

# High-contrast imaging with liquid crystals

**Frans Snik**

Universiteit Leiden  
NOVA  
erc  
LEOPARDO  
LEIDEN  
EXTREME  
OPTICS &  
PHOTONICS  
ASTRONOMY  
DESIGN &  
DEVELOPMENT

instrumentation for high-contrast imaging  
 wavefront sensing  
 coronagraphy  
 (integral field) spectroscopy  
 polarimetry  
 interferometric masking  
 adaptive optics control

exoplanet observations  
 direct atmospheric characterization  
 disk science  
 Earth & Venus as an exoplanet  
 all-sky transit observations  
 HARPS3: radial velocity + spectropolarimetry

astrobiology  
 circular spectropolarimetry of photosystems

atmospheric remote sensing  
 compressive trace gas imaging  
 eclipse+aurora polarimetry  
 flySPEX  
 SPEX  
 hyperspectropolarimetric imaging

citizen science  
 ISPEX2.0 measurements of air + water quality  
 Citizen Science Lab

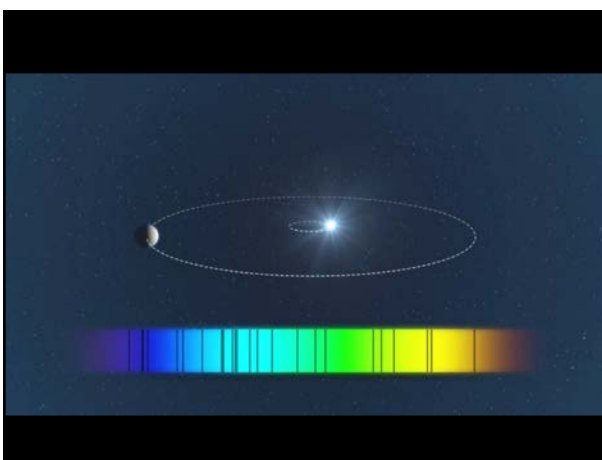
art+science collaborations  
 art projects  
 artist in residence program

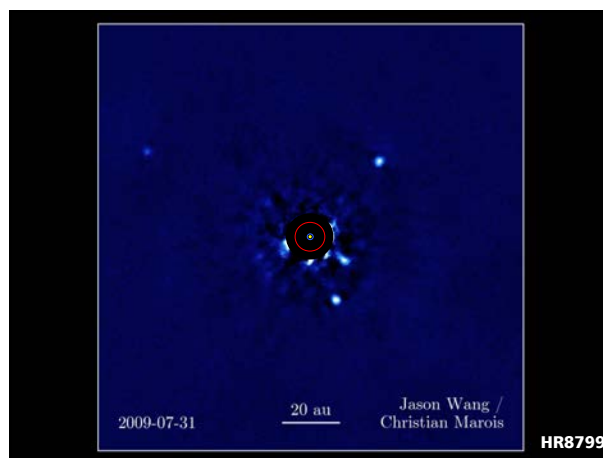
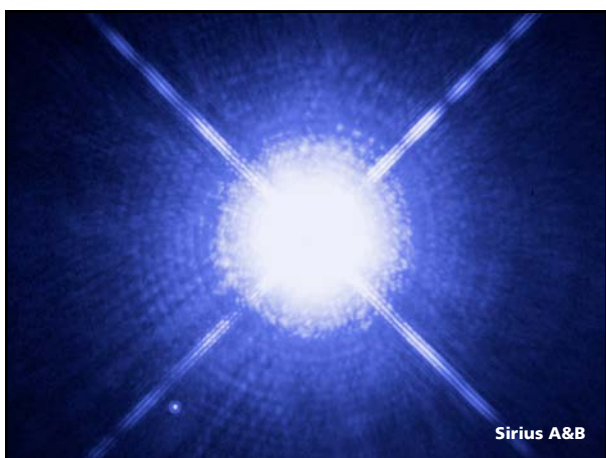
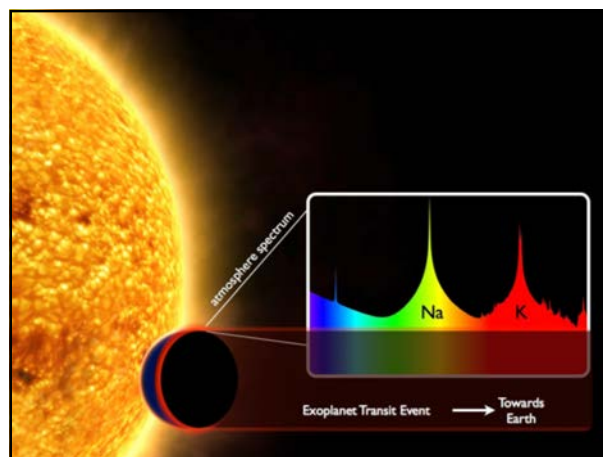
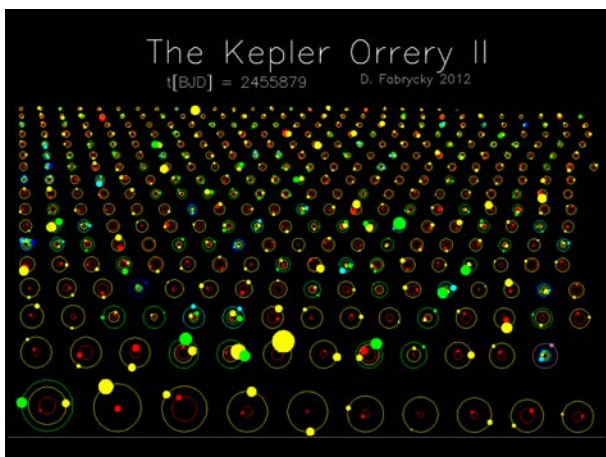
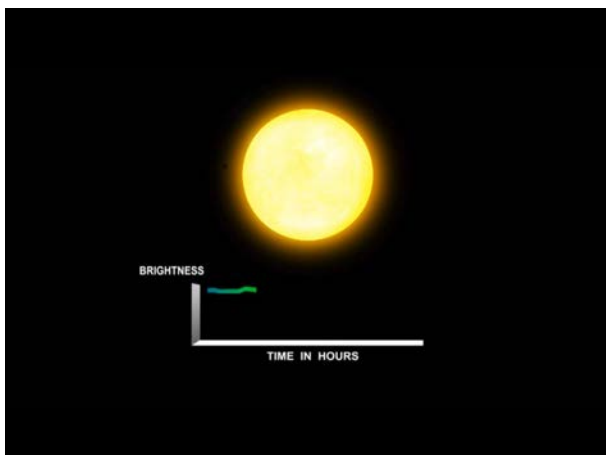
number of known planets in 1995

