Direct Detection of Exoplanets and Debris Disks with Polarimetry

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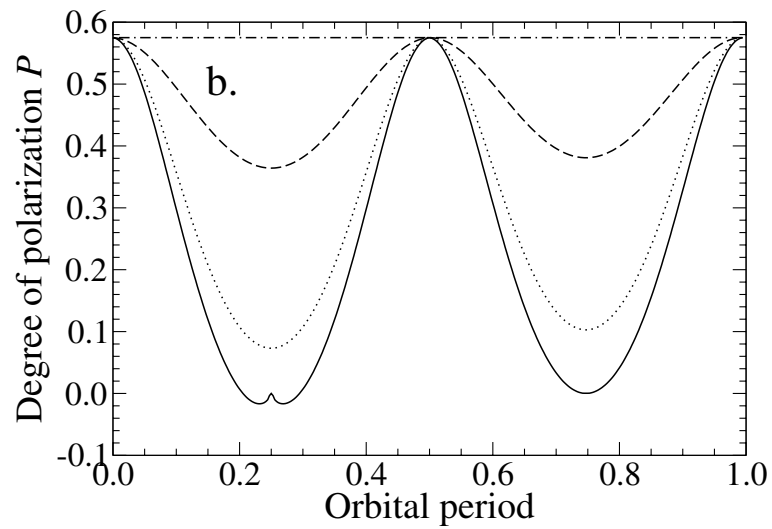
February 9, 2011

Sagan Fellowship

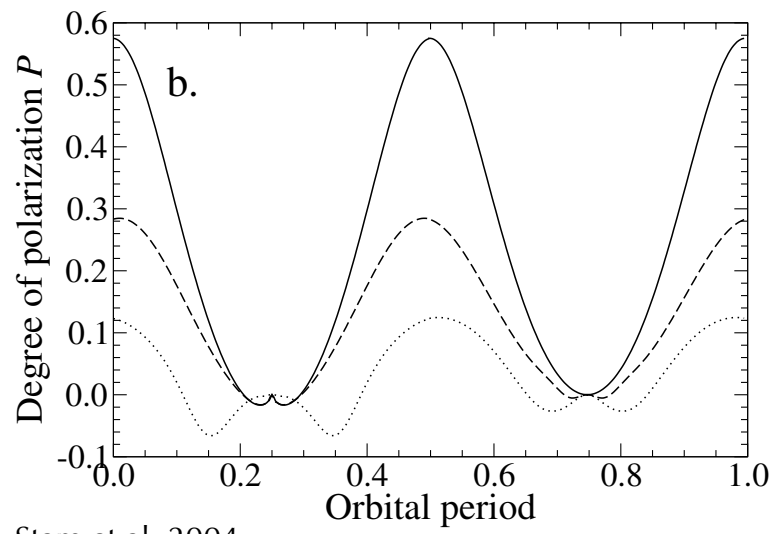
Polarized Exoplanets

- Scattered light from exoplanets is polarized
- The **minimum** degree of polarization during the orbit is indicative of **orbital inclination**: face-on (dot-dashed), 30° (dashed), 60° (dotted), and edge-on (solid)
- Can therefore determine inclination for RV planets, removing sin *i* mass ambiguity



