ULTRAVIOLET ASTRONOMY IN THE XXI CENTURY

JcUVa

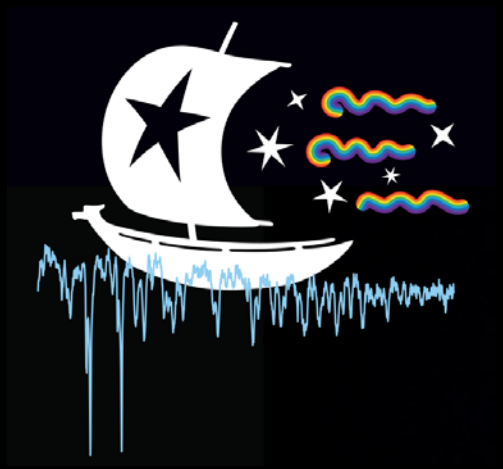
Outflows and Disks around Young Stars: Synergies for the Exploration of Ullyses Spectra (ODYSSEUS)

Catherine Espaillat (Boston University),
Gregory Herczeg (Peking University),
& the ODYSSEUS team

NASA/JPL-Caltech

ULLYSES: Hubble UV Legacy Library of Young Stars as Essential Standards

Director’s Discretionary Hubble Ultraviolet Legacy program with ~1,000 orbits dedicated to star formation and associated stellar physics.



STScI

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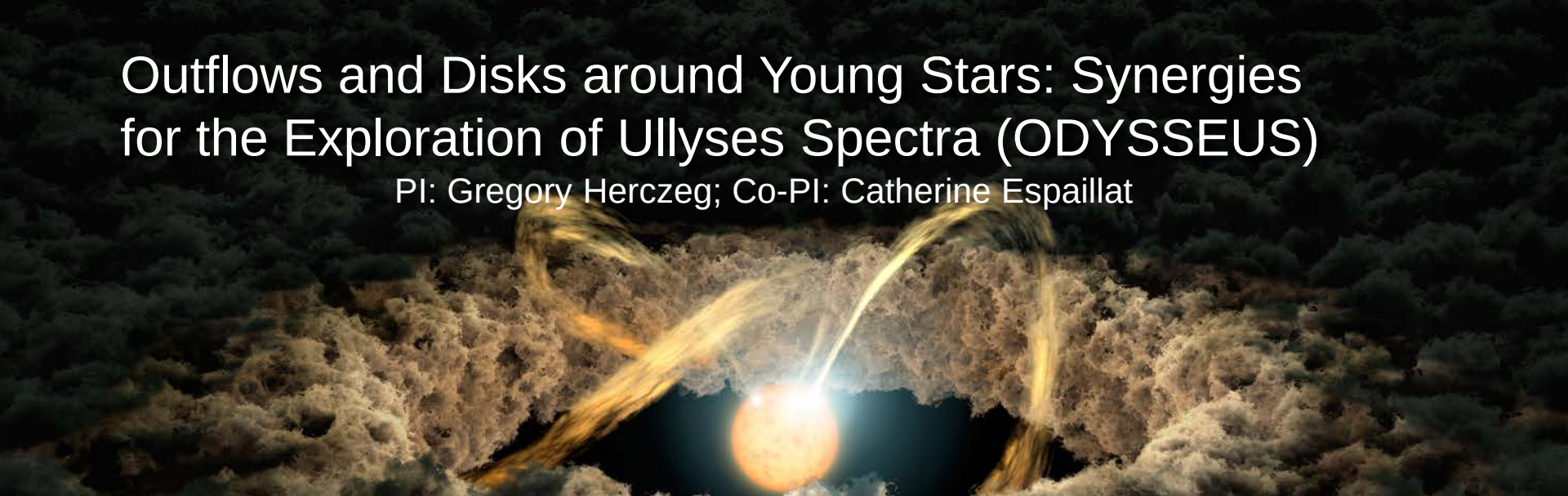
PI: Gregory Herczeg; Co-PI: Catherine Espaillat



- Mass accretion via the stellar magnetic field
- Mass outflow via winds and jets
- The structure and chemistry of the inner planet-forming disk regions
- Supplementary data

