



The Extreme Polarimeter

First light observations

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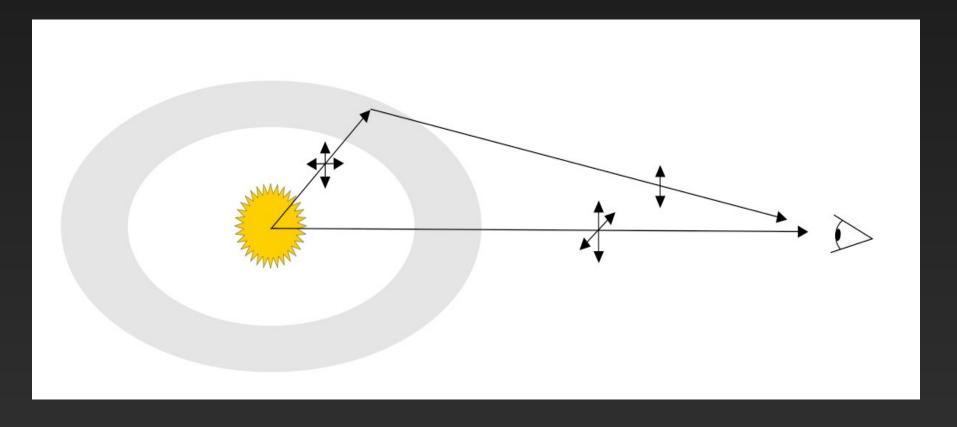
Why Polarimetry?

- → Direct imaging of circumstellar environments is limited because they are very much fainter than their central stars
- → Methods commonly used to remove the unwanted light include sophisticated A.O. systems + coronographs
- → ExPo: uses the basic physics that light reflected from circumstellar environment is linearly polarized
- → Polarimetry has additional advantage of being able to constrain the distribution of dust sizes





Scattering Polarization







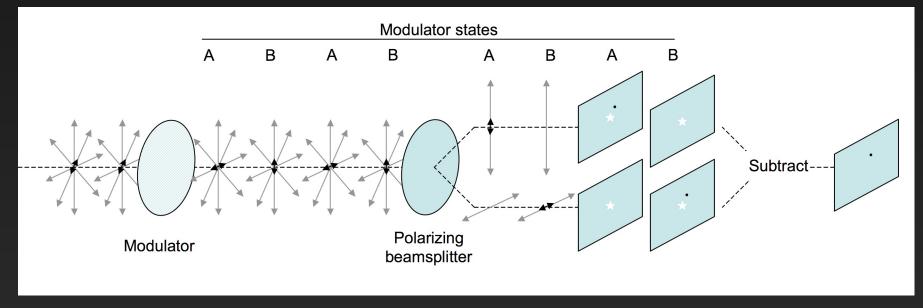
Complications:

- Small angular separation with star
- High contrast ratio:
 - Disks: ~10-4
 - Exoplanets: <10-9
- Atmospheric effects:
 - Seeing
 - Atmospheric polarization
- Instrumental effects

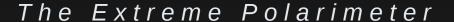




Dual beam-exchange technique



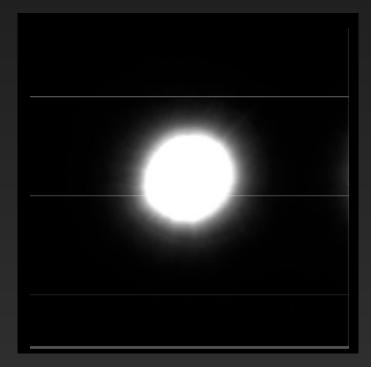
- → Innovative Design: ExPo uses liquid crystals to change polarization states (no moving parts)
- \rightarrow Using a fast + sensitive imaging camera allows fast modulation (0.03 s) \Rightarrow comparable to seeing effects

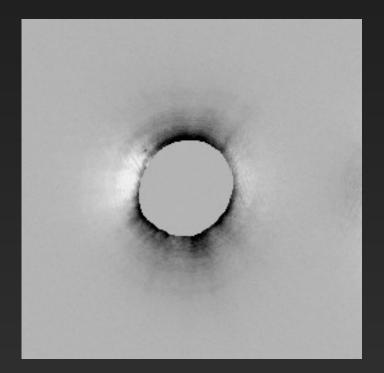






Concept demonstration using laboratory simulator of star + linearly polarized planet at 1 arcsec



