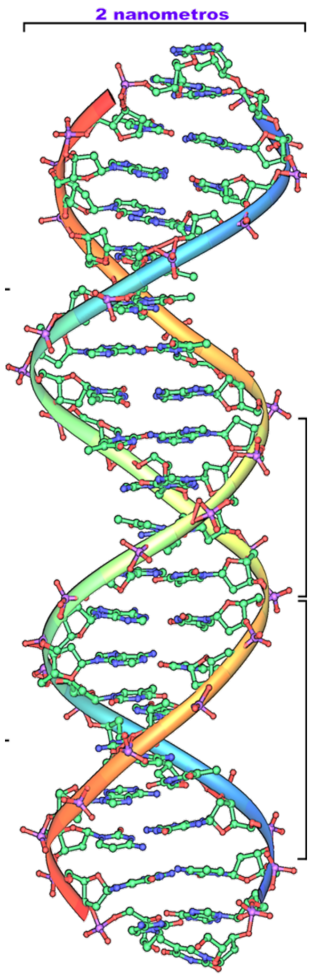
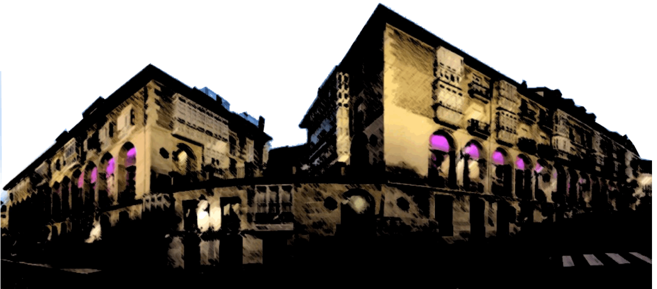
ULTRAVIOLET ASTRONOMY IN THE XXI CENTURY