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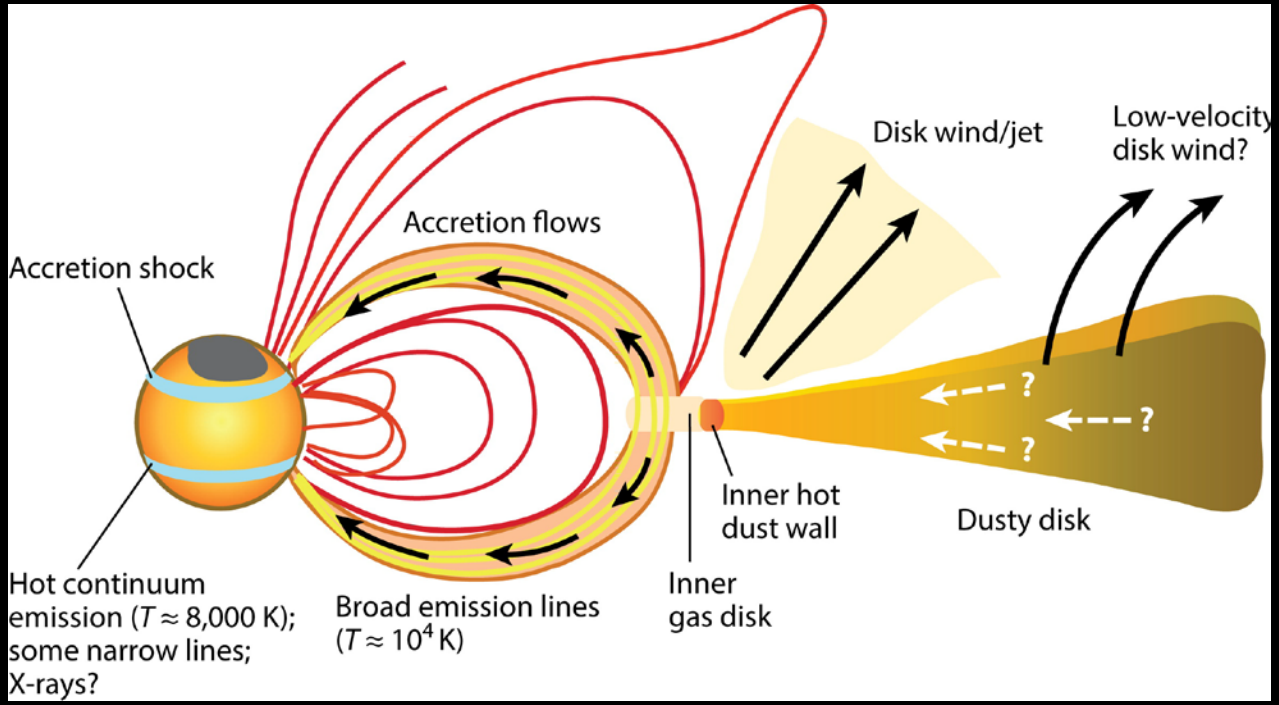
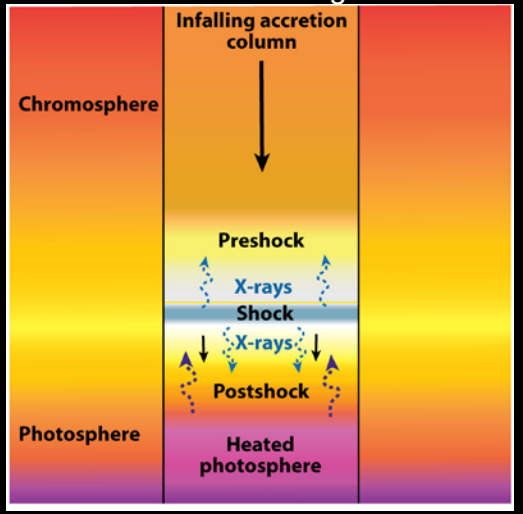
Mass accretes from the disk onto the star via the magnetic field lines and is launched via jets/winds