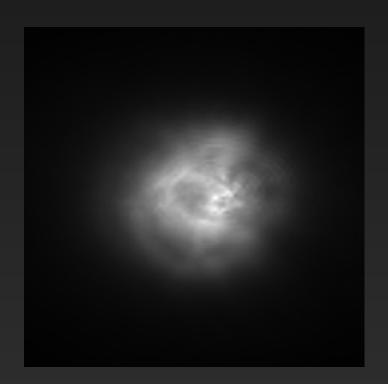


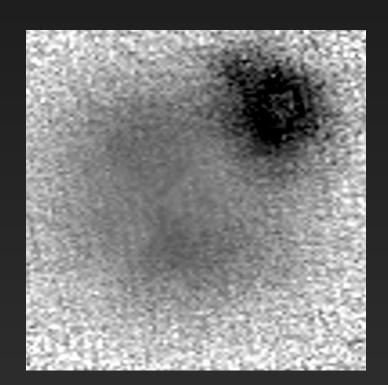
no seeing, 10⁻⁵





Concept demonstration









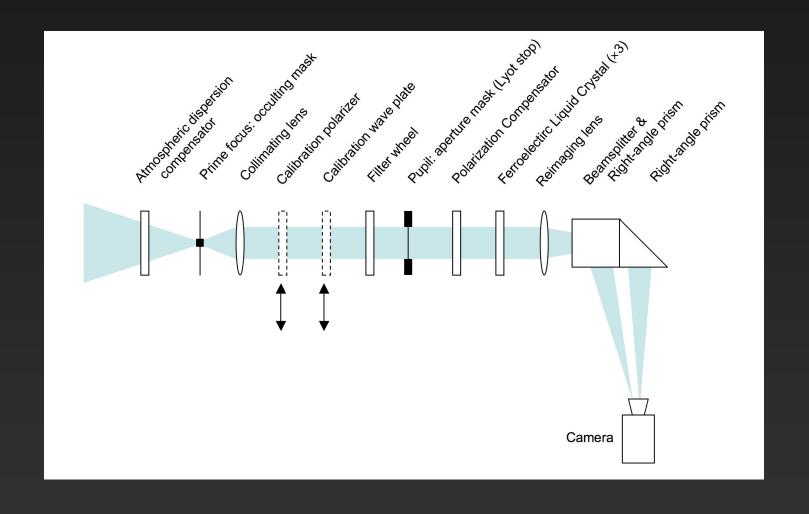
ExPo: Facts & figures:

- Working in the visible: 600 900 nm
- Field of view: 20 x 20 arcsec (with option for 8x8 arcsec)
- Polarimetric contrast: 10⁻⁴
- + data analysis = AIM: 10⁻⁷





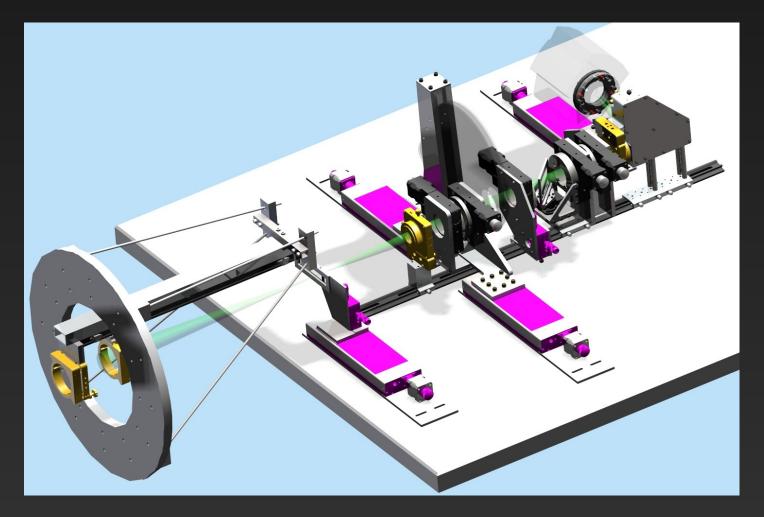
Design overview







Mechanical design

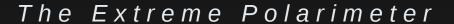


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ExPo at the WHT







First Light!







Targets:

- Debris disks:
 - Vega
 - Epsilon Eri, Tau Ceti
- Protoplanetary disks:
 - AB Auriga
 - SU Auriga
 - FU Orionis
 - T Tau
 - & others...
- Calibration targets:
 - Diskless stars
 - Polarized & unpolarized standard stars
 - Dome flats



The Data Analysis



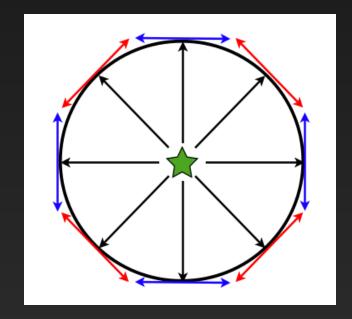
Trying to push the telescope until the diffraction limit:

Speckle **Technique** Atmosphere effects **Cross-Correlation** Filter Flats, Darks, etc Instrumental **Double Ratio** effects Cross-Correlation Filter



Explaining the Image...





