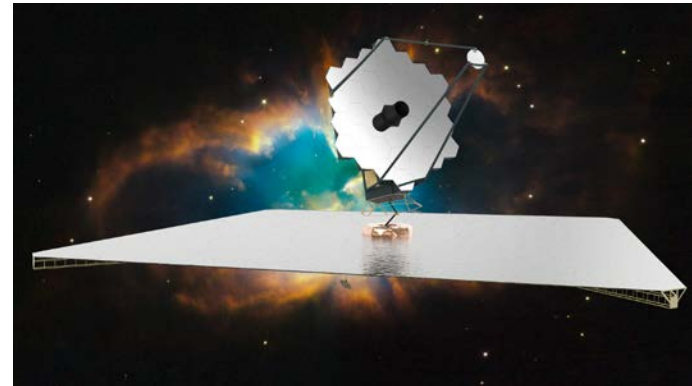


ULTRAVIOLET ASTRONOMY IN THE XXI CENTURY



e-Workshop 2020 – October 27-29

Astrophysics with POLLUX, a UV High-Resolution Spectropolarimeter for LUVOIR

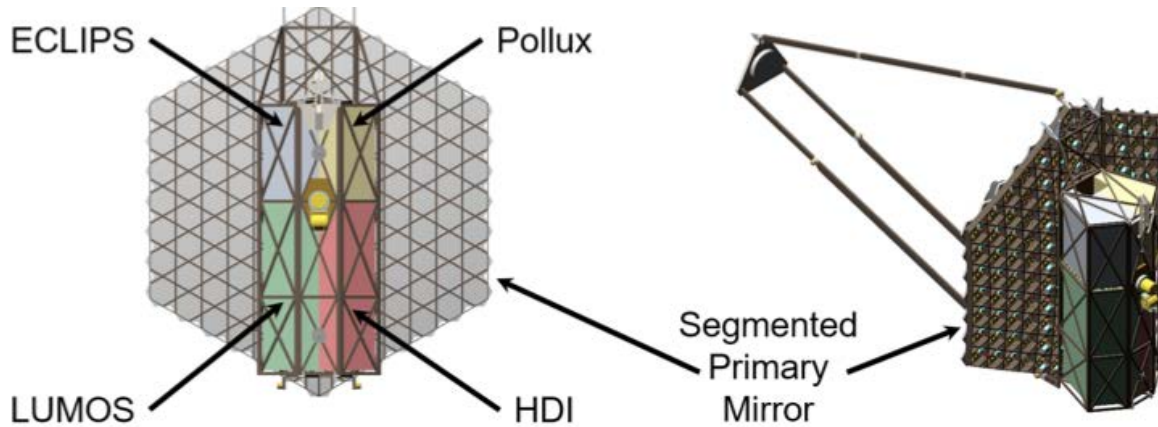


JC Bouret

C. Neiner, Eduard Muslimov, Maelle Le Gal, Arturo Lopez-Ariste, Luca Fossati, Chris Evans, Pasquier Noterdaeme, Frédéric Marin, Jean-Yves Chaufray, Boris Gaensicke, Ana Inès Gómez de Castro, Cécile Gry, Steve Shore, Vianney Lebouteiller

Context

LUVOIR-A (NASA Decadal survey 2020) : 3 instruments (USA) + 1 (EU)