e-Workshop 2020 – October 27-29

JcUVa

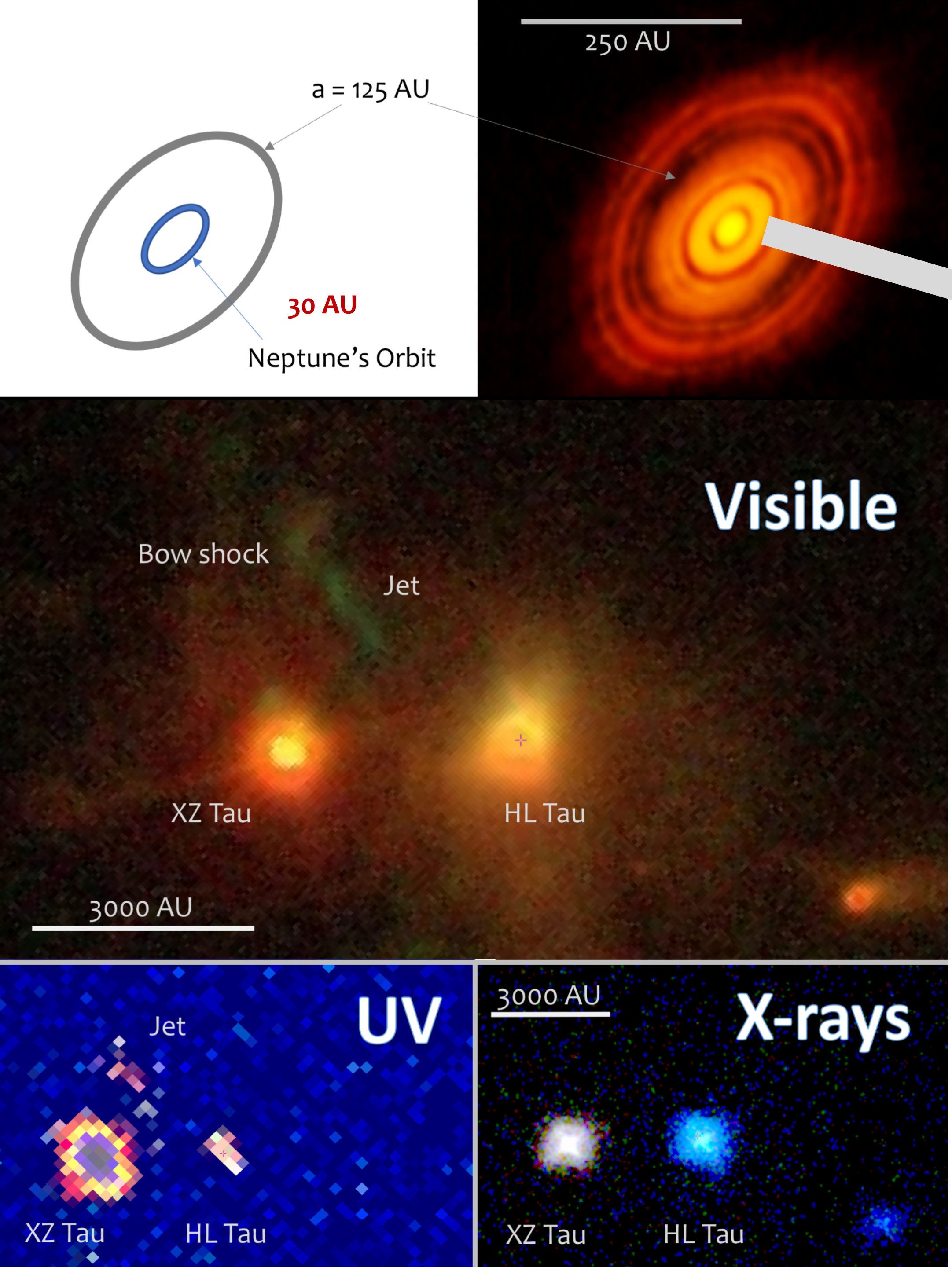


ULTRAVIOLET ASTRONOMY IN THE XXI CENTURY



The Ultraviolet Researcher for the Investigation of the Emergence of Life

Gómez de Castro and the URIEL consortium



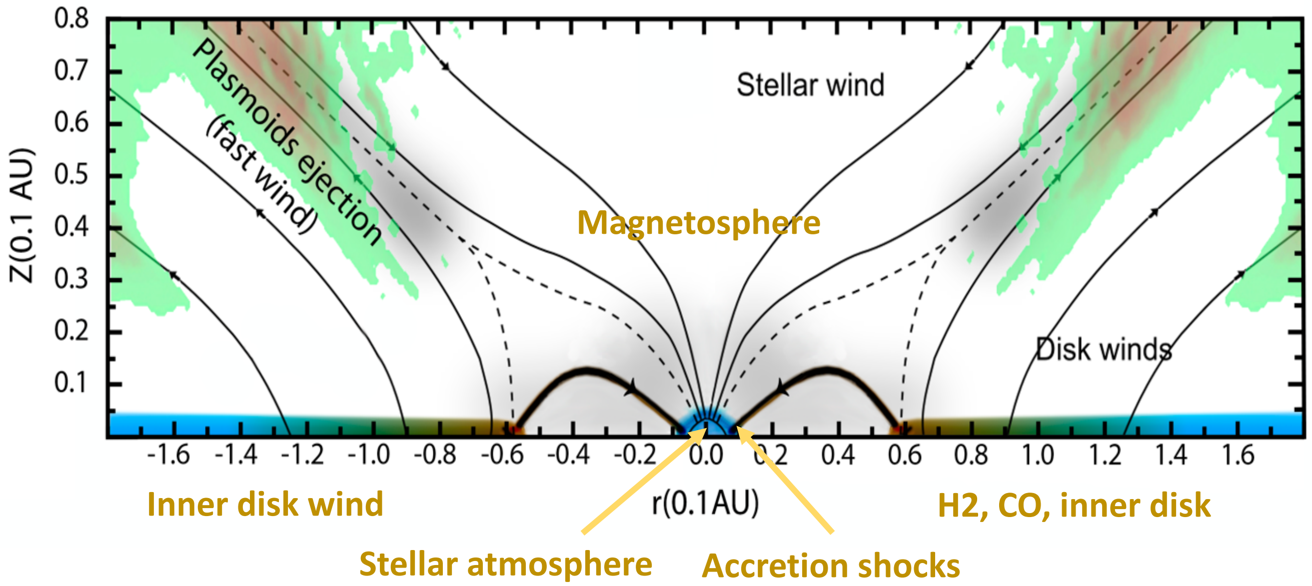
FORMATION OF EARTH-LIKE PLANETS

- The inner most region of young planetary systems is only accessible via spectroscopic means.
- This is the area were terrestrial planets do form.
- The radiating plasmas as dusty thus polarimetry provide additional information on the composition and dynamics of the inner part of young planetary disks.

UV Spectropolarimetry is the most sensitive tool to monitor and quantify the characteristics of the small dust particles carried by winds, and accretion streams. To detect the disturbances caused by nascent Earth-like planets.