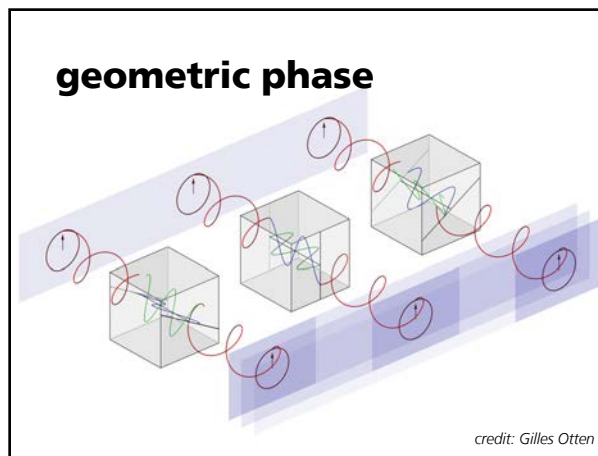
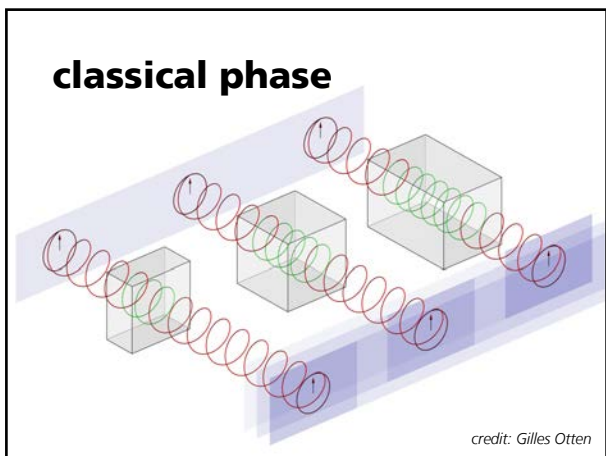
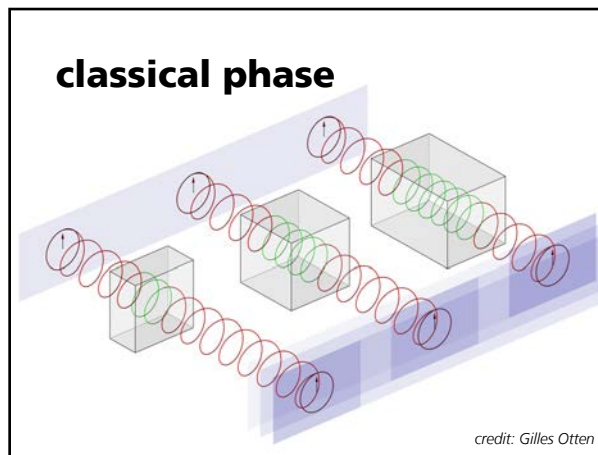
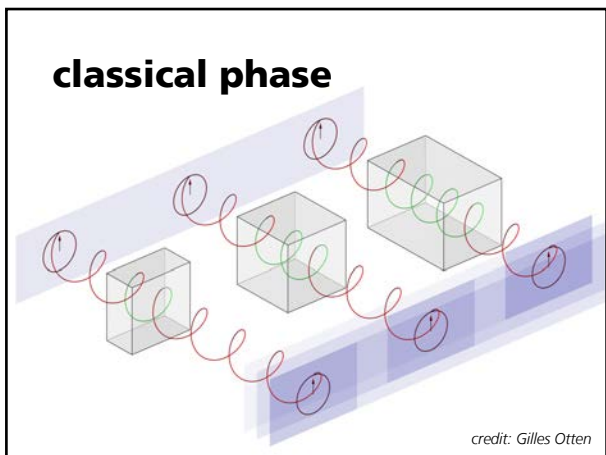
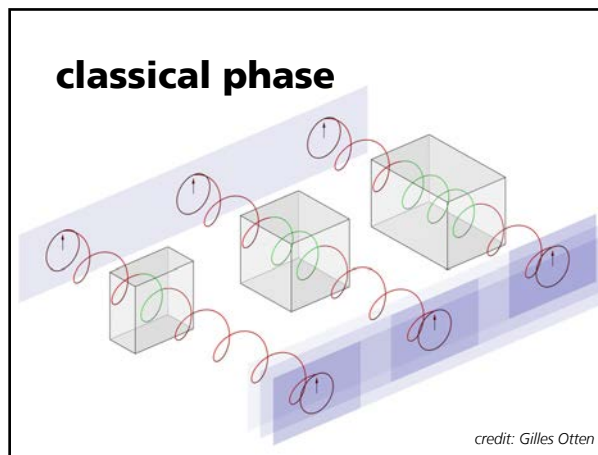
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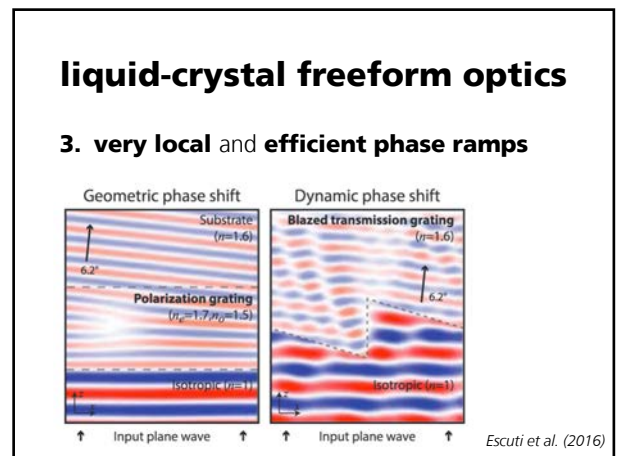
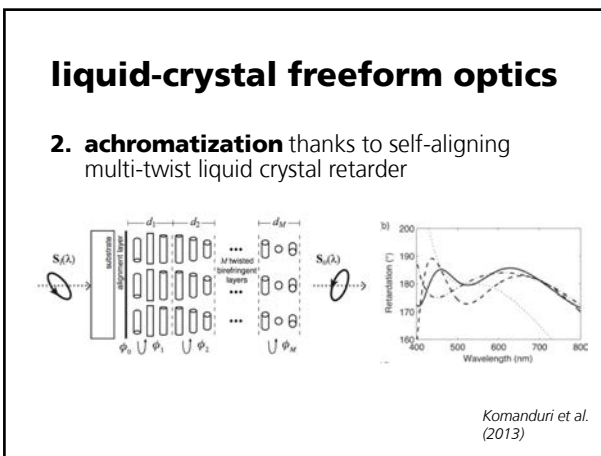
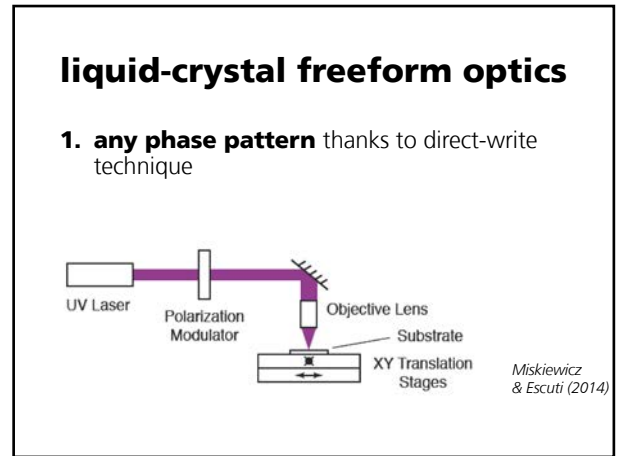
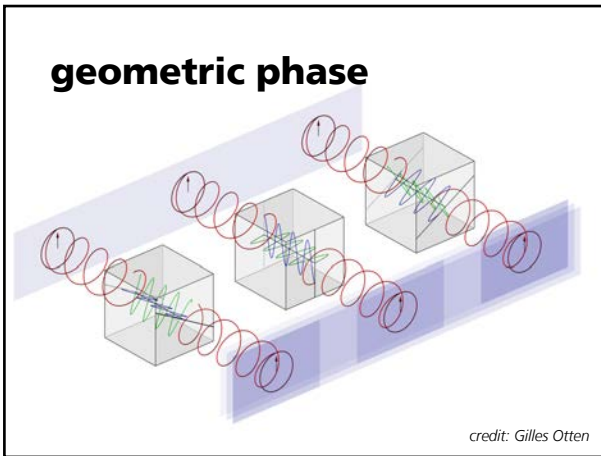
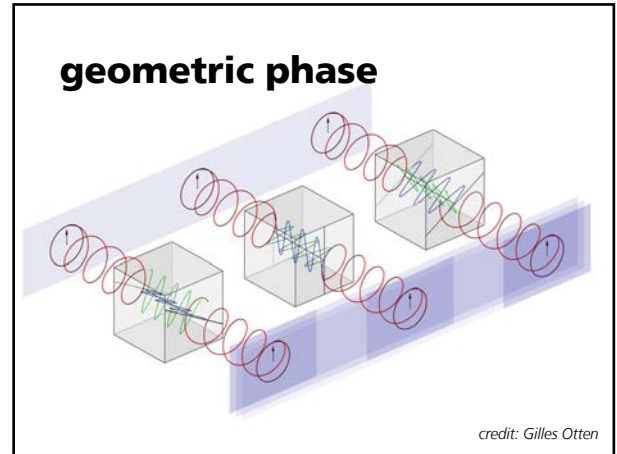
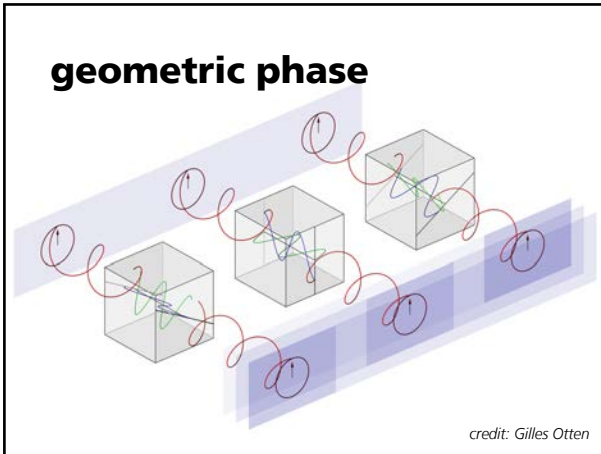
number of known planets 13 Mar 2018

**8+3743**



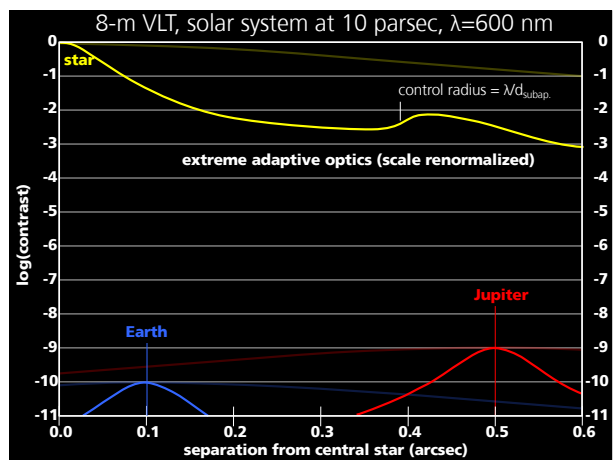
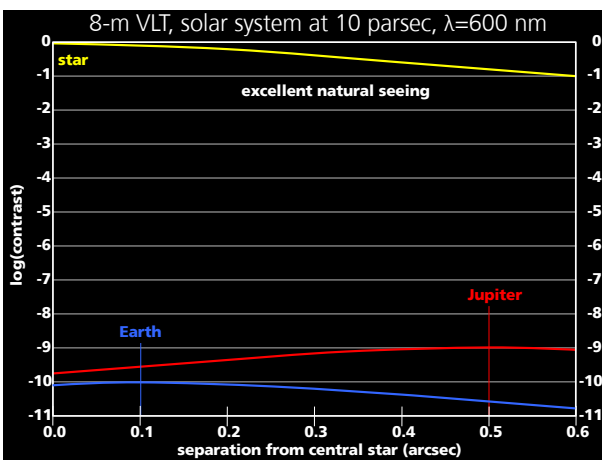


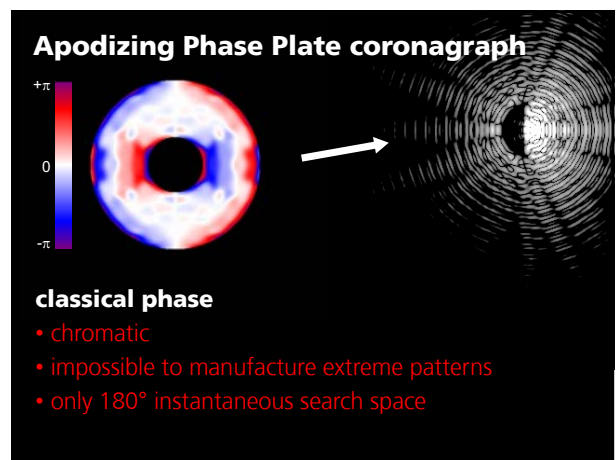
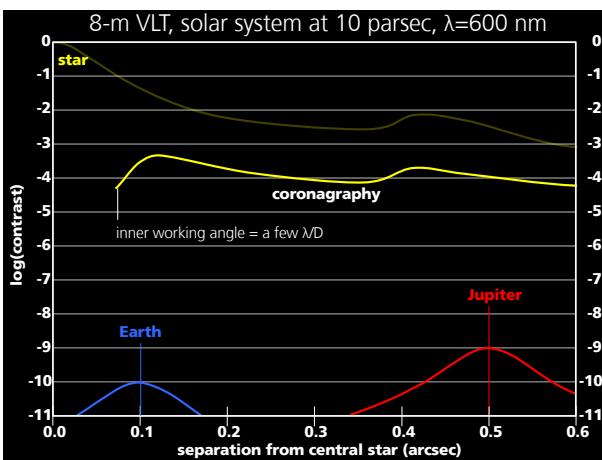
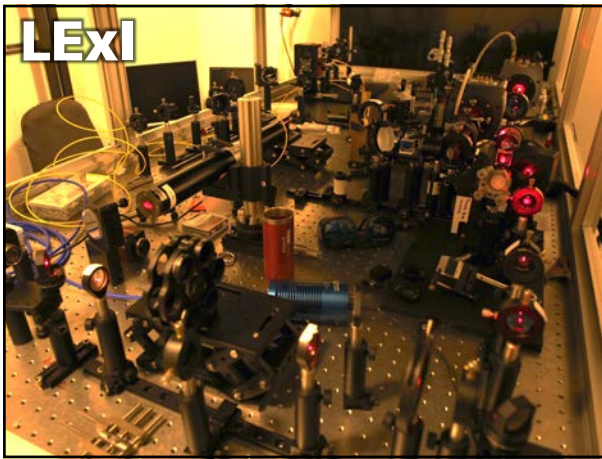
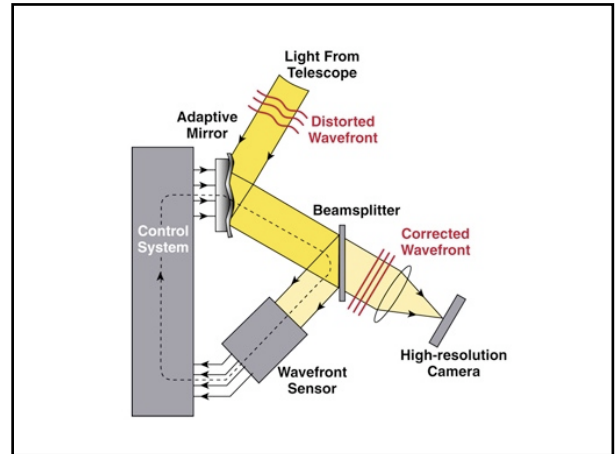
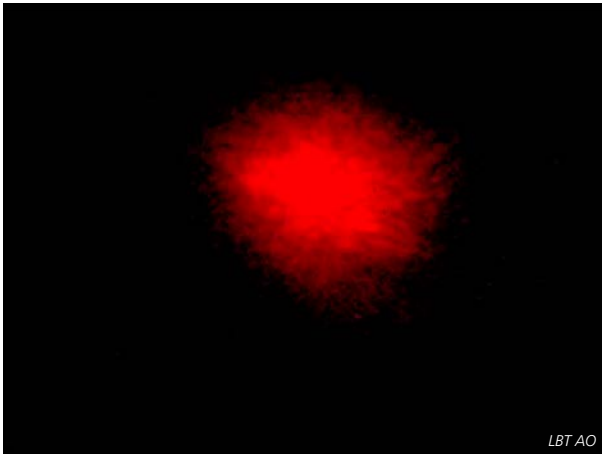