Fractional polarization

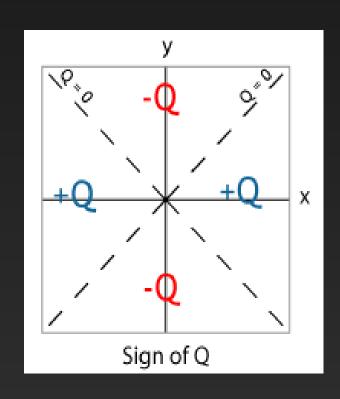
⇒ outer edges of disk

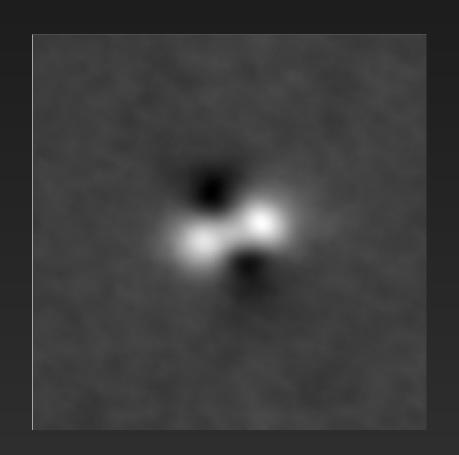
Diameter = 9"



Explaining the Image...



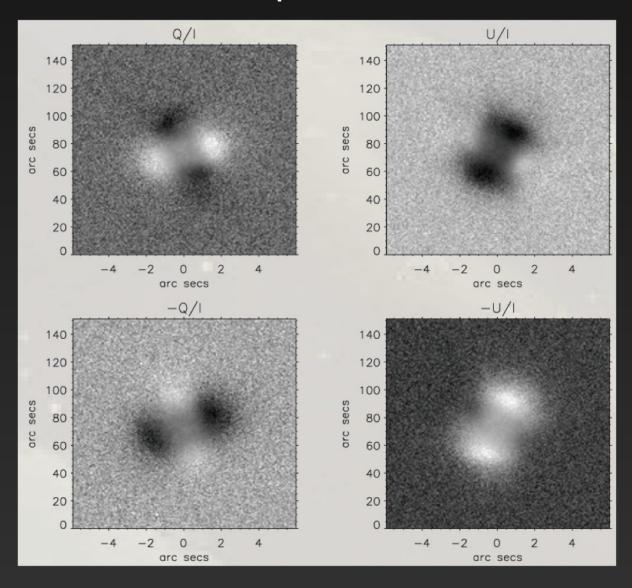






All four linear polarization states

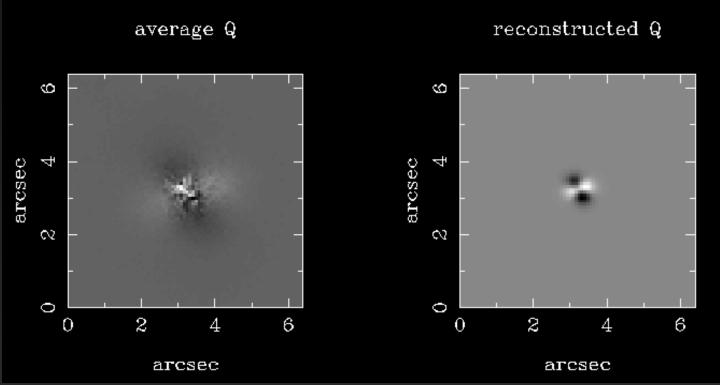












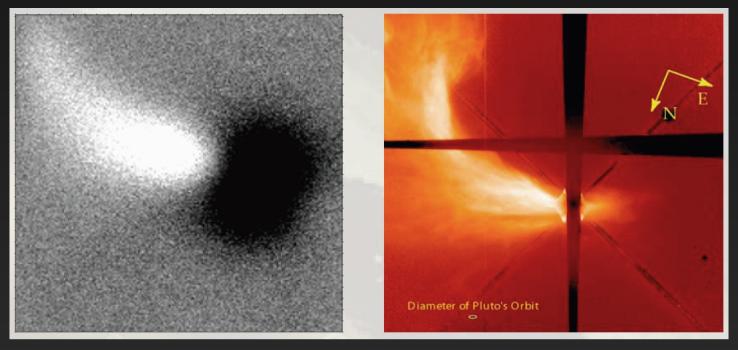
Polarized intensity images

- ⇒ inner disk where Intensity is higher
- \Rightarrow resolution of 0.2"



Jets: T Tauri Star SU Aur





ExPo HST



Conclusions



- ExPo is an innovative instrument for imaging circumstellar environments
- It is experimental ⇒ flexibility over design and future improvements
- First light results have shown that ExPo excells in the imaging of circumstellar environments... first publications are forthcoming
- Future improvements:
 - → filters for disk characterization
 - → 8X8 " fov
 - → further testing in the laboratory to fine-tune instrument
 - → Data analysis techniques