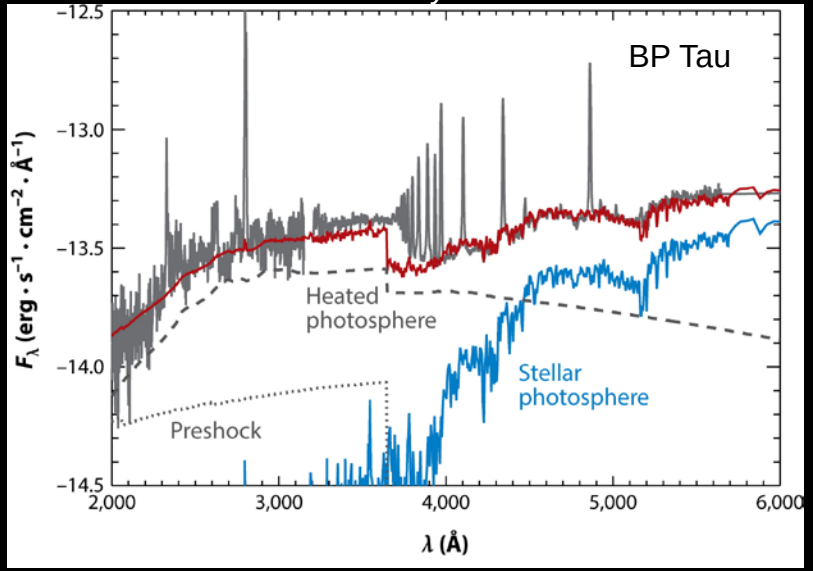
Hartmann, Herczeg, & Calvet 2016

The accretion process produces significant NUV excess emission

Accretion shock model of Calvet & Gullbring 1998



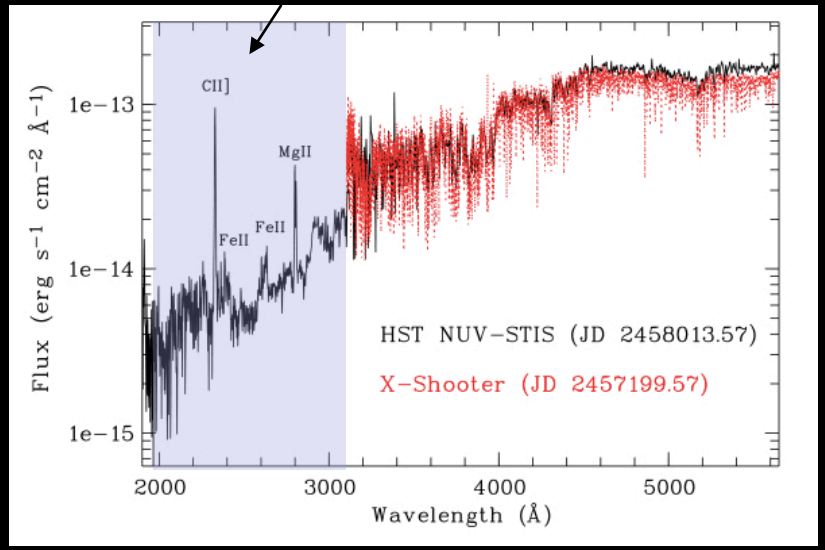
Modeling the NUV excess emission to extract the accretion luminosity



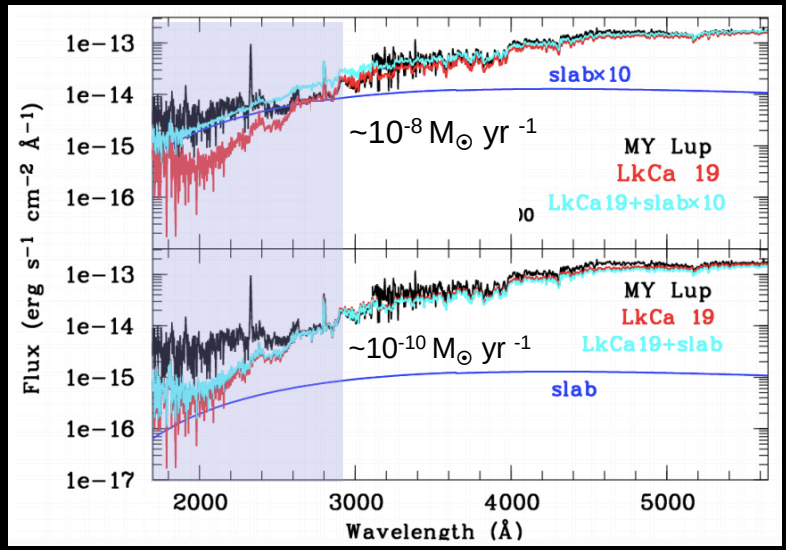
Hartmann, Herczeg, & Calvet 2016

Ground-based measurements can underestimate the accretion rate

Most of the UV, where the accretion excess emission peaks, is only accessible from space.