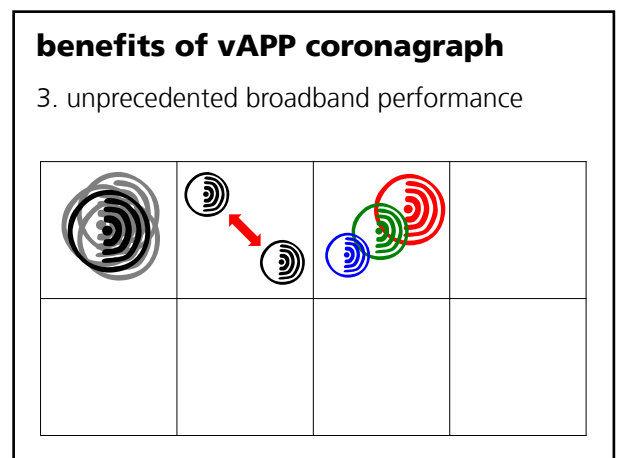
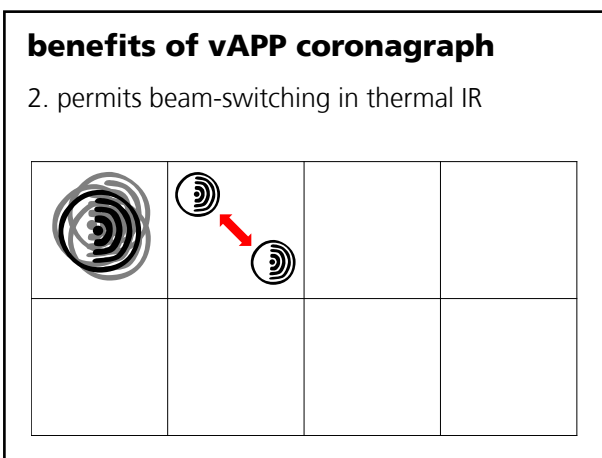
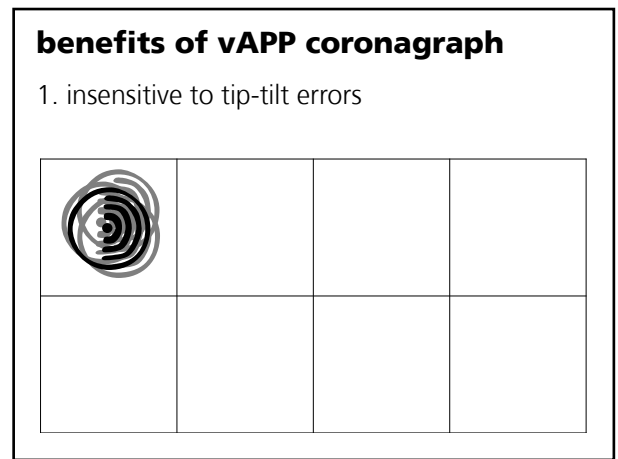
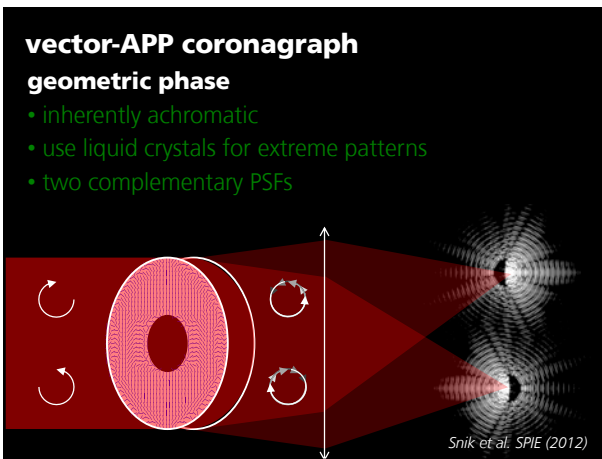
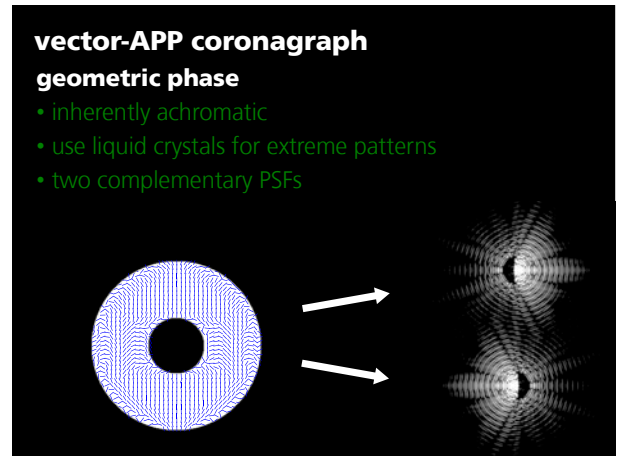
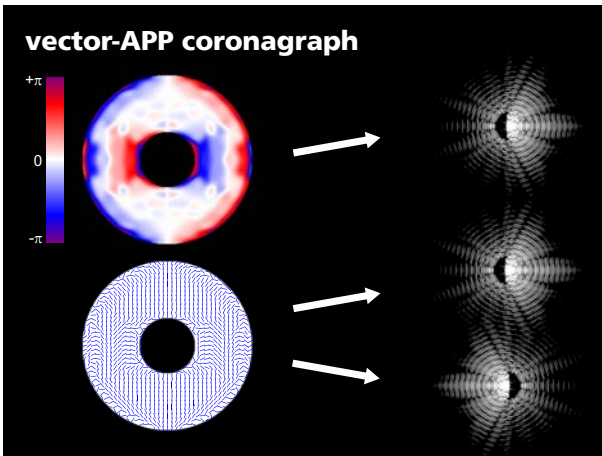


the rest of the talk:

**1001 ways to exploit this amazing technology**

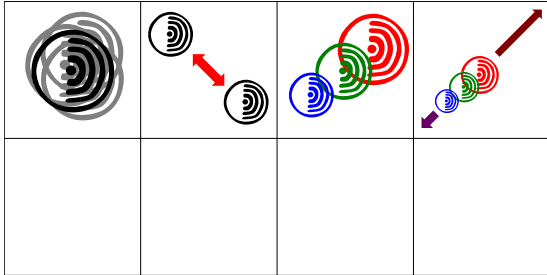






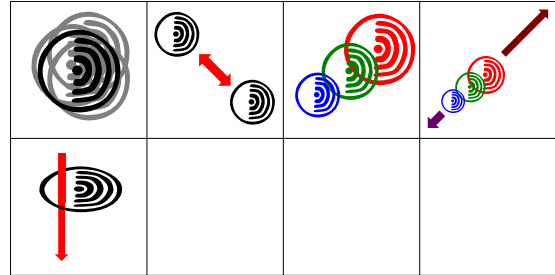
**benefits of vAPP coronagraph**

4. can be manufactured for UV – mid-IR



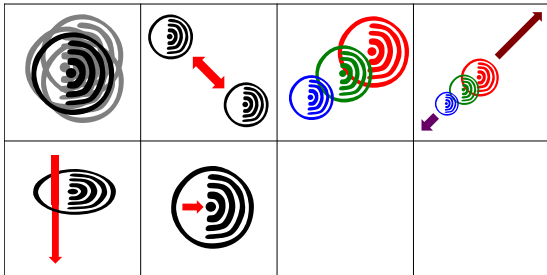
**benefits of vAPP coronagraph**

5. high contrast thanks to extreme phase pattern



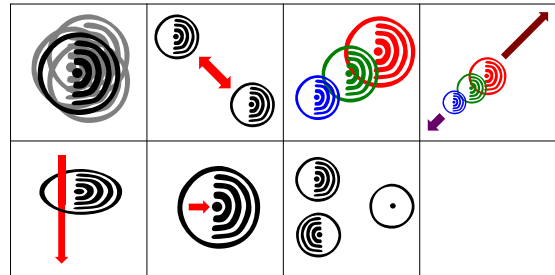
**benefits of vAPP coronagraph**

6. small inner working angle



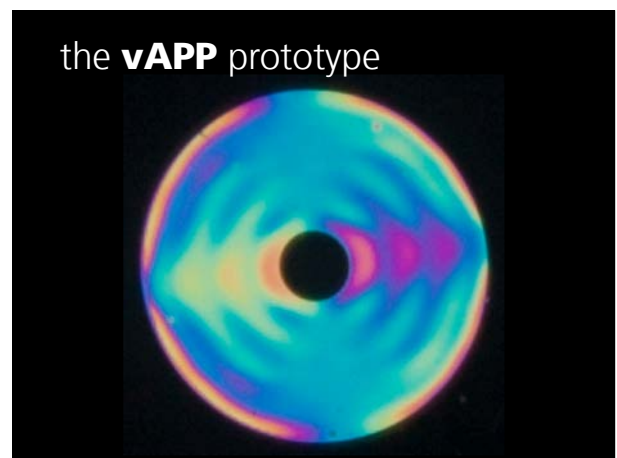
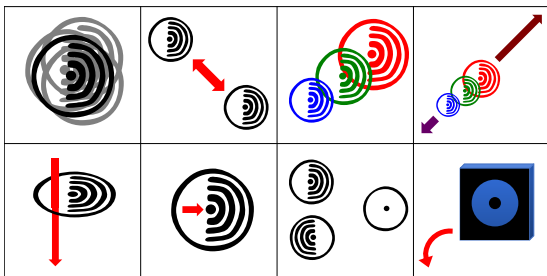
**benefits of vAPP coronagraph**

