

Accretion and Circumplanetary Disk Properties of a Wide Orbit Planet with HST and JWST

Claire Finley

The University of Texas at Austin; University of California, Santa Barbara

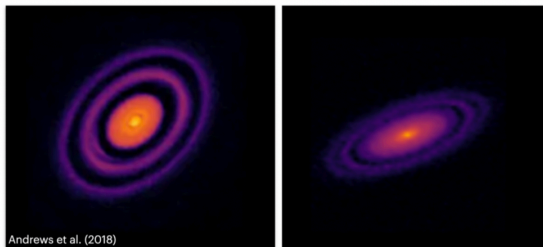
Collaborators: **Brendan Bowler**, Ya-Lin Wu, Adam Kraus, Yifan Zhou, Yuhiko Aoyama, William Best, Ian Czekala, Catherine Espaillat, Katherine Follette, Raquel Martinez, Connor Robinson, Quang Tran, Kimberly Ward-Duong

How and when do giant planets form?



Core accretion

e.g. Pollack et al. (1996),
Lambrechts & Johansen (2012)



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<0.1 AU

0.1-1 AU

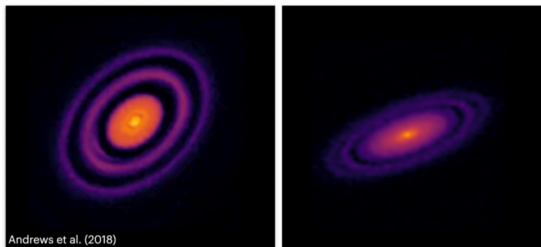
1-10 AU

10-100 AU

>100 AU

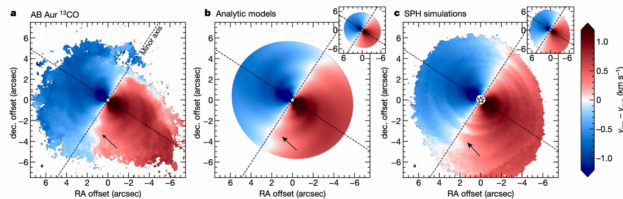
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Gravitational/disk instability

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Speedie et al. (2024)

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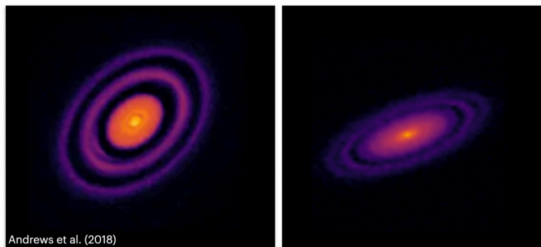
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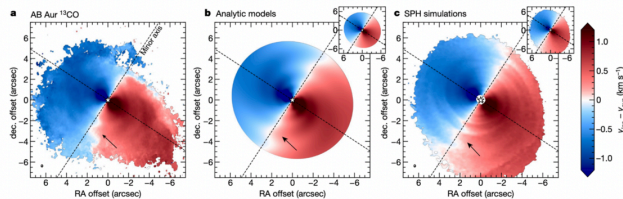
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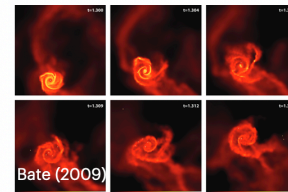
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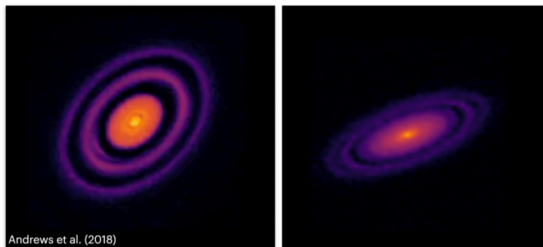


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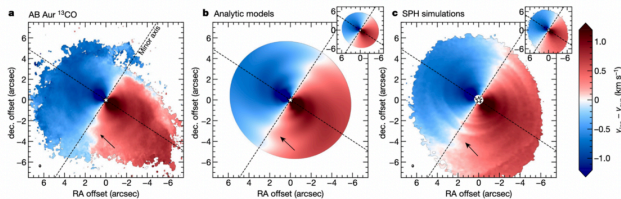
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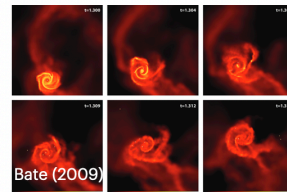
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Mass transfer is facilitated by a circumplanetary disk (CPD)

This program will place the first population-level constraints on accretion and circumplanetary disk properties

Motivation:

- ~50% of wide companions show signs of CPDs, yet many basic properties remain poorly constrained (Bowler+2017, Martinez+2022)