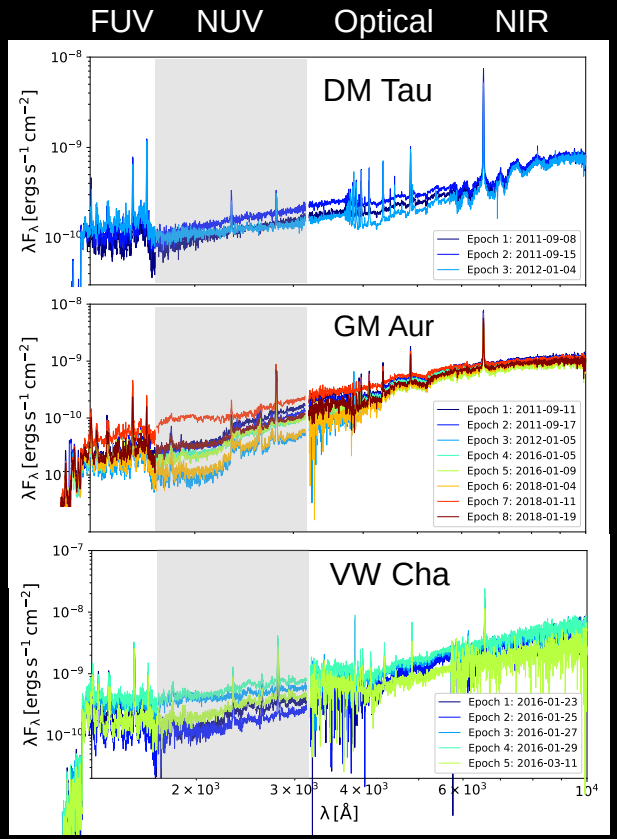


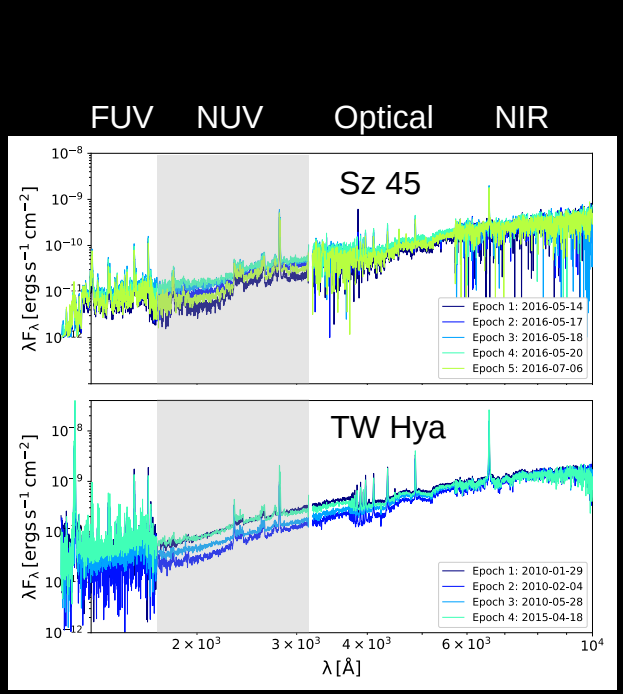
The accretion rate can be significantly underestimated if the NUV is not considered.