7. 360° search space around star



**benefits of vAPP coronagraph**

8. easy upgrade to existing instruments





the **vAPP** prototype



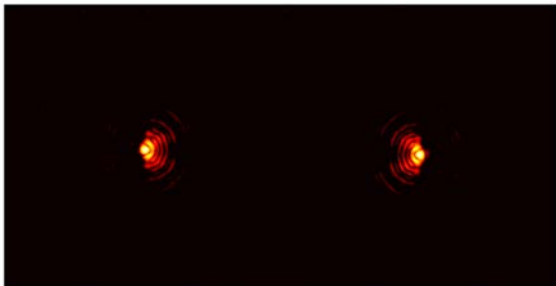
*Otten, Snik, et al. (2014)*

the **vAPP** prototype



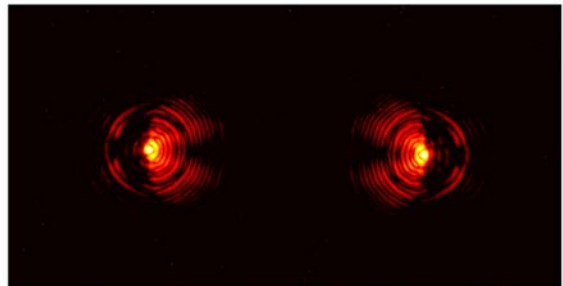
*Otten, Snik, et al. (2014)*

the **vAPP** prototype



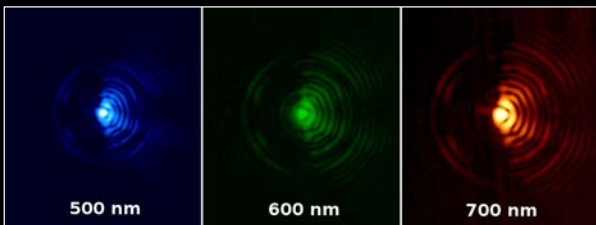
*Otten, Snik, et al. (2014)*

the **vAPP** prototype



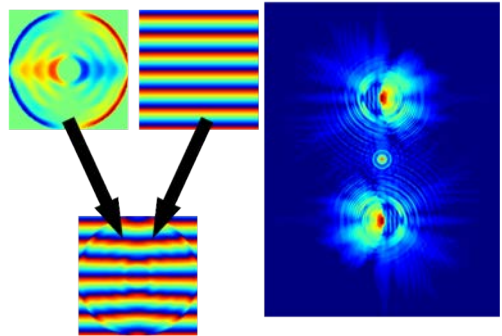
*Otten, Snik, et al. (2014)*

the **vAPP** prototype

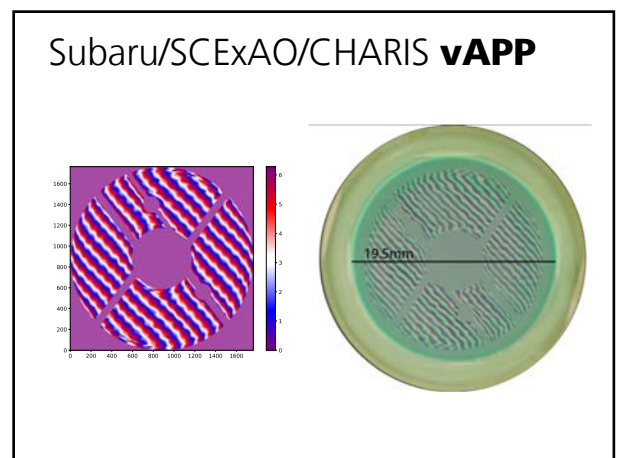
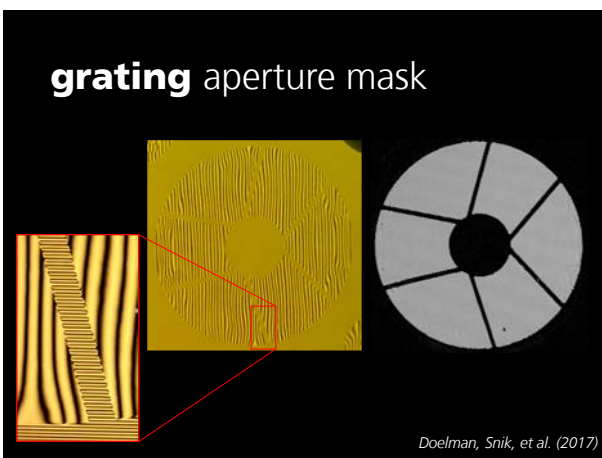
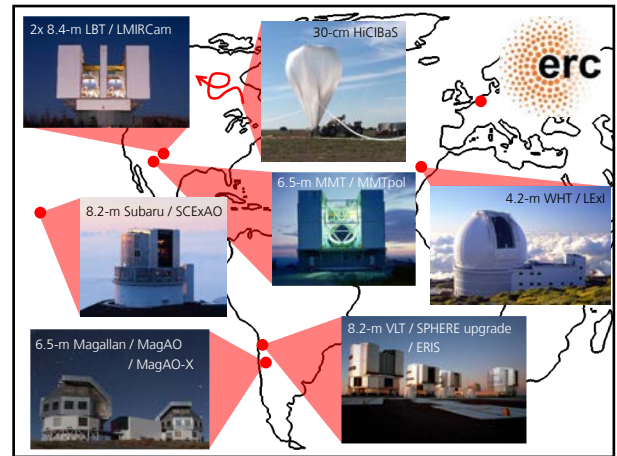
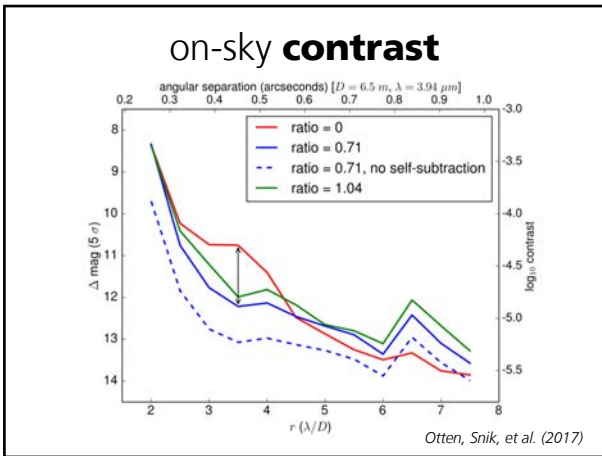
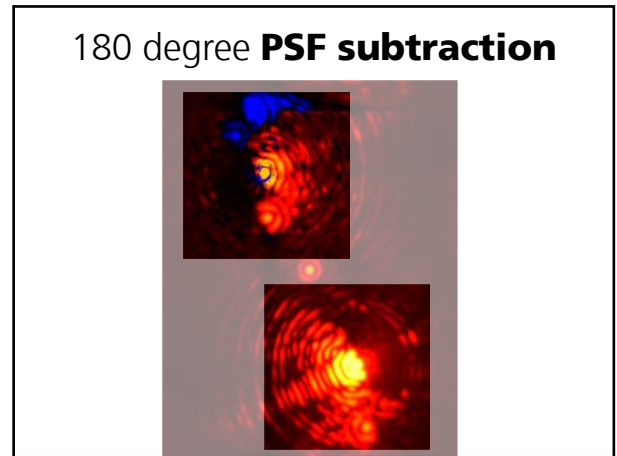
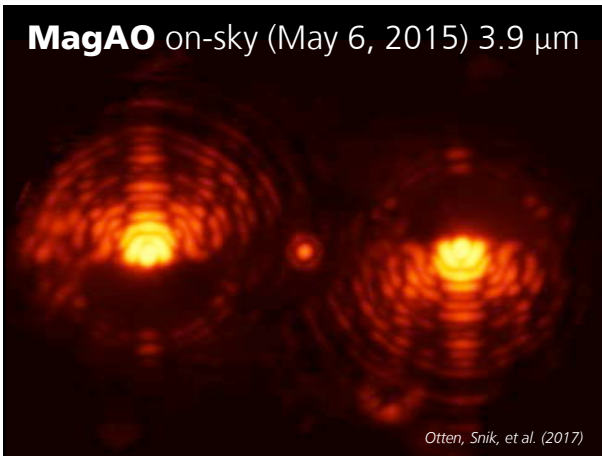


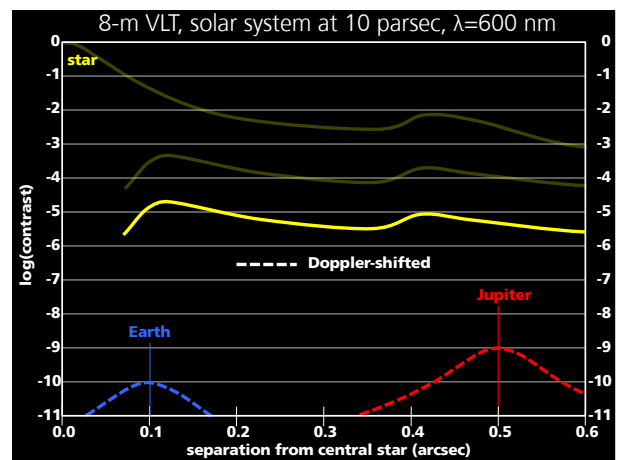
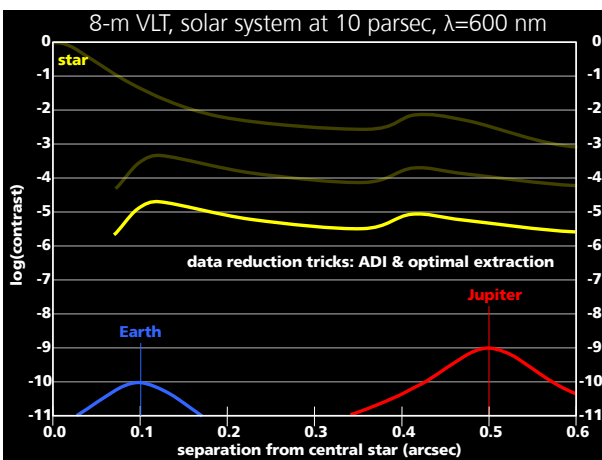
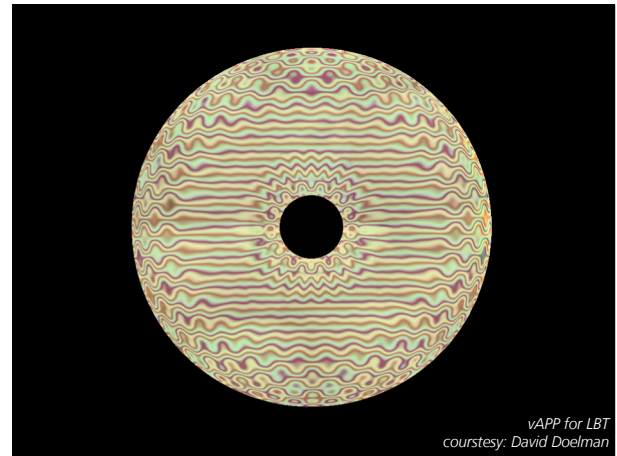
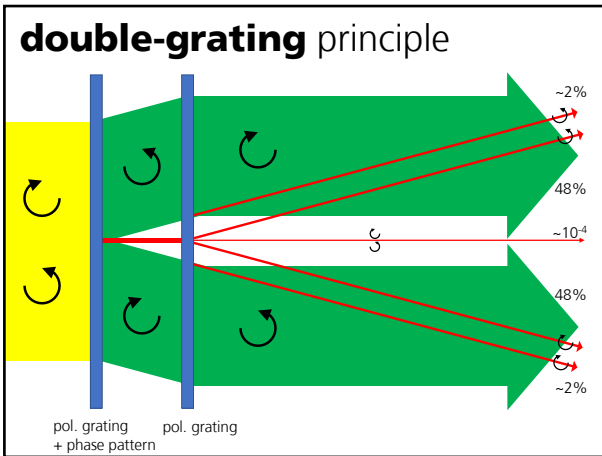
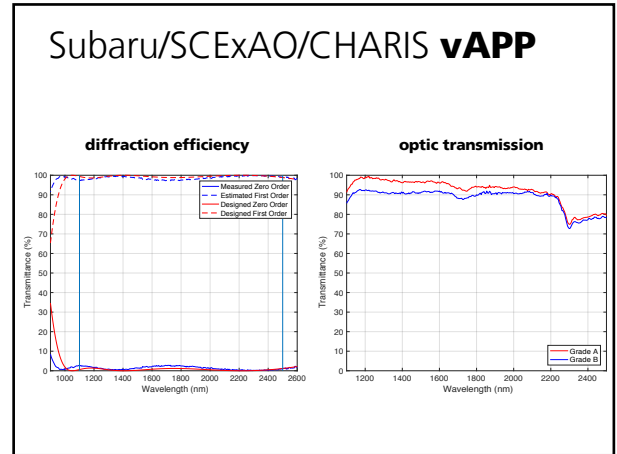
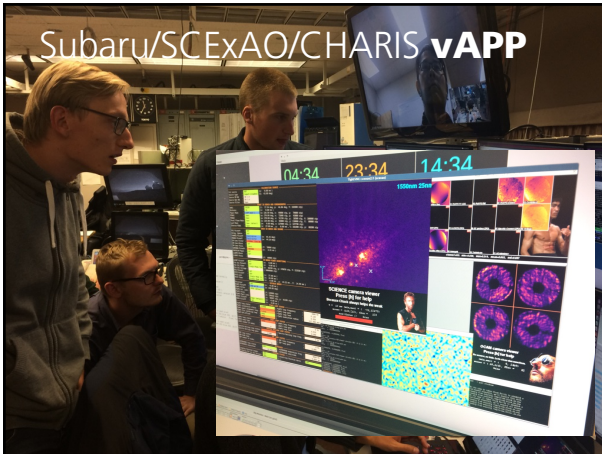
*Otten, Snik, et al. (2014)*