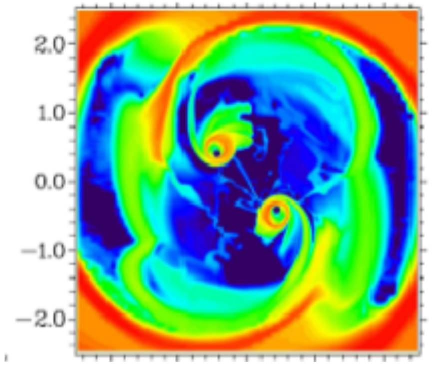
(from Gómez de Castro & Canet, 2021)

POLARIZATION IS VARIABLE ON TIME SCALES OF DAYS



- It is a complex area where many physical components share similar electron temperatures and radiating at UV wavelengths
- Polarization variability has been detected in 35% of the stars with more than 2 observations.
- The spectral tracers are not always different and polarimetry enables discrimination trough the dust column, dust size distribution and alignment.
- Comets during early life of planetary systems will be accesible

Distribution of CS matter in AK Sco



Gómez de Castro et al. 2013

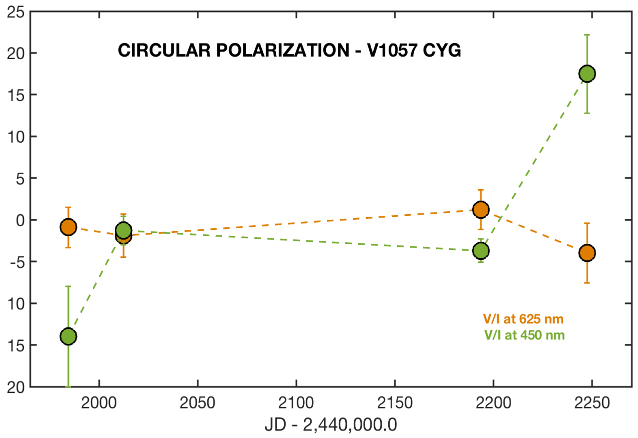
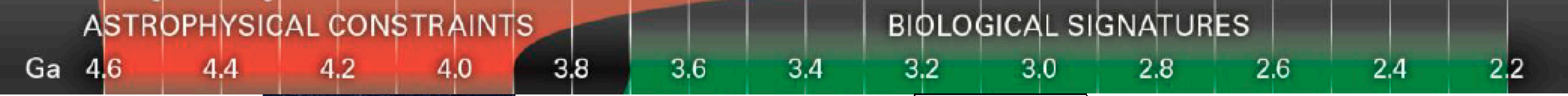