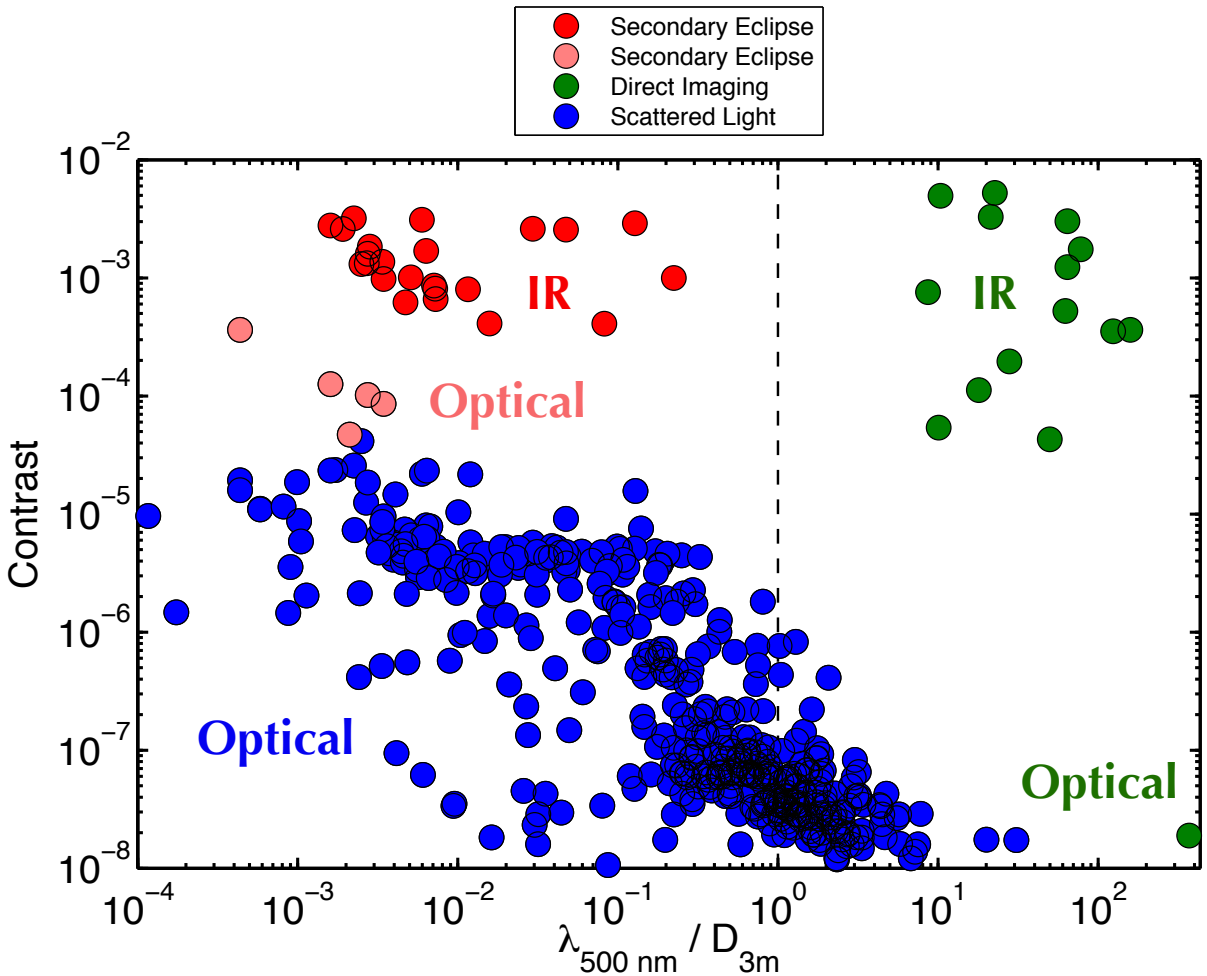
- The **maximum** degree of polarization during the orbit is indicative of **cloud structure**: high haze (dotted), low clouds (dashed), clear (solid)
- Can therefore estimate cloud structure and composition
- Note: sulfuric acid droplets in Venus' atmosphere were discovered by polarimetry

Coffeen & Gehrels (1969); Hansen & Hovenier (1974)