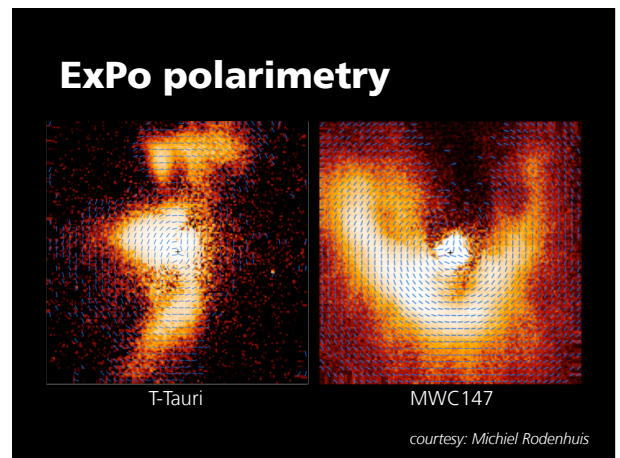
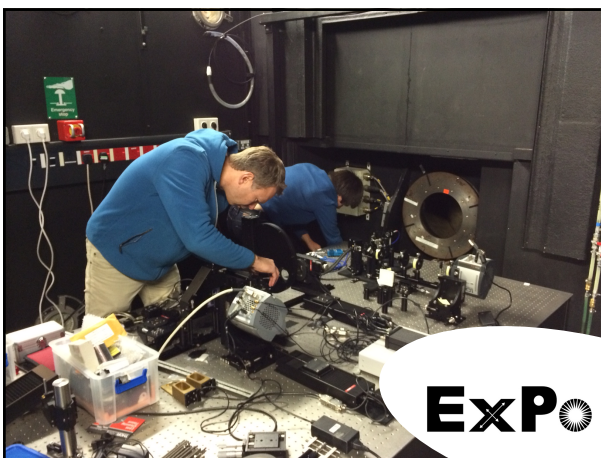
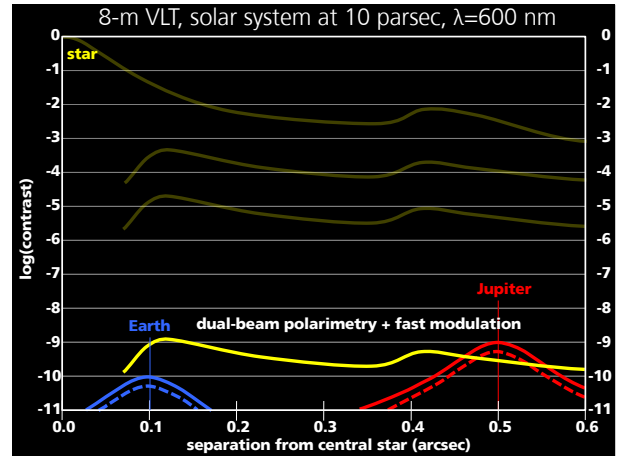
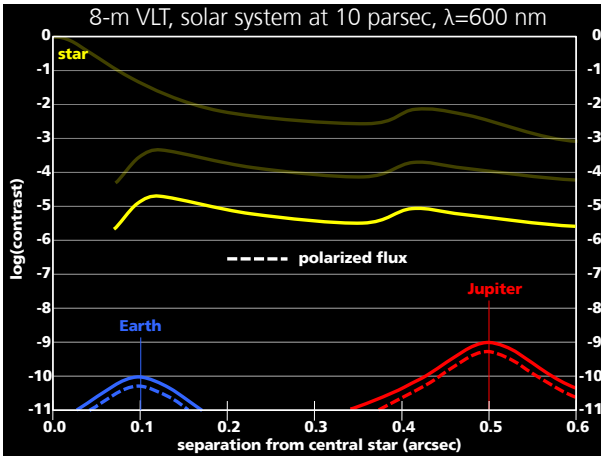
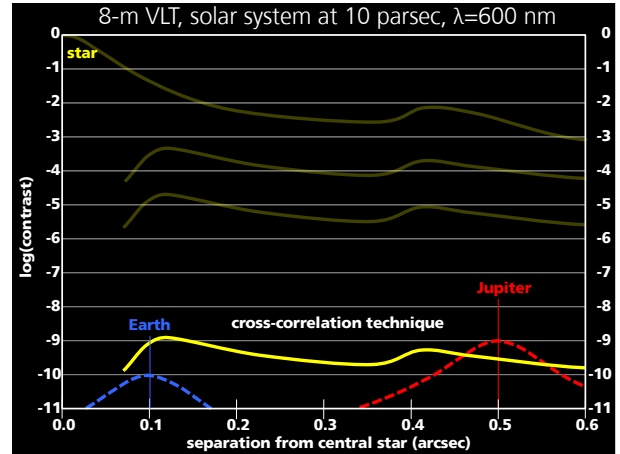
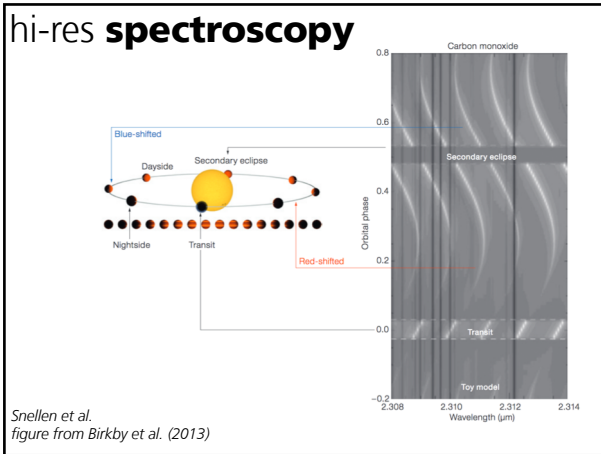
**grating-vAPP** (gvAPP)

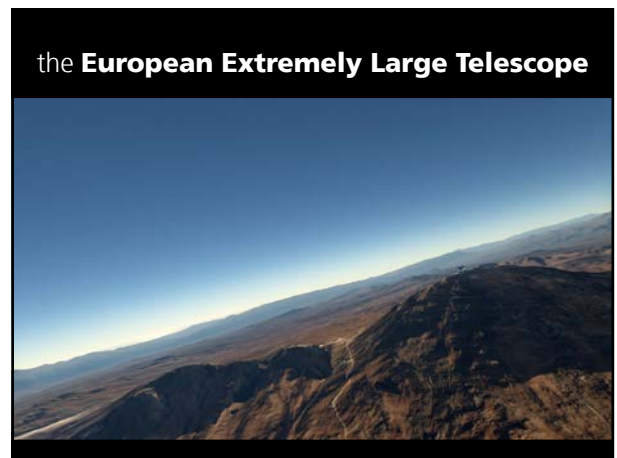
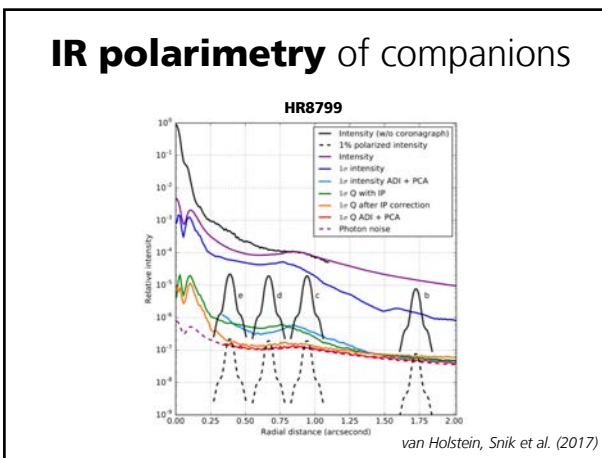
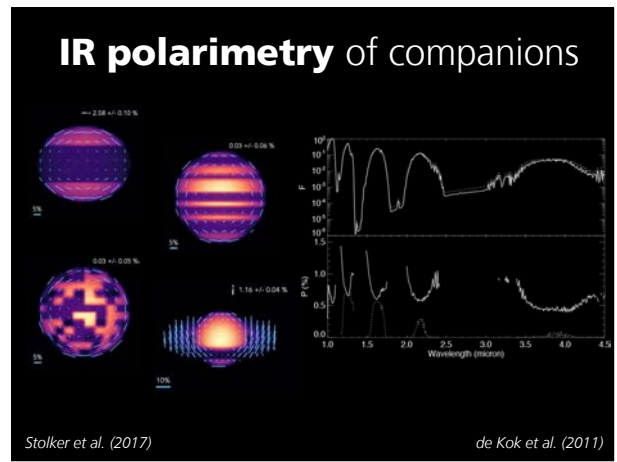
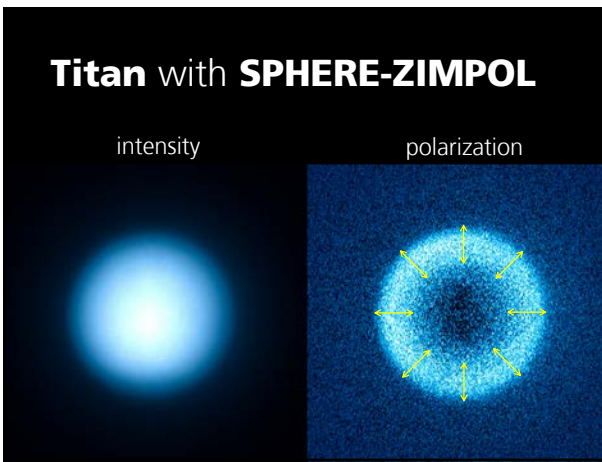
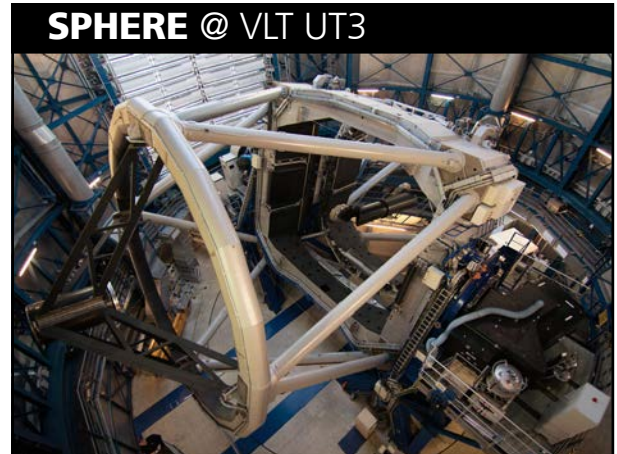