Alcala et al. 2019

Young stars display NUV variability due to accretion





Robinson & Espaillat 2019

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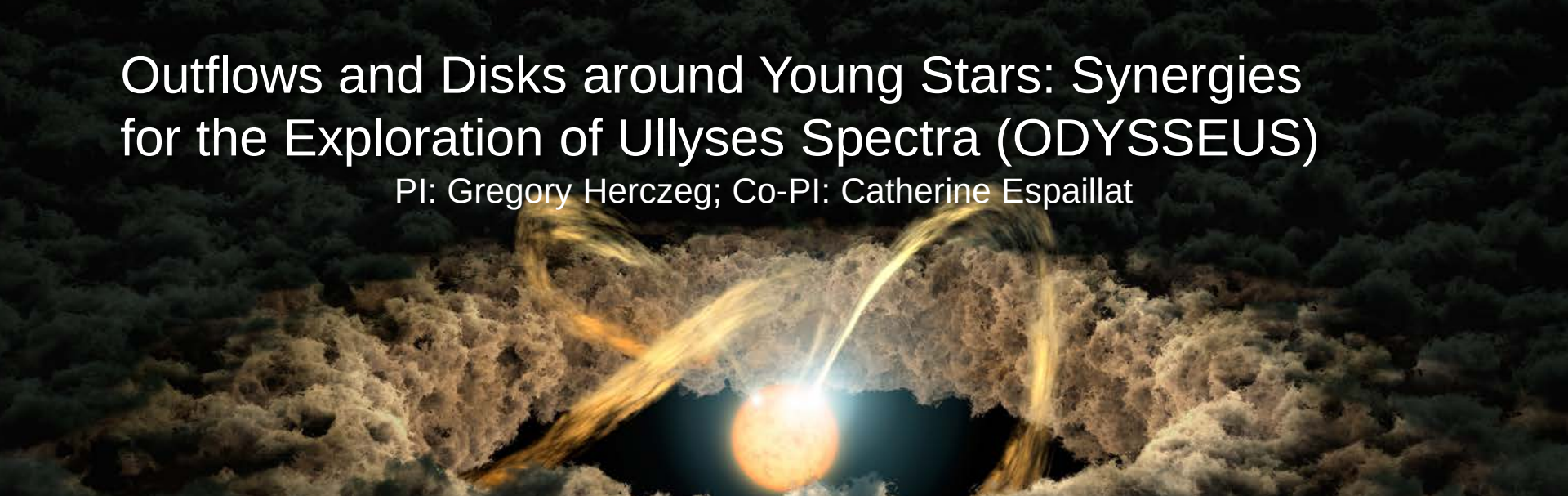

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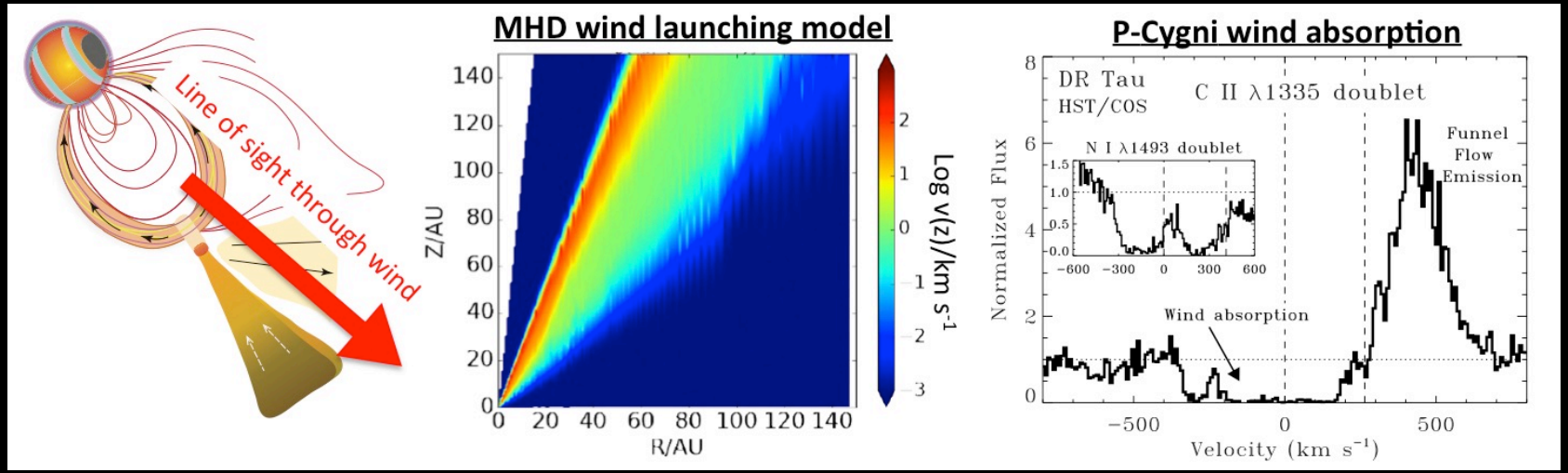
Developing MHD wind models to interpret P-Cygni lines to extract wind launching parameters