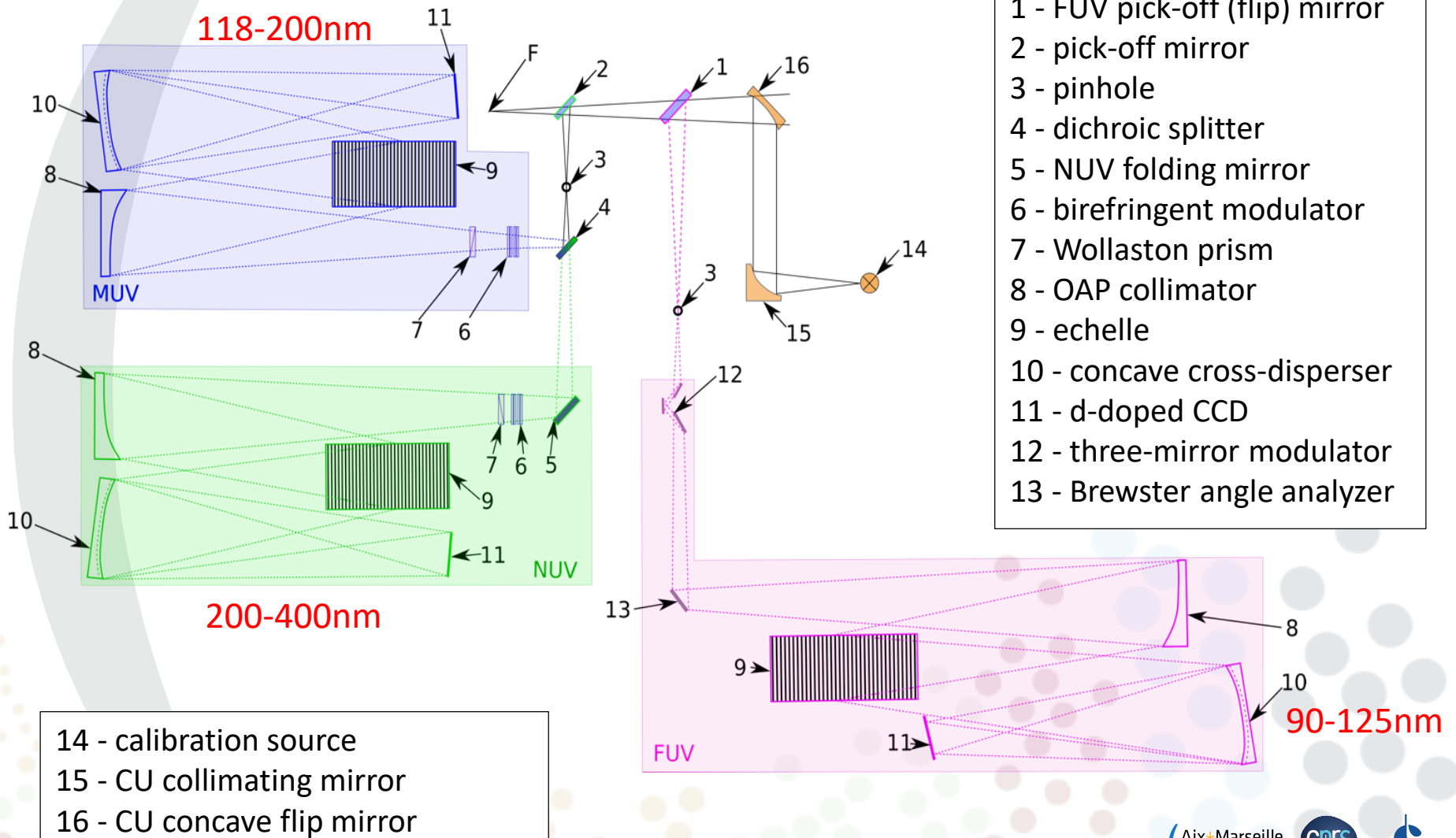


Parameter	Requirement
Wavelength range	90 - 400 nm
Spectral resolving power	120,000
Spectral length of the order	6 nm
Observing modes	Spectropolarimetry and pure spectroscopy
Polarisation mode	Circular+linear (= IQUV)
Polarisation precision	10^{-6}



- Management → CNES (France)
- PIs **LESIA & LAM**
- Consortium: 170 participants
67 institutes
13 European countries

