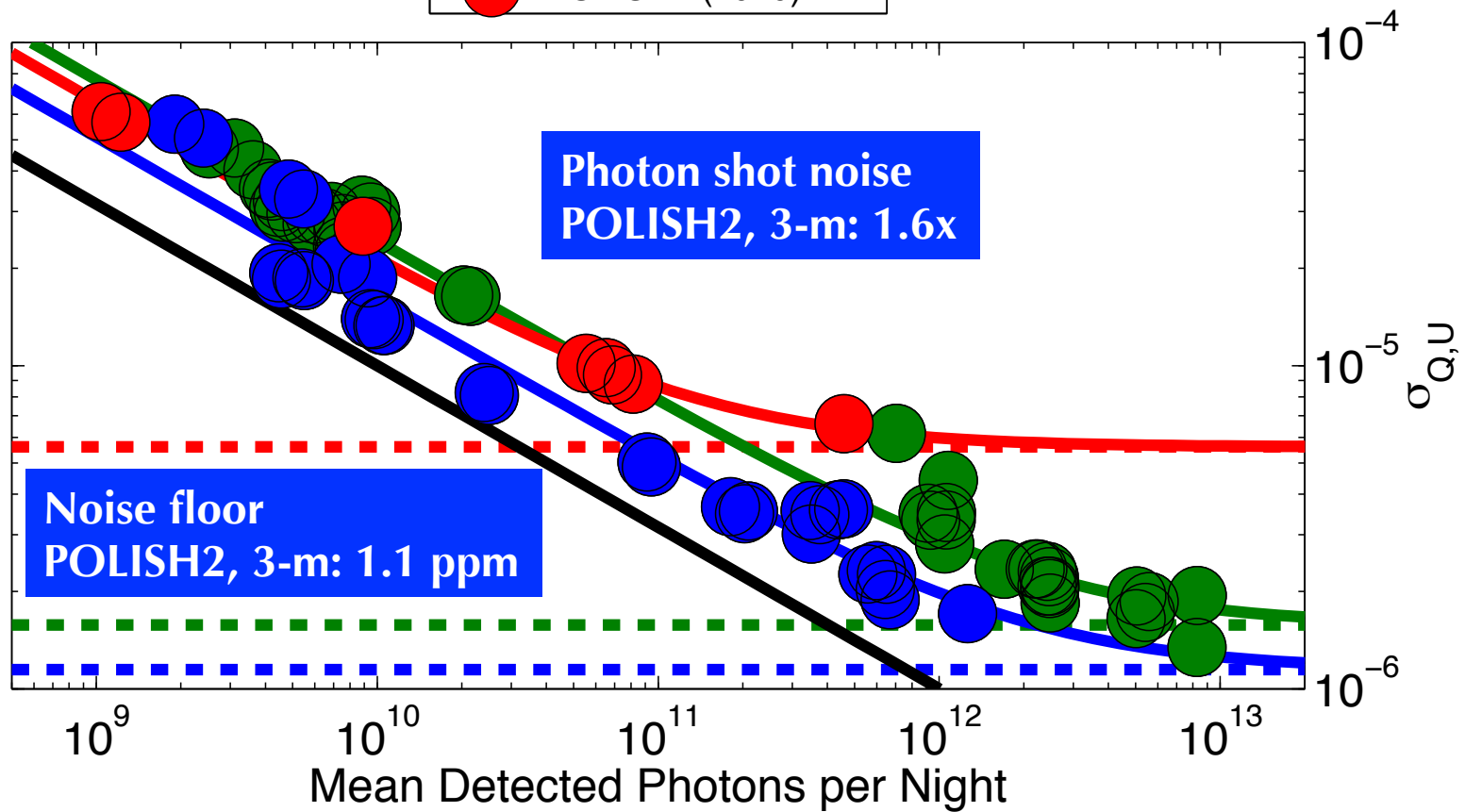




POLISH2 Performance

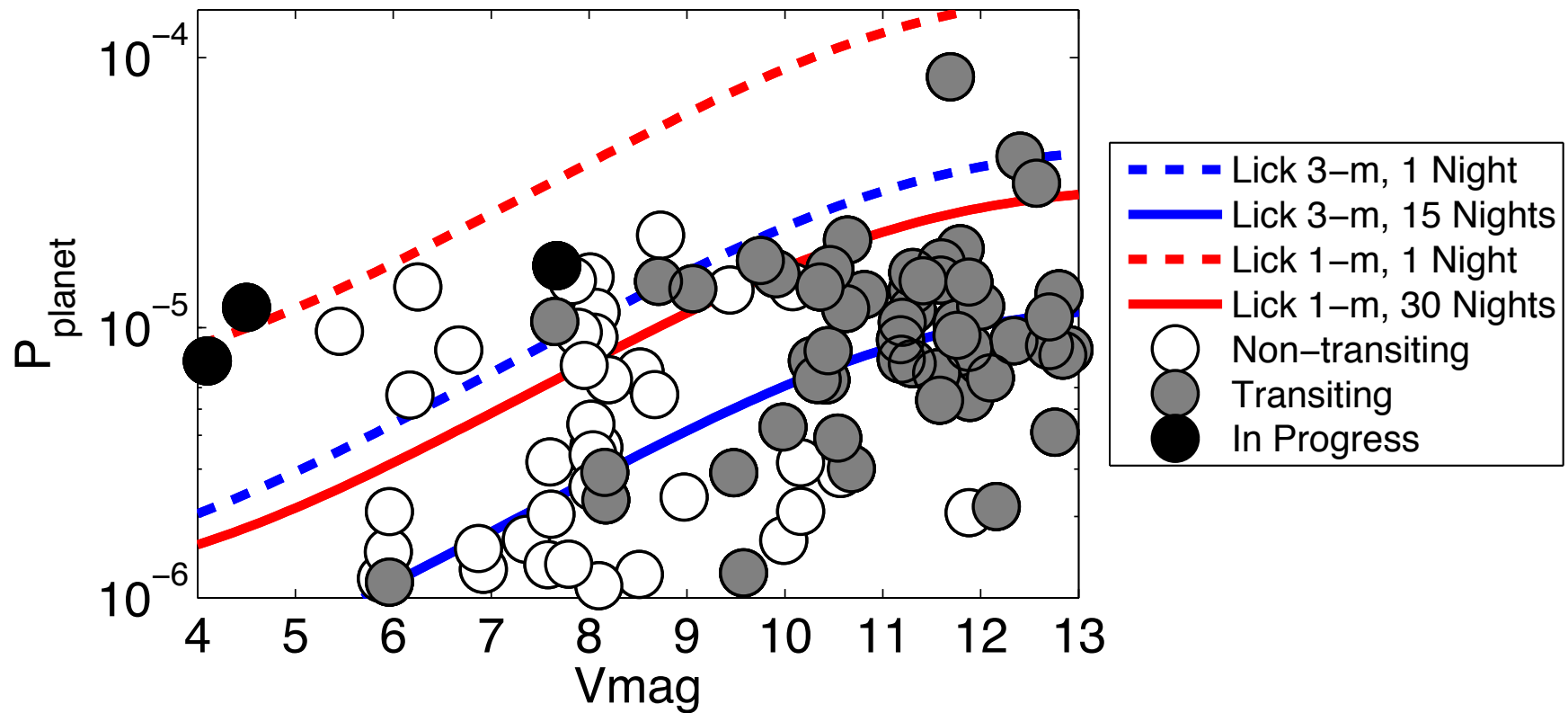


- POLISH (2009) 3-m
- POLISH2 (2010) 3-m
- POLISH2 (2010) 1-m





Exoplanet Detectability





Exoplanet Conclusions



- Scattered light from exoplanets will be polarized
- Allows direct detection even in face-on systems
- Albedo, inclination, and scattering properties (cloud structure, composition) will be probed
- Upgraded POLISH2 capable of detecting up to 30 exoplanets at Lick 3-m, up to 11 at Lick 1-m
- No conclusive detections yet, but systematics seem to dominate



polish2