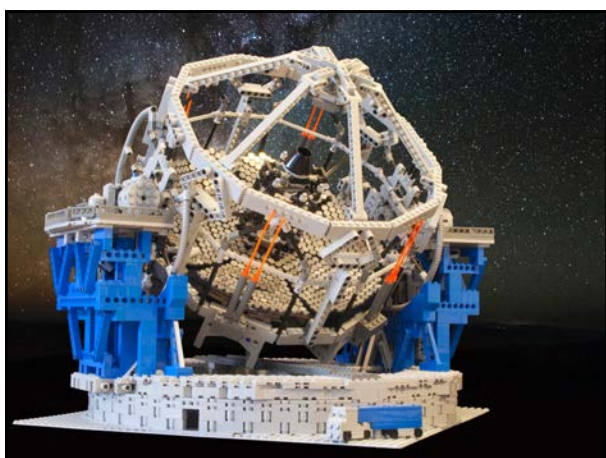
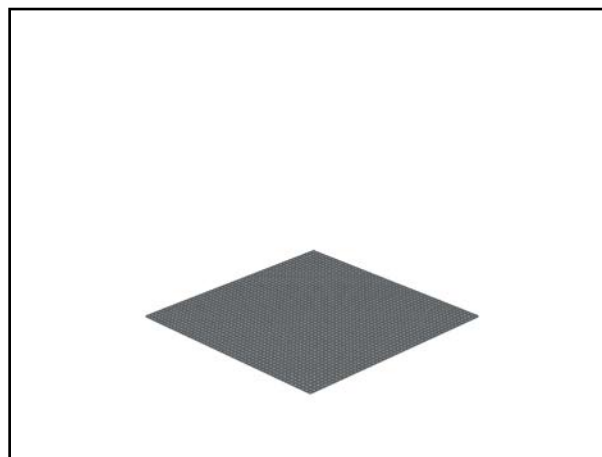
*Otten, Snik et al. SPIE (2014)*







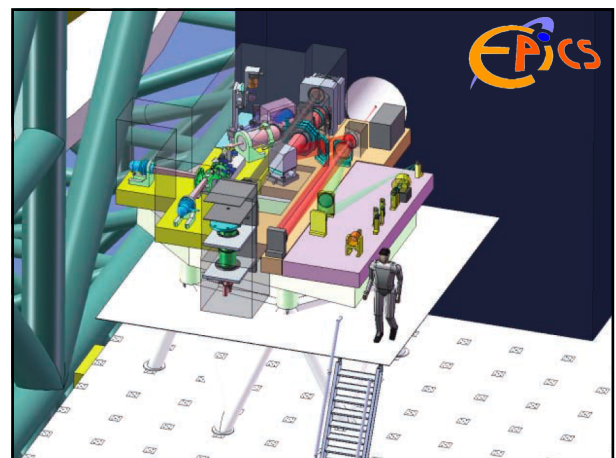
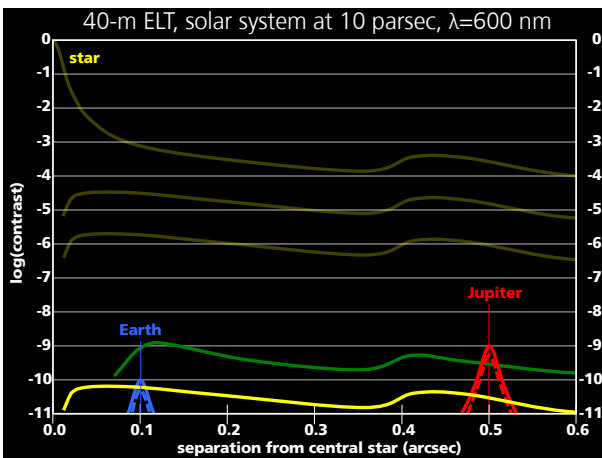
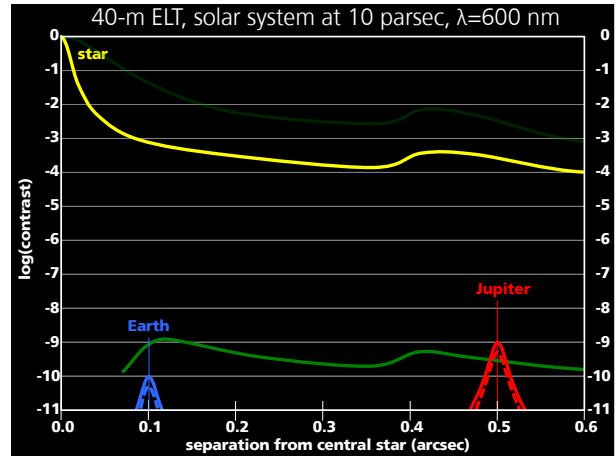
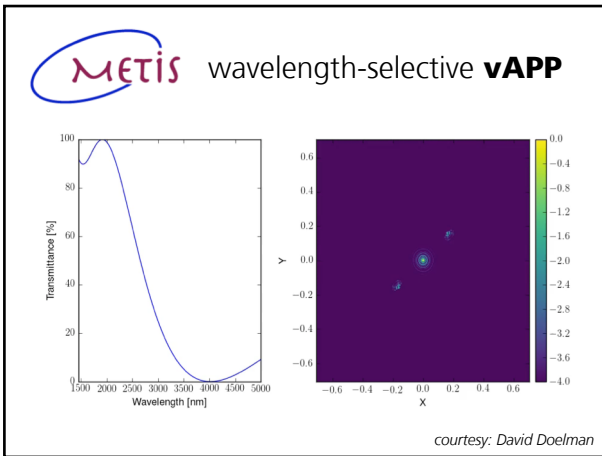
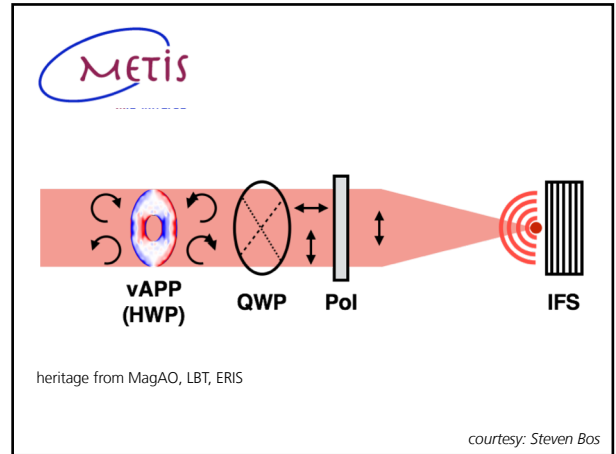
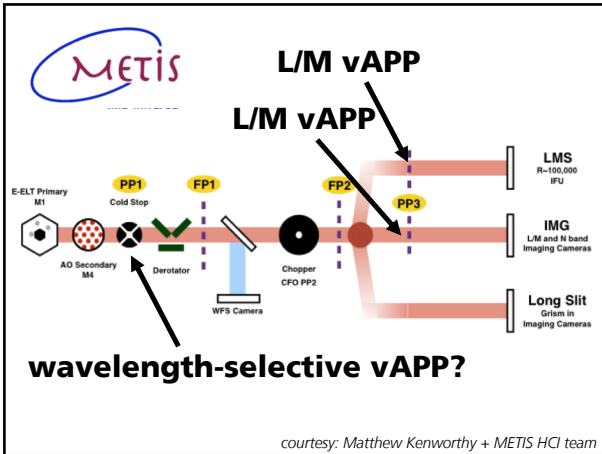