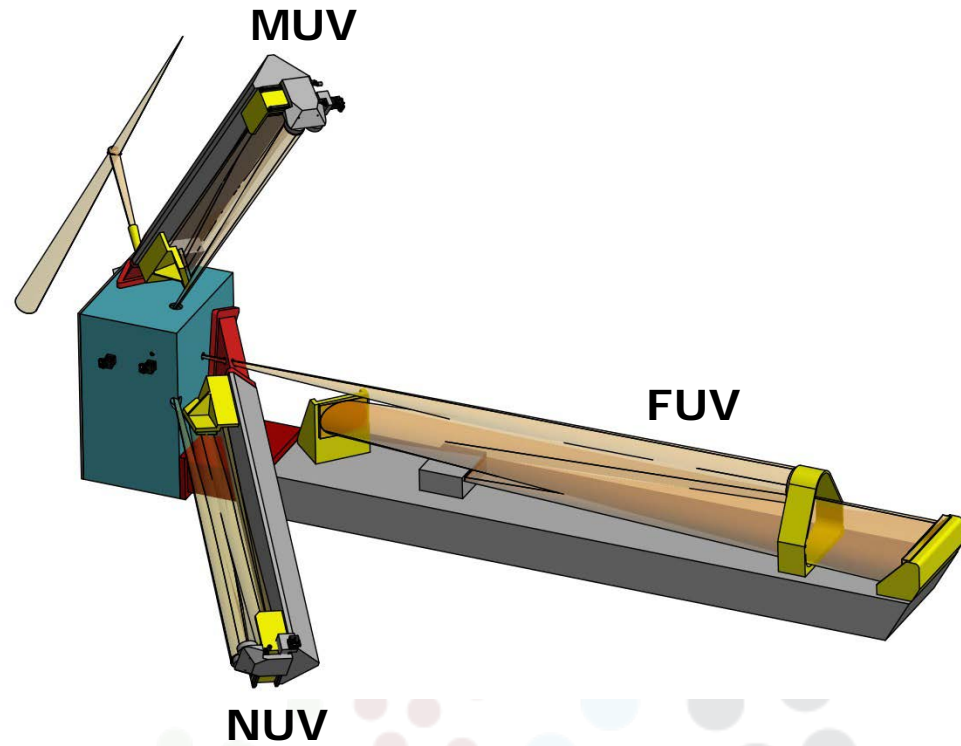
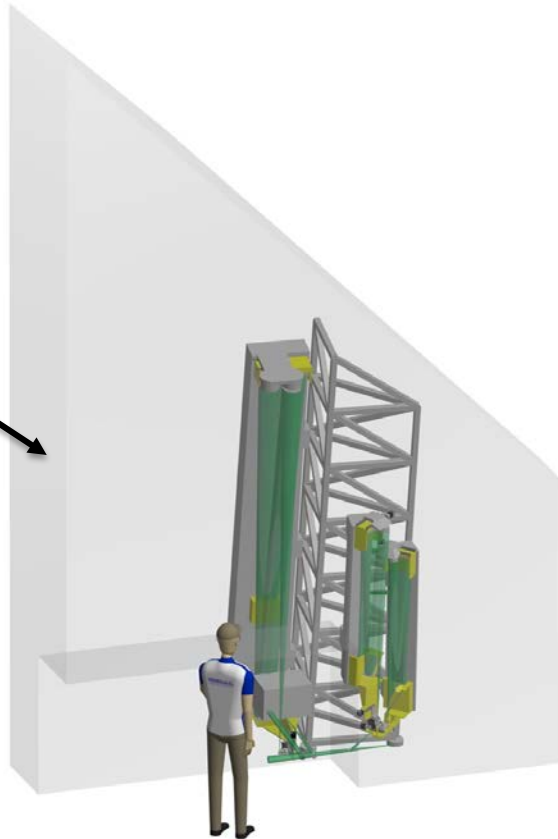
Concept



- F - telescope focus
- 1 - FUV pick-off (flip) mirror
- 2 - pick-off mirror
- 3 - pinhole
- 4 - dichroic splitter
- 5 - NUV folding mirror
- 6 - birefringent modulator
- 7 - Wollaston prism
- 8 - OAP collimator
- 9 - echelle
- 10 - concave cross-disperser
- 11 - d-doped CCD
- 12 - three-mirror modulator
- 13 - Brewster angle analyzer