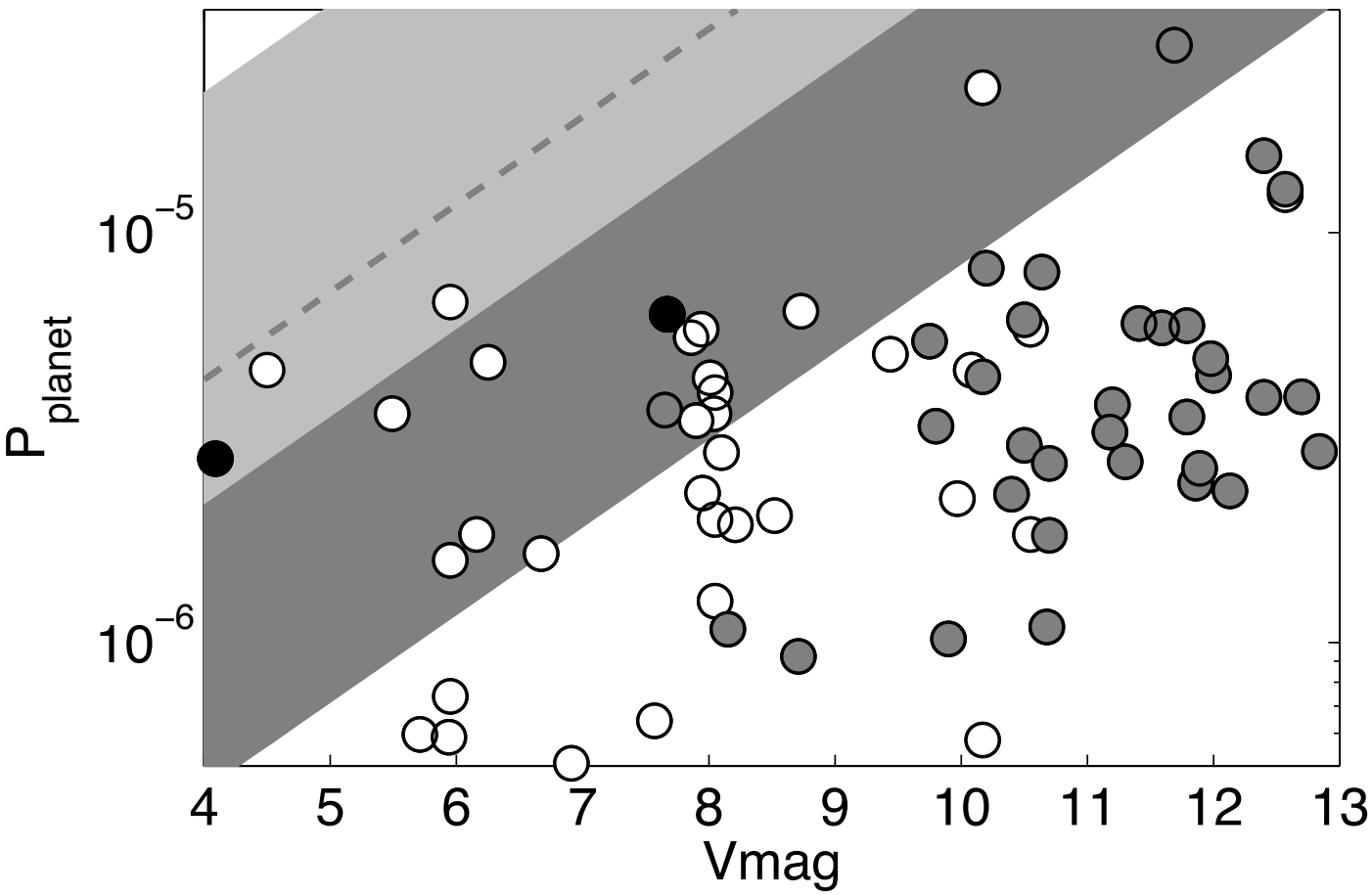
Stam et al. 2004

Exoplanet Contrast



- Known exoplanets: contrast ratio with different techniques vs. angular separation in units of the optical diffraction limit of a 3-m telescope
- **Direct imaging** impossible for most known exoplanets
- **Secondary eclipse** observations (*Spitzer*, CFHT, *Kepler*, *CoRoT*) impossible for non-transiting exoplanets
- **Polarized, scattered light** observations possible for many exoplanets, transiting and non-transiting alike