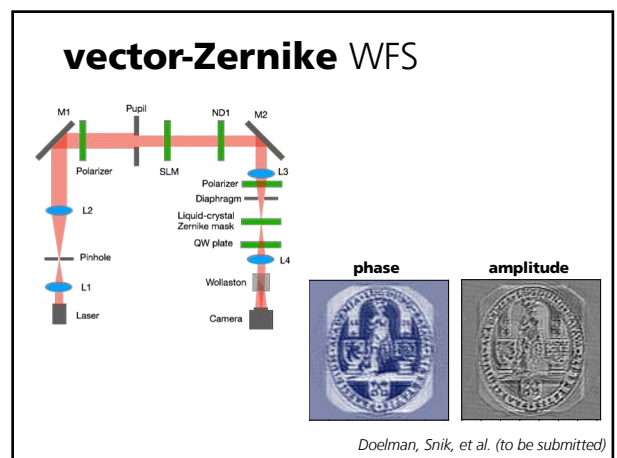
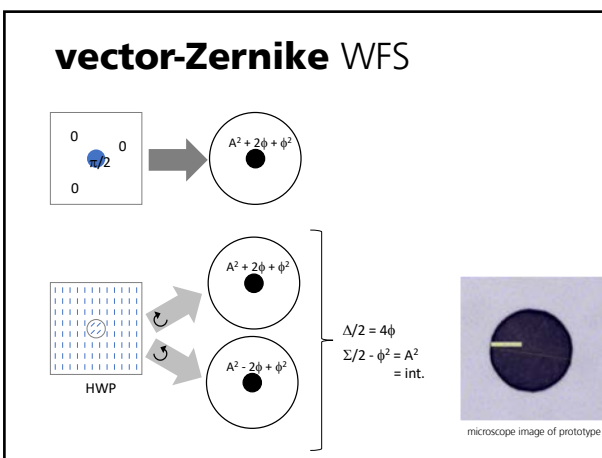
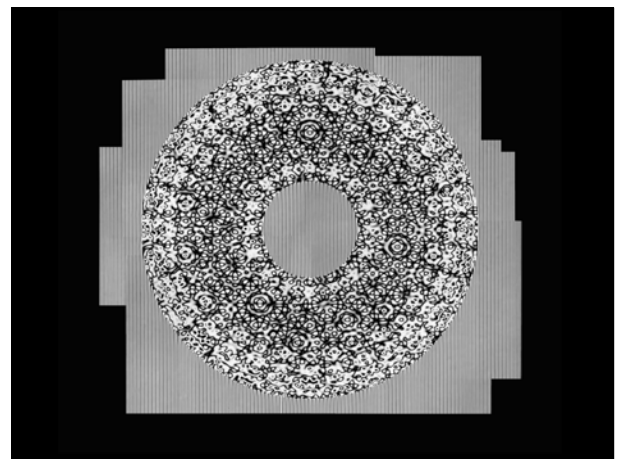
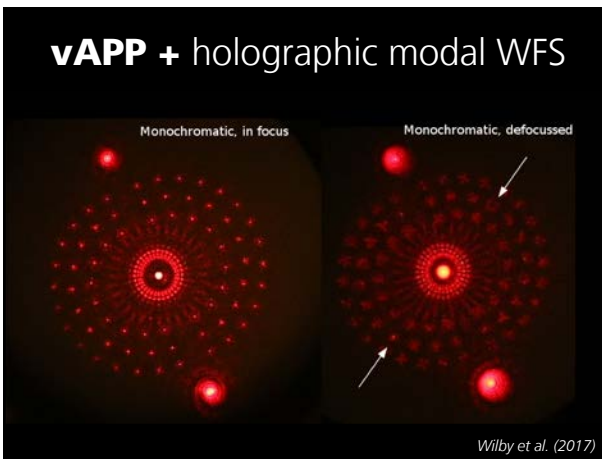
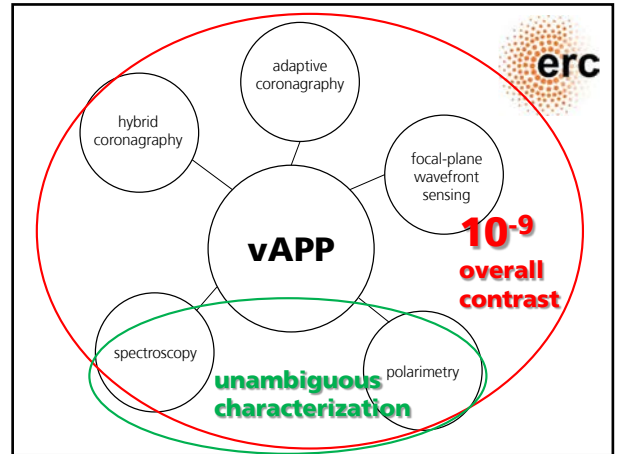
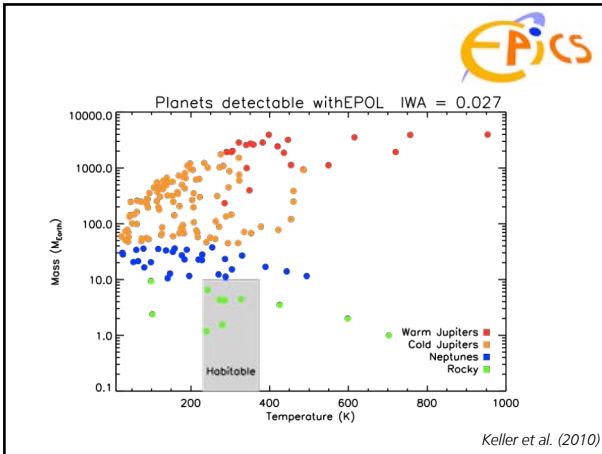


MICADO

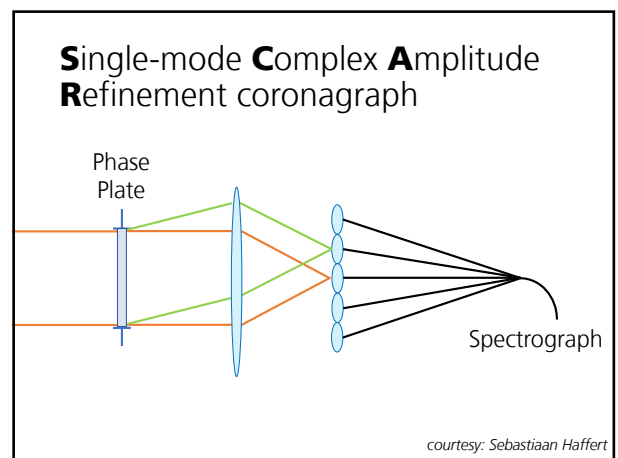
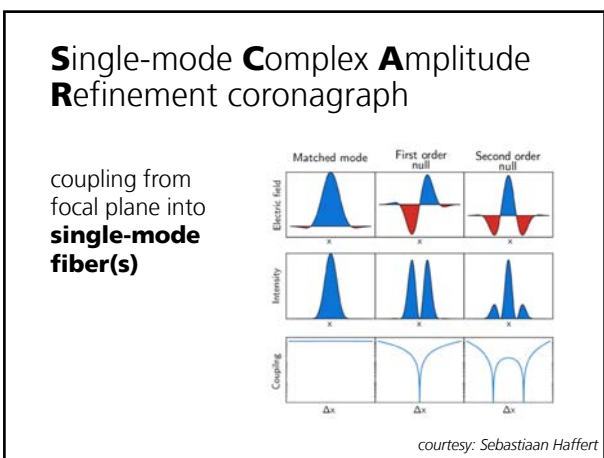
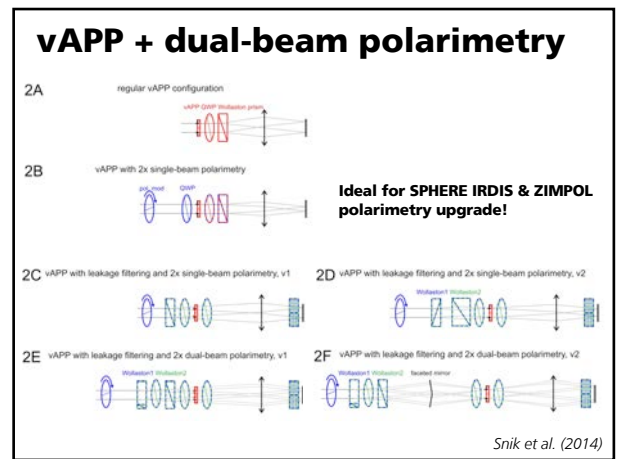
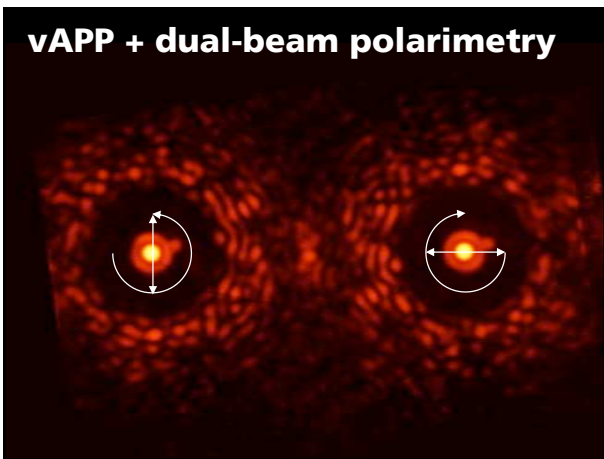
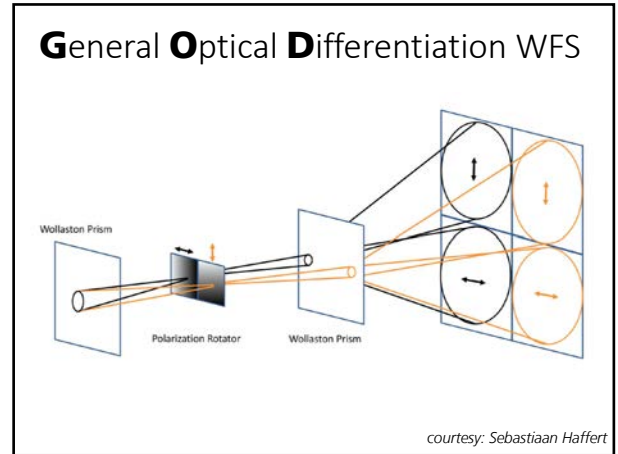
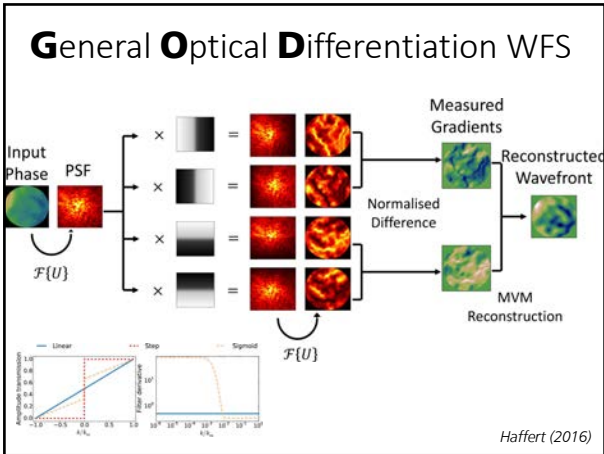
also 360-vAPP  
with huge outer  
working angle for  
**crowded-field  
observations**

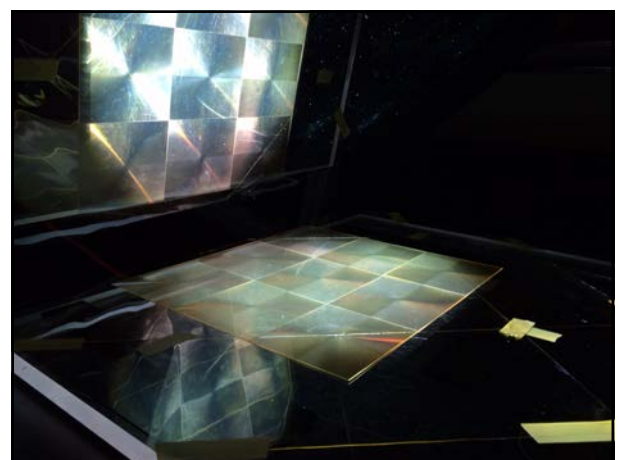
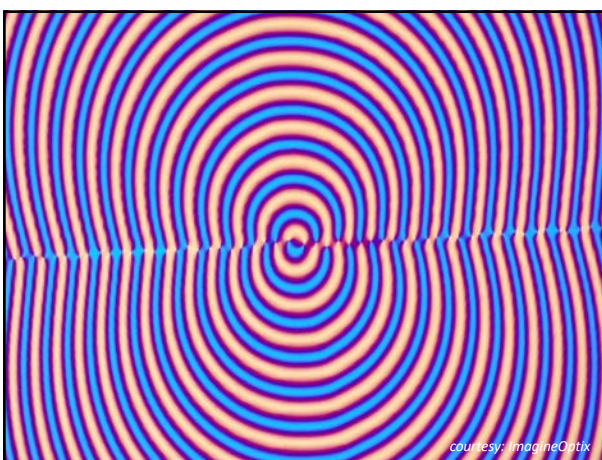
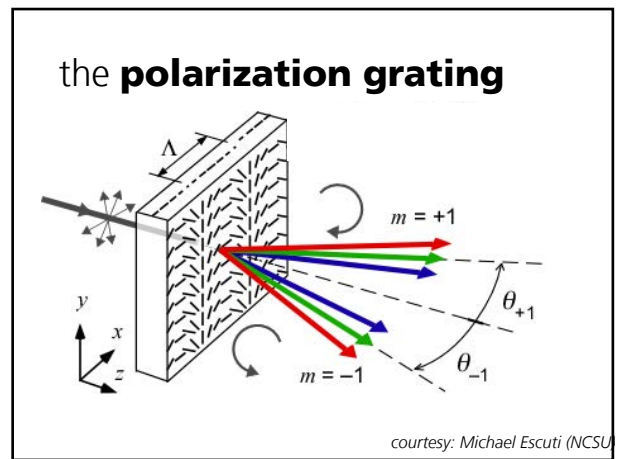
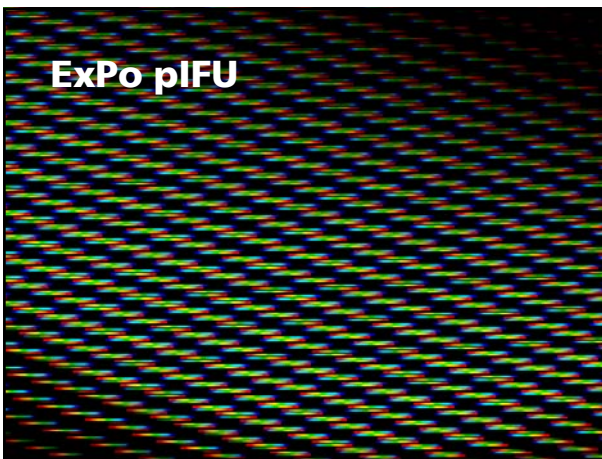
courtesy: David Doelman  
optimal phase pattern design code by Emiel Por