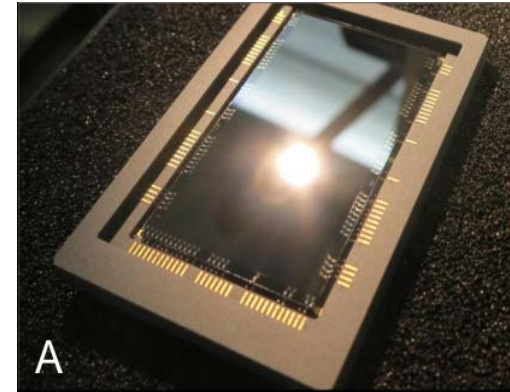
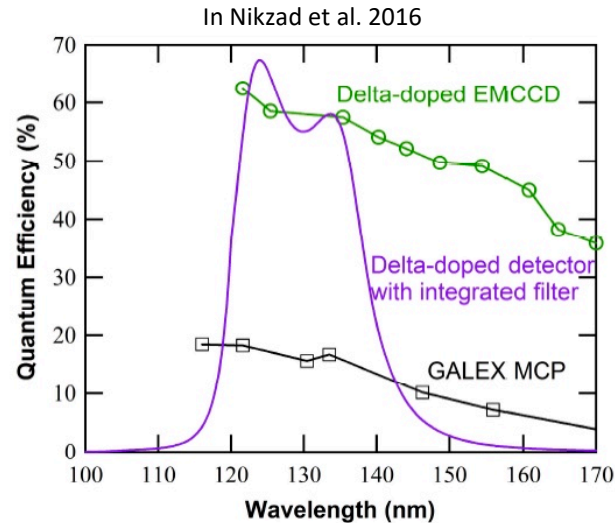
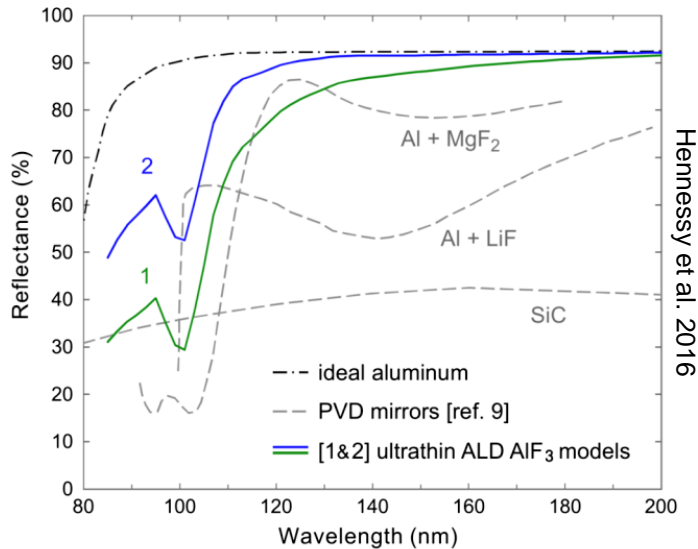
POLLUX: mechanical design

allocated
volume



POLLUX: technology development

- Optimized coatings for each channel: MgF_2 , LiF , SiC , Al/AlF_3 , $\text{Al}/\text{LiF}/\text{MgF}_2$, $\text{Al}/\text{LiF}/\text{AlF}_3$

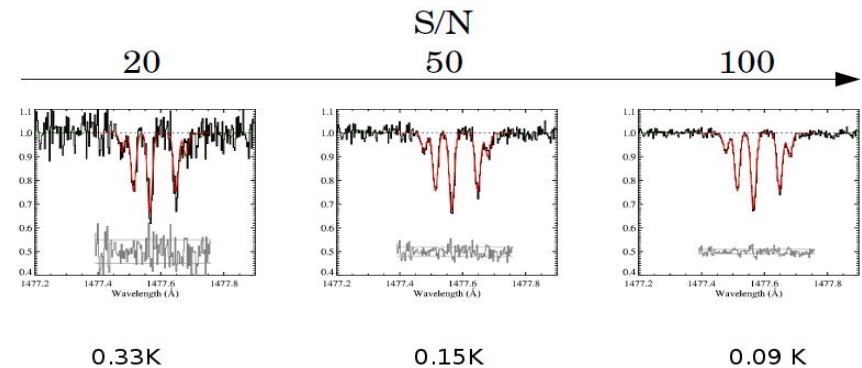


- Large Detectors: ($\sim 200 \times 200 \text{ mm}$) δ -doped CCDs, high-QE, $13 \mu\text{m}$ pixels
- Echelle gratings with high-groove densities ($\sim 500 \text{ gr/mm}$)
- But also : freeform holographic gratings, FUV, MUV/NUV polarimeters, dichroics