TABLE 2

GENERAL AND LINEAR POLARIZATION PROPERTIES

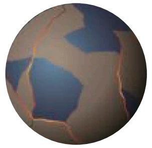
Star	A_v	$\log L/L_\odot$	$\langle P(0.76)\rangle$ (%)	$P(t)$ (%)	$\psi(t)$	$\psi(\lambda)$	$\psi_*(\lambda)$
RY Tau	1.88 ± 0.15	1.24	2.70 ± 0.22	$\Delta P > 1.0$	$\Delta\psi > 30°$	0° to ~ 23°	yes
T Tau...........	1.44 ± 0.10	1.45	1.17 ± 0.05	$\Delta P > 1.0$	$15° < \Delta\psi < 30°$	0°	no
SU Aur	0.93 ± 0.14	1.25	0.21 ± 0.05	$\Delta P < 0.5$	$\Delta\psi > 30°$	0° to ~ 20°	yes
DG Tau	...	≥ 0.88	5.99 ± 0.05	$0.5 < \Delta P < 1.0$	$\Delta\psi < 15°$	0°	no
FU Ori	2.50 ± 0.22	2.43	0.76 ± 0.01	no	no	0°?	no?
V1057 Cyg	3.1	...	1.67 ± 0.02	?	no	0°	(no)

Nadeau & Bastien, 1986

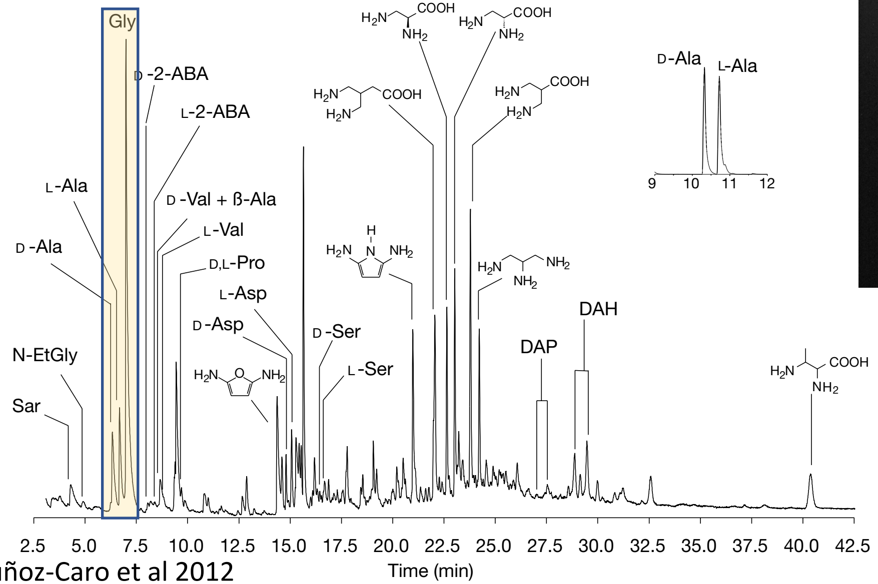


Earth Formation
(4.54 Gy)

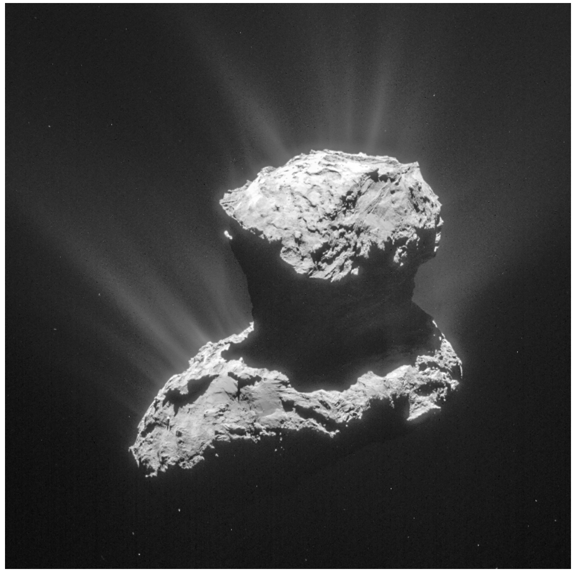
Oldest signs of life
-stromatolites-
(3.7 Gy)



Crust & Oceans
(4.5-4.3 Gy)