Exoplanet Detectability



Assumptions

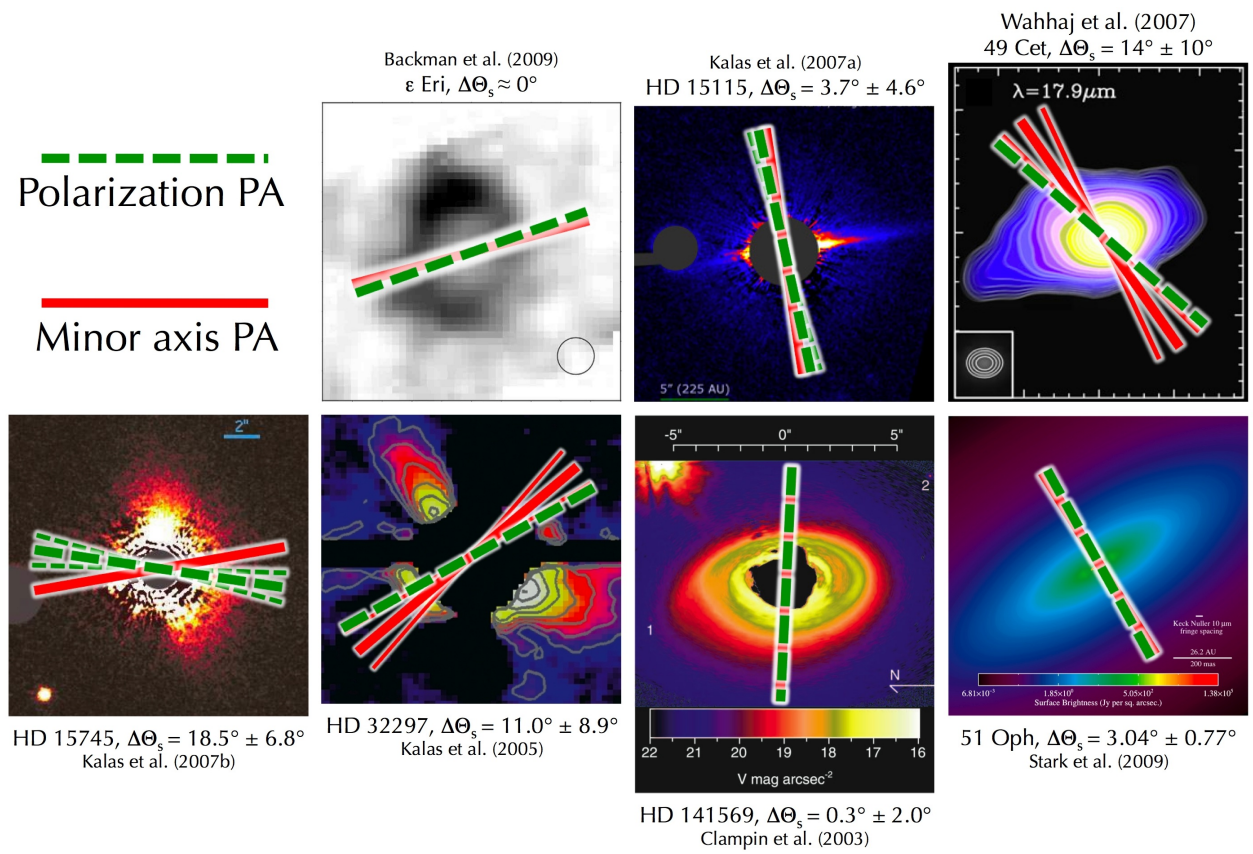
- Lick 3-m
- Albedo = 0.1
- $R_{face\text{-}on} = 1.2\ R_J$

POLISH
POLISH2
Non–transiting
Transiting
Survey

- Up to 18 exoplanets observable with upgraded POLISH2 polarimeter, 2 currently being monitored

Debris Disks

- Single scattering by small dust grains gives disk-integrated polarization parallel to disk minor axis
- This is observed with POLISH and POLISH2 in disks with prior imaging
- Optical, scattered light seen for the first time in ε Eri, 49 Cet, and 51 Oph disks
- *UBV* polarimetry will allow grain size to be probed beginning April 2011



Wiktorowicz et al. 2011, submitted