Testing fundamental physics and cosmology using absorption lines towards quasars

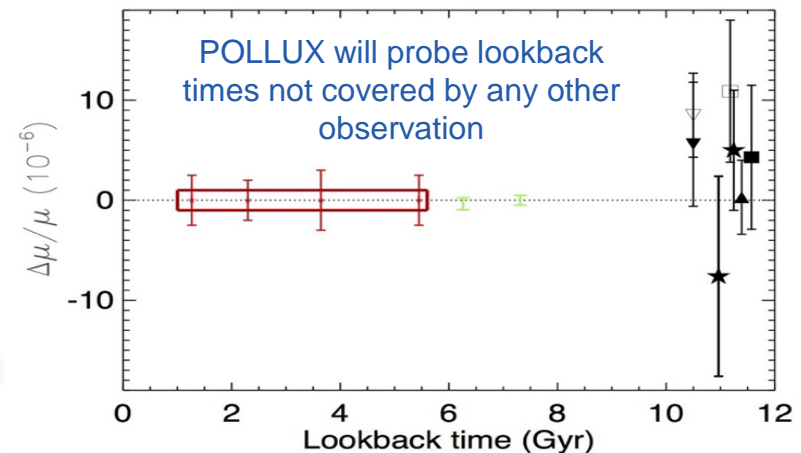
- measure the primordial abundance of deuterium, through Lyman series of DI and HI (rest-frame wavelengths in the range [911-1215] Å) → measurements at $0.3 < z < 2.3$ in the MUV/NUV

- excitation (UV electronic bands) of CO molecules by CMB radiation → probe the redshift evolution of the CMB temperature through high-precision measurement of the excitation temperature, covered by POLLUX at $z < 2.4$



- Constrain the proton-to-electron mass ratio (μ) by observations of the Lyman and Werner bands of molecular hydrogen ($\sim 900-1100$ Å rest-frame).

- POLLUX → better precision on single-component wavelength measurements
- de-blending of different kinematic components
- identification of hidden components



The characteristics of exoplanet atmospheres and how do planets interact with the host stars

- Unveil the chemical and physical properties (aerosols, clouds particles) of exoplanetary atmospheres through polarization of reflected starlight
- Detect polarization signatures for close-in gas giants (and brown dwarfs) orbiting stars out to distances of 70 pc
- Study Star-Planet Interaction: identify the stellar regions mostly affected by SPI to understand their origin
- Study atmospheric evaporation of exoplanets down to Earth-mass planets