See talk by Ziyan Xu

Left: adapted from Hartmann, Herczeg, & Calvet 2016; Middle, Right: Xu et al. in prep

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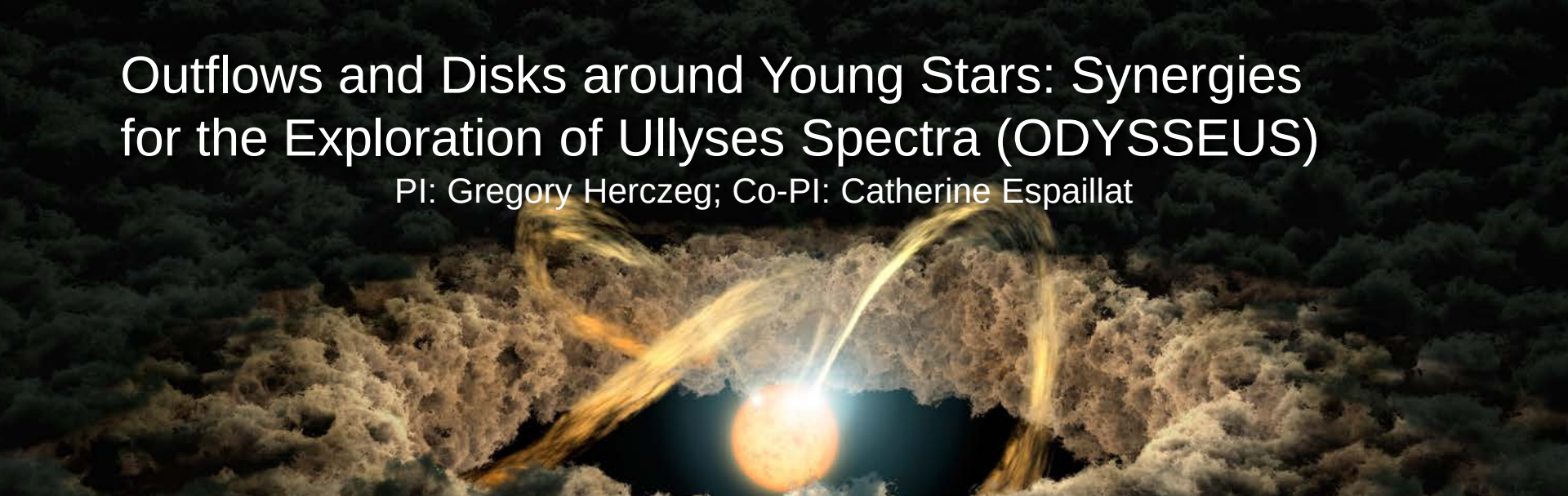

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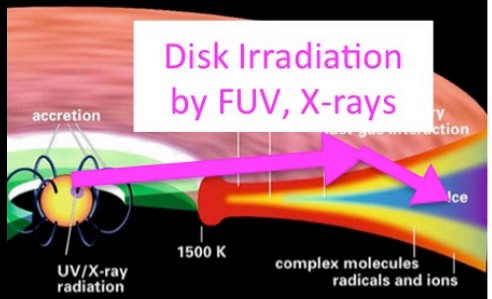
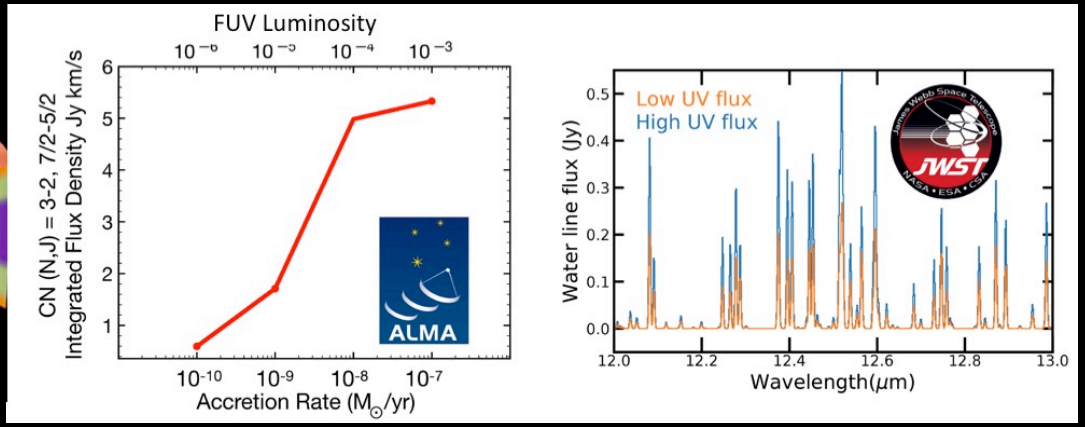
UV measurements necessary to interpret ALMA and JWST emission