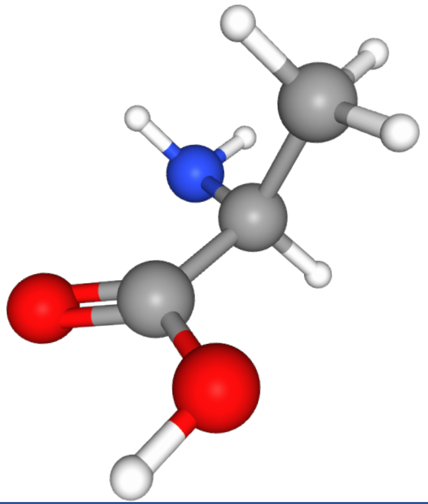
Muñoz-Caro et al 2012



67P/Churyumov–Gerasimenko

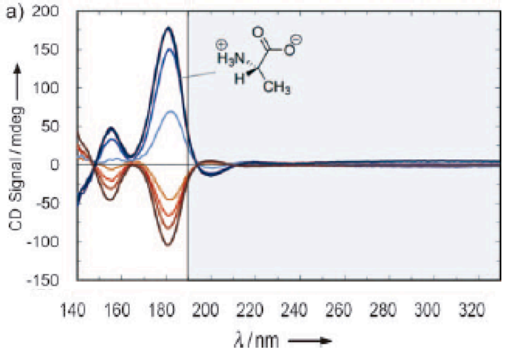
Glycine detected
(Altwegg et al. 2016)

PROTEINOGENIC AMINOACIDS formed in the experiments	LABORATORY EXPERIMENTS SIMULATING			
	EARLY EARTH CONDITIONS		SPACE ICE & COMETS	
	Miller 1952	Parker et al. 2011	Muñoz-Caro et al 2002	Chen et al. 2008
Glycine	■	■	■	■
Alanine	■	■	■	■
Aspartic acid	■	■	■	■
Serine		■	■	■
Valine		■	■	
Glutamic acid		■		■
Phenylalanine				■
Methionine		■		
Isoleucine		■		■
Leucine		■		■
Cysteine				
Histidine				■
Lysine				
Asparagine				
Pyrrolysine			■	
Proline				
Glutamine				
Arginine				■
Threonine				
Selenocysteine				
Tryptophan				
Tyrosine				■