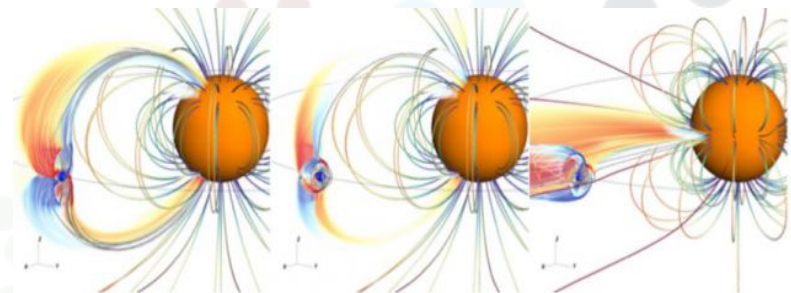
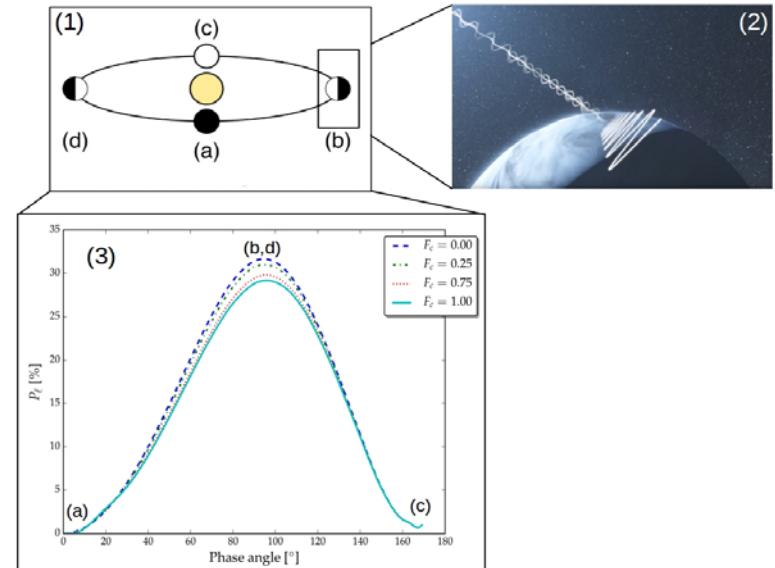
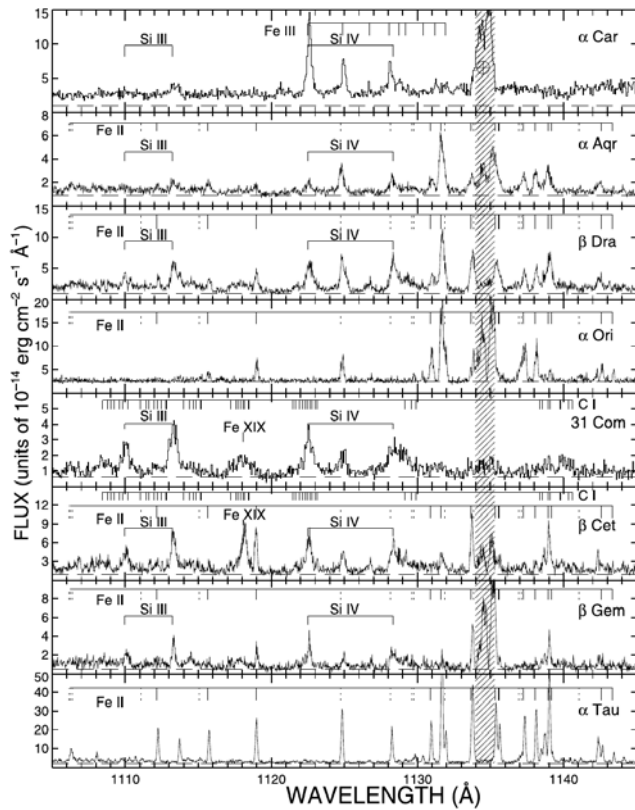
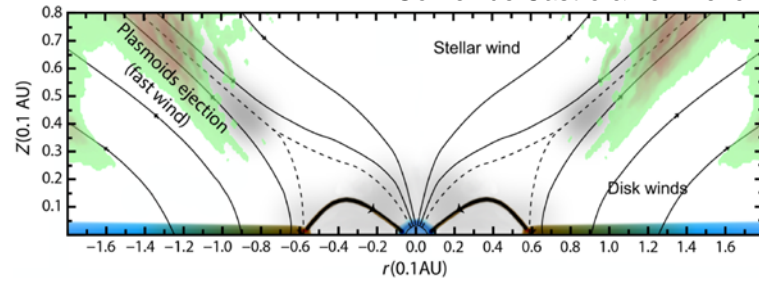
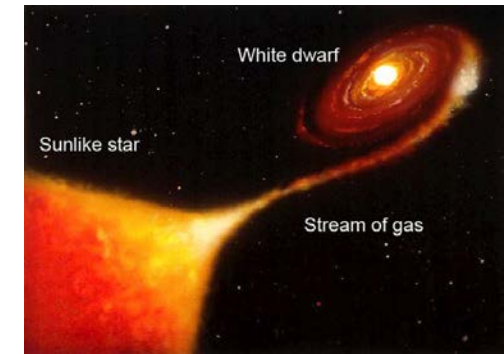