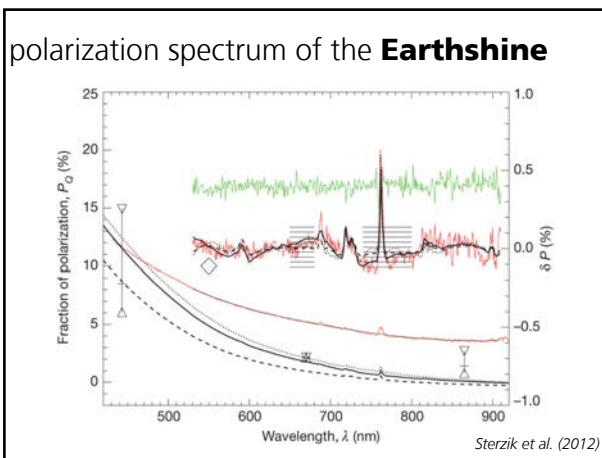
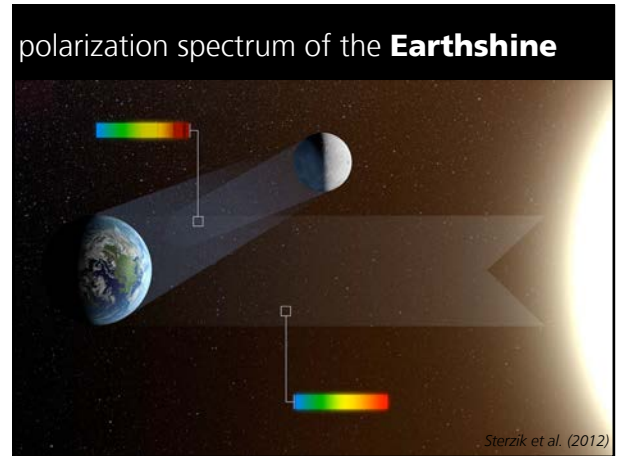
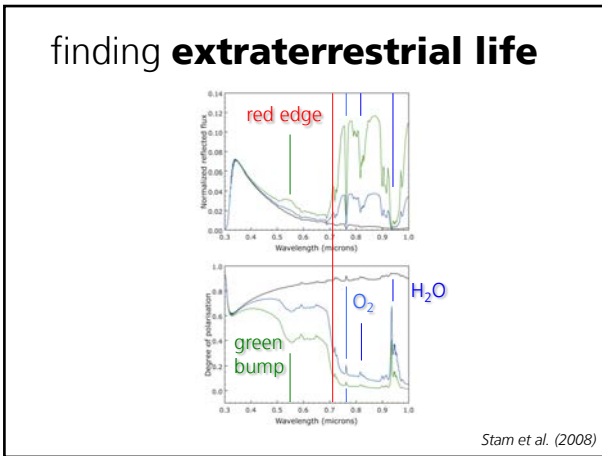
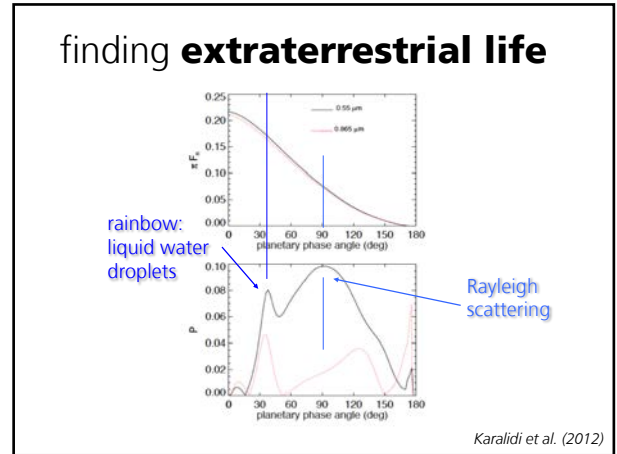


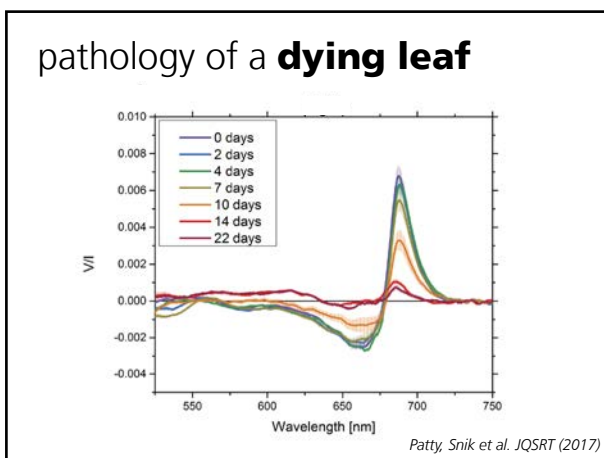
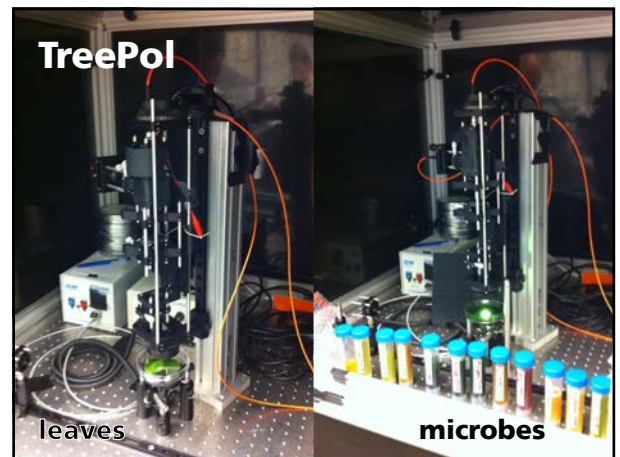
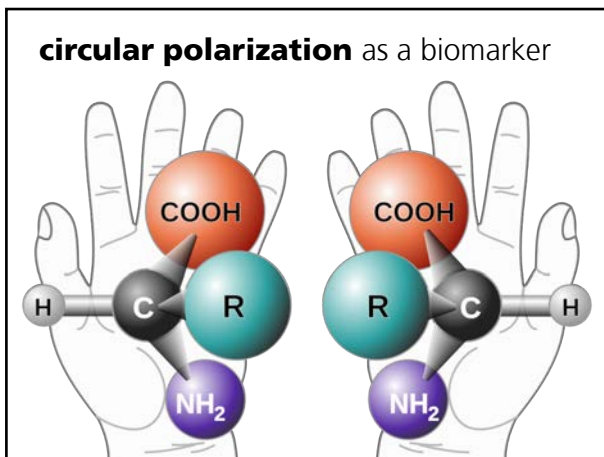
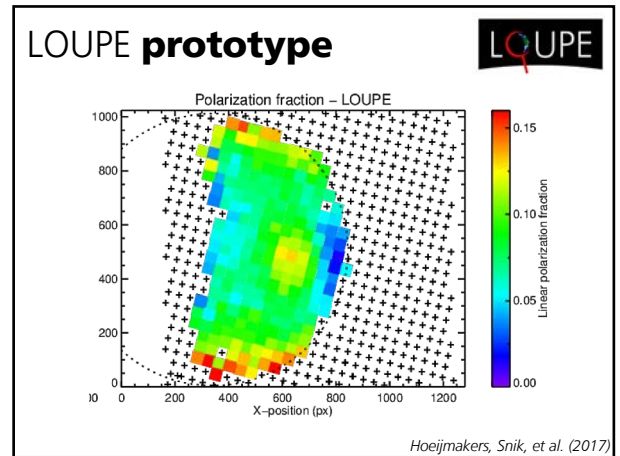
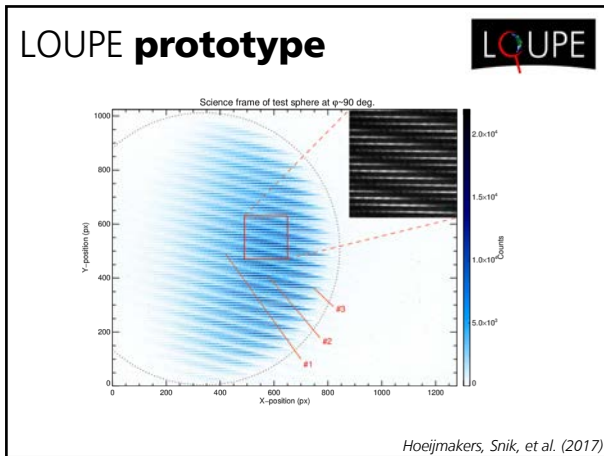






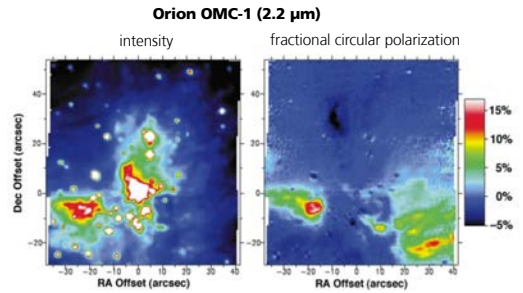






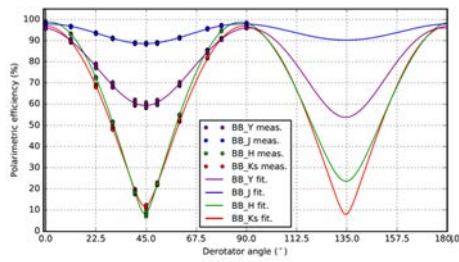


### cosmic origin of homochirality?



Bailey et al. (1998)

### circular polarimetry with SPHERE-IRDIS



van Holstein et al. (to be submitted)

### High-contrast imaging with liquid crystals