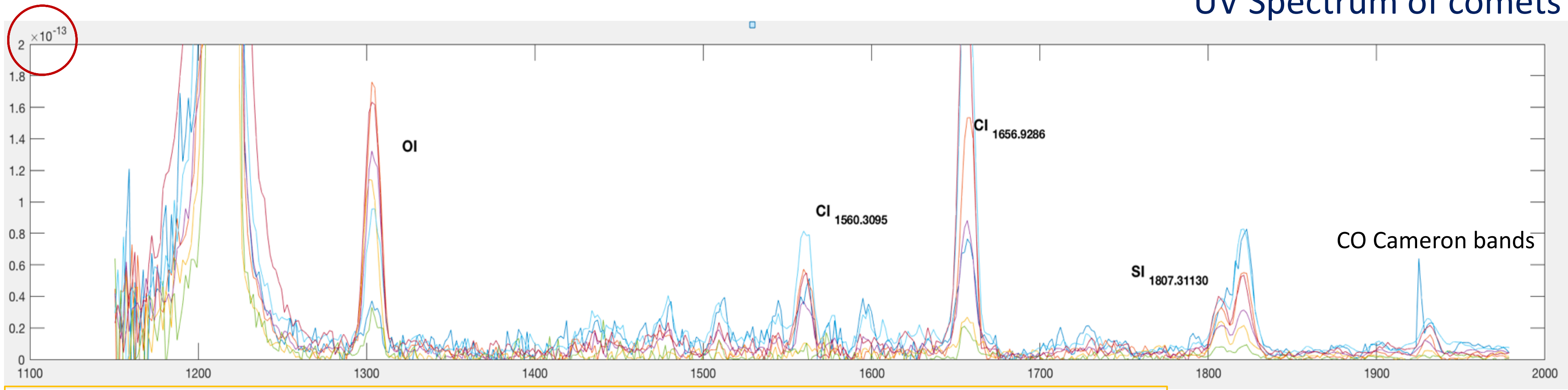


URIEL: THE PATH TO THE REMOTE DETECTION OF ALANINE

Alanine's **circular dichroism spectrum**
Meierhenrichs et al. 2012



UV Spectrum of comets

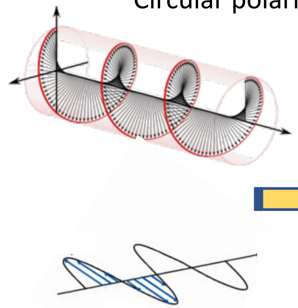


Spectra of comets obtained with the *International Ultraviolet Explorer*: Bradfield, Halley, Levy, Swift-Tuttle, Hyakutake

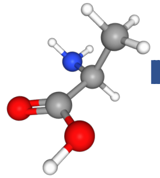
The **chirality of alanine**, the **enantiomeric imbalance** detected in comets and meteorites (1%-60%), the **polarization** of the radiation from comets through scattering by the dust grains in the coma can make alanine detectable by remote sensing opening a **new path to astrobiological research**.

Gómez de Castro & de Isidro-Gómez 2020

Circular polarized radiation



Linearly polarized radiation

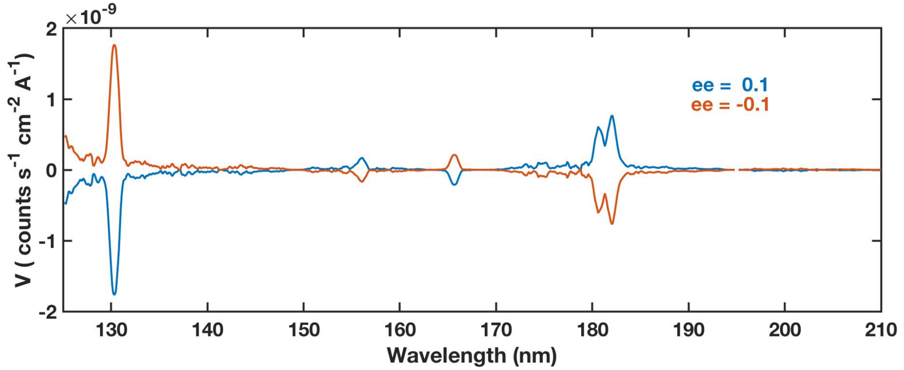


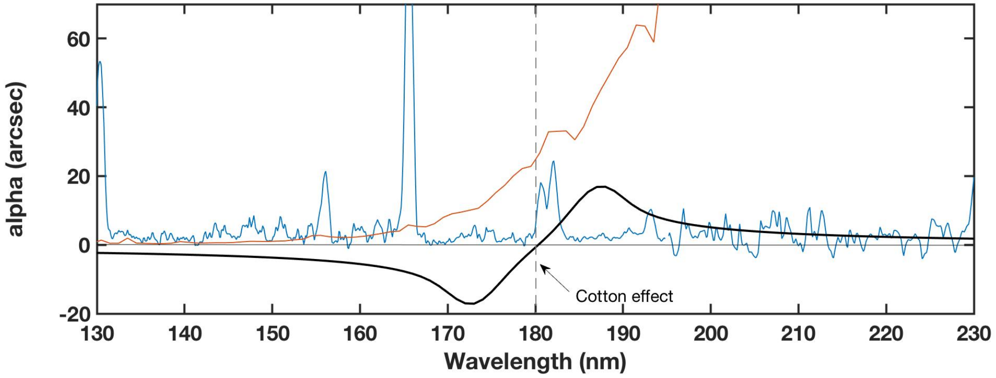
Circular dichroism (CD)