Left: adapted from Henning & Semenov 2013; Middle: Cazzoletti et al. 2018; Right: from E. Bergin

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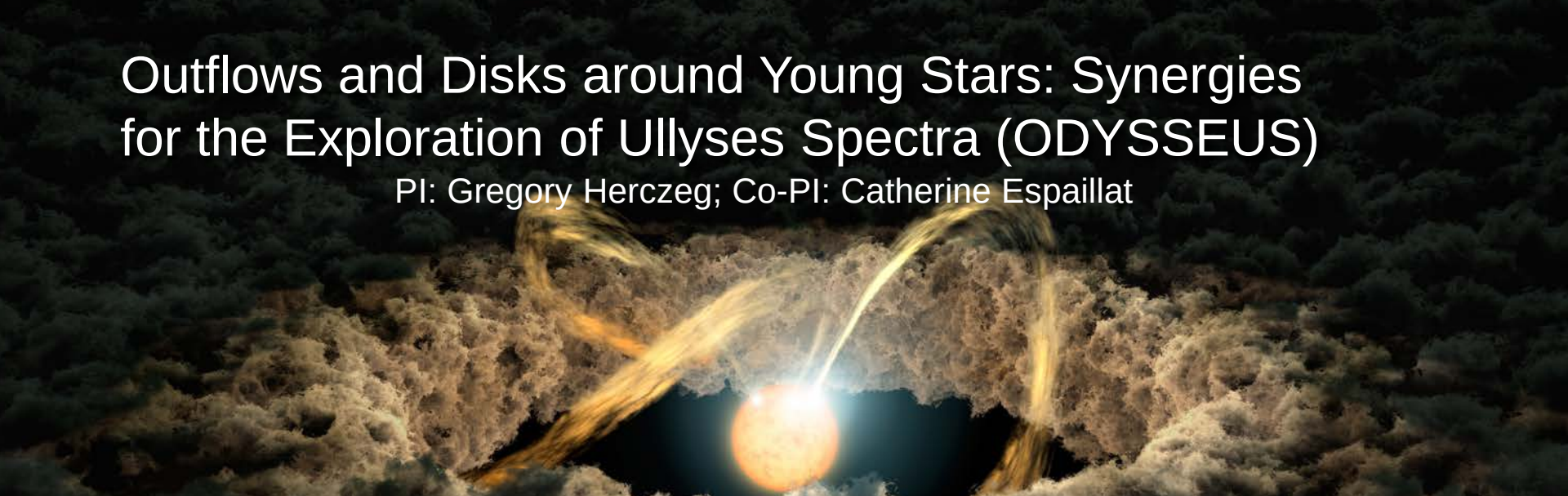

- Mass accretion via the stellar magnetic field
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Supplementary data from ODYSSEUS team

X-ray

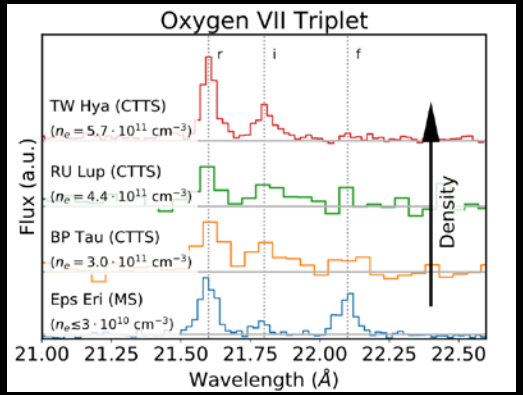
- NICER observations of TW Hya (PI: M. Günther) – approved
- Chandra observations of TW Hya (PI: M. Günther) – approved
- XMM-Newton observations of subset (PI: C. Schneider) – proposed