Image credit: CEA/IRFU

Stellar magnetic fields across the Hertzsprung-Russell diagram

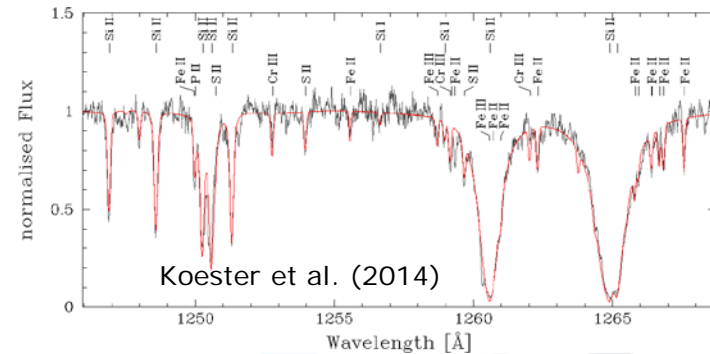
Gomez de Castro & von Rekowski 2011

Pre-main sequence stars:
star-disk interaction and
accretion-ejection



Chromospheric and
coronal heating in
evolved stars

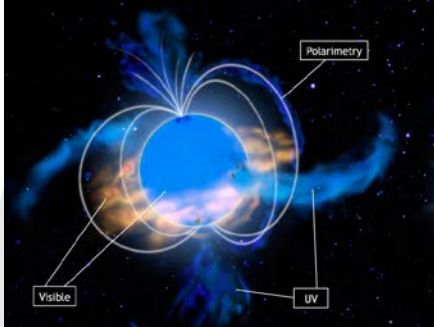
Dupree et al. (2005)



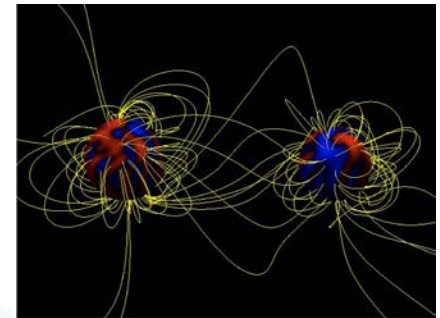
- Origin of magnetic fields in white dwarfs
- The physics of accretion discs
- White dwarfs accreting planetary debris

Stellar magnetic fields across the Hertzsprung-Russell diagram

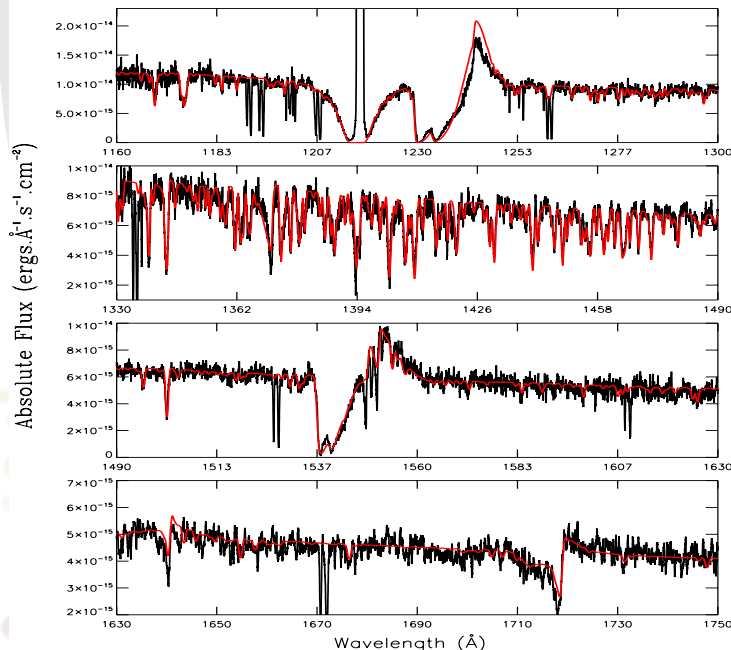
Image credit: LESIA



- 3D mapping of the environment (magnetosphere, CIRs,...) and stellar surface (ejections...)
- Rotational modulation of wind confinement (UV resonance lines) → accurate determination of rotation period
- Magnetic reconnection in massive binaries