Optical Rotatory Dispersion (ORD)

$$I_{L,R} = I^0_{L,R} 10^{-A_{L,R}}$$

$$[\alpha](\lambda) = \ 2.1018{\times}10^3 \int_0^\infty \Delta\mu(\lambda') \frac{\lambda'^2}{\lambda^2 - \lambda'^2} d\lambda',$$





Alanine abundance scaled from 67P/Churyumov–Gerasimenko’s glycine

(graphs after Gómez de Castro & de Isidro-Gómez, 2020)

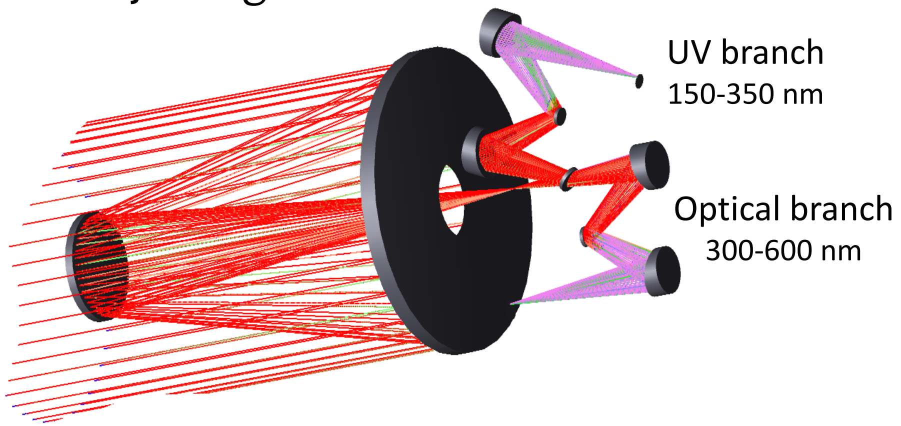
URIEL Scientific Requirements and traceability matrix

Scientific Objectives	Scientific Requirements	Measurements
Search for signatures of alanine in comets	High sensitivity spectro-polarimetry in the 150-250 nm spectral range. Long slit.	Rotation of the polarization vector
Mineralogy of Solar System and interstellar minor bodies	High sensitivity spectropolarimetry in the 150-600 nm spectral range	Composition
Measure the abundance of small dust grain in the disk atmosphere	High sensitivity spectropolarimetry in the 150-600 nm spectral range	Variation of polarization with wavelength. Variation of the polarization strength with the age of the system
Measure abundance of holes and rings in the discs	High sensitivity Spectro-polarimetry in the 150-600 nm spectral range	Variation of the polarization strength between systems with similar ages and stellar activity
Measure the size of the stellar magnetosphere	High sensitivity spectroscopy in the 150-350 nm spectral range	Lines and continuum flux
Detect dust clouds close to the star and comets	Monitoring during 1.5- 2 stellar rotation periods of the spectropolarimetric signal in the 150-600 nm range	Variations in the polarization with rotational phase.
UV radiation input on the disk	Monitoring during 1.5- 2 stellar rotation periods of the spectropolarimetric signal in the 150-350 nm range. Photon counting detector	UV radiation field and variability time-scales.
UV radiation field for ARIEL targets	UV spectroscopy in the 150-600 nm range to overlap with ARIEL photometric bands	UV spectra and flares (if required)

Main characteristics of URIEL

Optical layout	Ritchey-Chretien Mounting Minimization of instrumental polarization
Primary size	50 cm diameter
Instrument	MgF2 Polarizer-Wollaston Prism Analyzer Curved grating – dispersion 600 Wavelength range 150-300 nm Solar blind detector
Orbit	HEO or L2
Tech. Probe	AURORA (target < 0.03% @ 180 nm)

URIEL early design to be flown with ARIEL



Summary:

- UV spectropolarimetry is a fundamental technology for the investigation of the formation of planetary systems, Earth-like planets and astrobiological research, in general.
- The technology needs to be optimized for astronomical observations (see CLASP1/2 for solar observations).

URIEL consortium is growing now.

Please, contact Prof. Ana I Gómez de Castro, aig.at.ucm.es, if interested in participating in it