HERA: High-Energy Radiation from Accretion in young stars

PI: Christian Schneider

System	M ($M_\odot$)	d (pc)	P_{rot} (d)	Typical $\dot{M}$ (log $M_\odot$/yr)	Disk incl. (°)	Archival X-ray grating data	t_{exp} (ks) (per epoch)	(total)
TW Hya	0.7	60	4.7	a few 10^{-9}	7	Chandra/XMM	Approved Chandra	
RU Lup	0.7	160	3.7	1.8×10^{-8}	35	XMM	42.0	220.0
BP Tau	0.8	129	7.6	3×10^{-8}	39	Chandra/XMM	36.1	180.5
GM Aur	0.8	160	6.1	10^{-8}	55	XMM	46.3	231.5

Proposal submitted



From C. Schneider

Supplementary data from ODYSSEUS team

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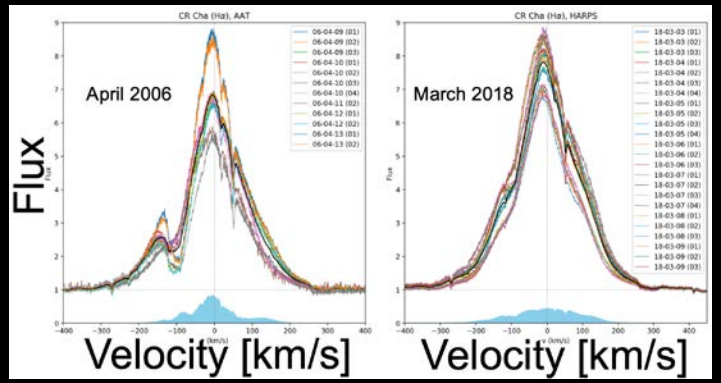
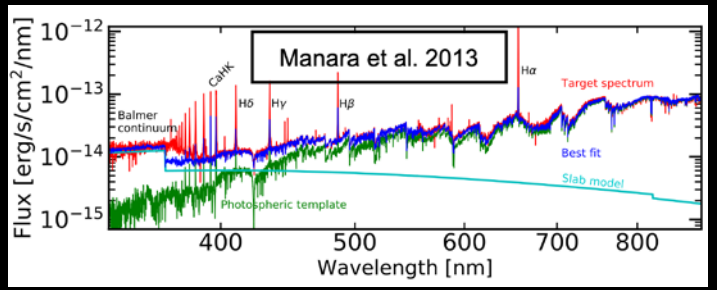
Optical/near-IR Spectroscopy

- VLT/X-Shooter, UVES, ESPRESSO (PI: C. Manara) – approved

PENELLOPE: the ESO data legacy program to complete the Hubble UV Legacy Library of Young Stars (ULLYSES)

PI: Carlo Manara





<u>High-resolution spectroscopy: 3 x target</u>

- Bright targets: ESPRESSO, 380–788 nm
- Faint targets: UVES, ~300-1100 nm

<u>Medium-resolution spectroscopy: 1 x target</u>

- X-Shooter, ~320-2500 nm

<u>Scientific goals:</u>

- Emission line kinematics and variability for accretion and winds
- Accurate estimate photospheric parameters
- Metallicity estimates
- Balmer continuum and IR emission lines tracing accretion and winds

From C. Manara

Supplementary data from ODYSSEUS team

X-ray

- NICER observations of TW Hya (PI: M. Günther) – approved
- Chandra observations of subset (PI: M. Günther) – approved
- XMM-Newton observations of subset (PI: C. Schneider) – proposed

Optical/near-IR Spectroscopy

- VLT/X-Shooter, UVES, ESPRESSO (PI: C. Manara) – approved
- GIARPS/HARPS-N+GIANO (PI Alcala) – pilot program approved
- IRTF (PI: W. Fischer) – approved
- CFHT/ESPaDOnS and SPIRou of subset – proposed and Legacy proposal

Optical Photometry

- LCOGT u'Vi – supported by STScI
- Konkoly RC80, SAAO, DFOT, AZT-11/FLI PL-230, Thai National telescopes, Catania 0.91m, McDonald, and other small telescopes

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1. How does the shock depend on the accretion rate and magnetic structures, which in turn depend on the mass of the star?
2. How and where are winds launched, and how do those mass loss rates compare to mass lost in large scale collimated jets and to accretion?
3. What is the structure of the innermost regions, and how does it filter the chemistry-driving UV radiation incident on the disk, which alters the composition of forming planetary systems?

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