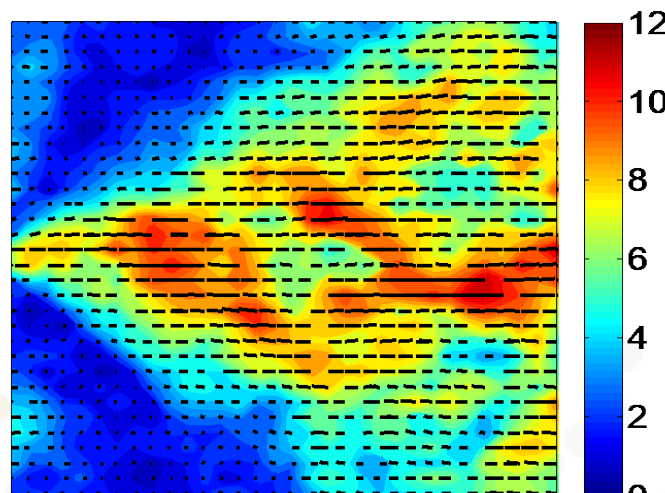
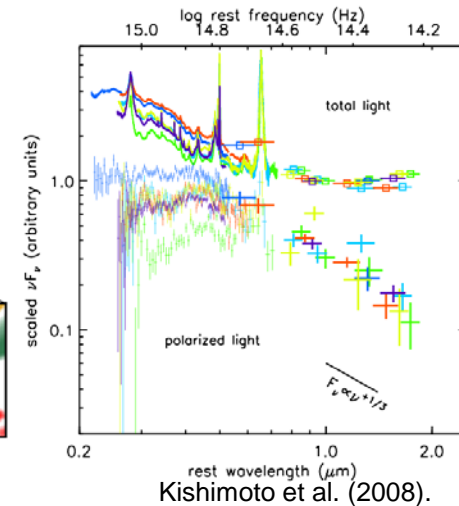
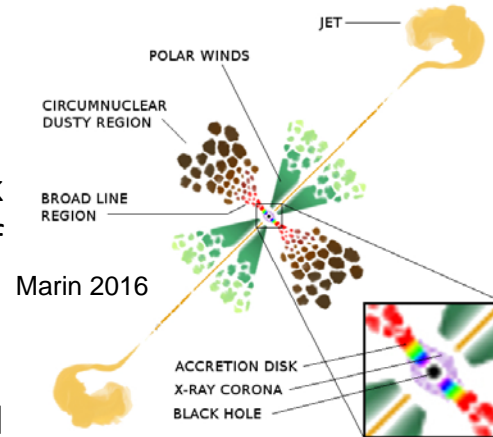
Bouret et al. 2013



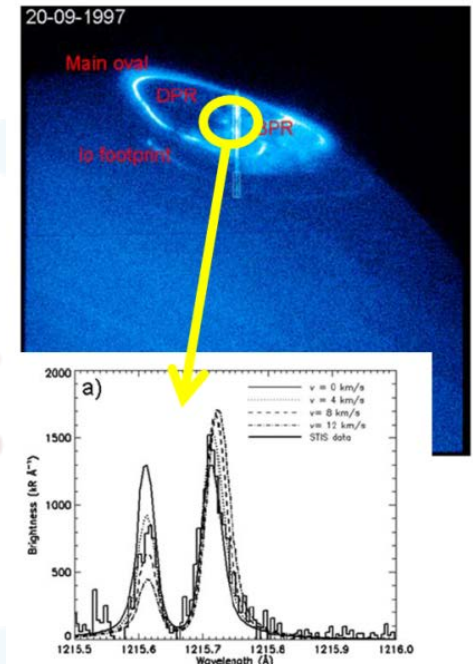
- High resolution spectroscopy of massive stars beyond the SMC → mass loss vs metallicity
- Stellar magnetism in the MCs, impact of metallicity

Other Science programs

- **Extragalactic Astronomy:** Accretion disk physics, dust composition and B-fields strength of AGNs
- **Solar System:** Surfaces, dust scattering and auroral emissions in the Solar System
- **ISM/IGM Science:** The various phases of ISM/IGM



Yan & Lazarian 2012



Chaufraay et al. 2010

Summary

- LUVUOIR: 3 instruments (USA) + POLLUX (EU)

- POLLUX → 90 – 390 nm
R=120,000

Linear + Circular Polarimetry

→ requires developments on UV polarimeters, UV coatings, dichroics, gratings, cross-dispersers, detectors,...

- Unique and novel capabilities
- High-potential for breakthrough discoveries
- Complementarity with LUMOS