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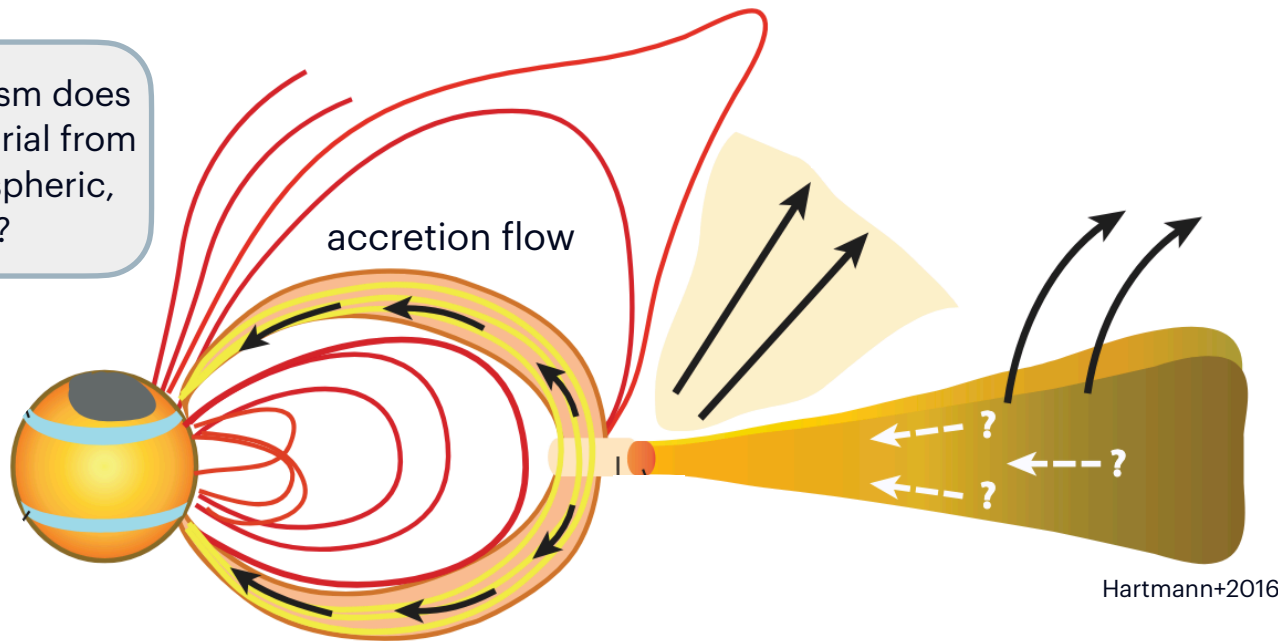
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- Our photometric program will be used to calibrate CPD properties to allow follow-up with higher resolution, e.g. MIRI/MRS

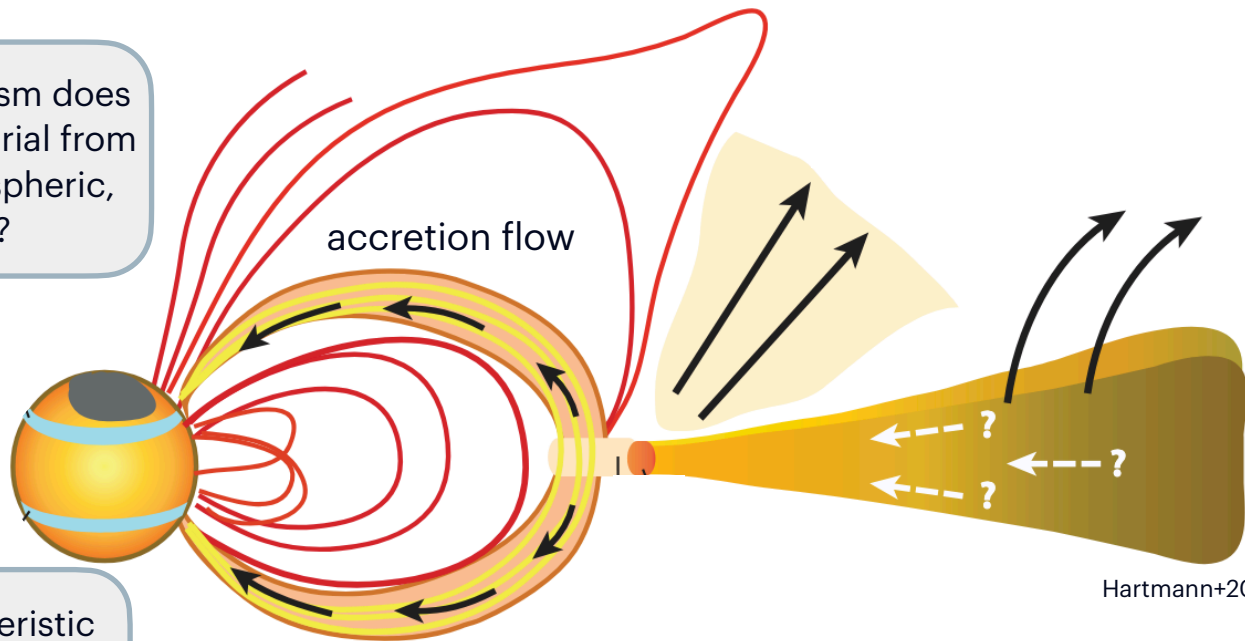
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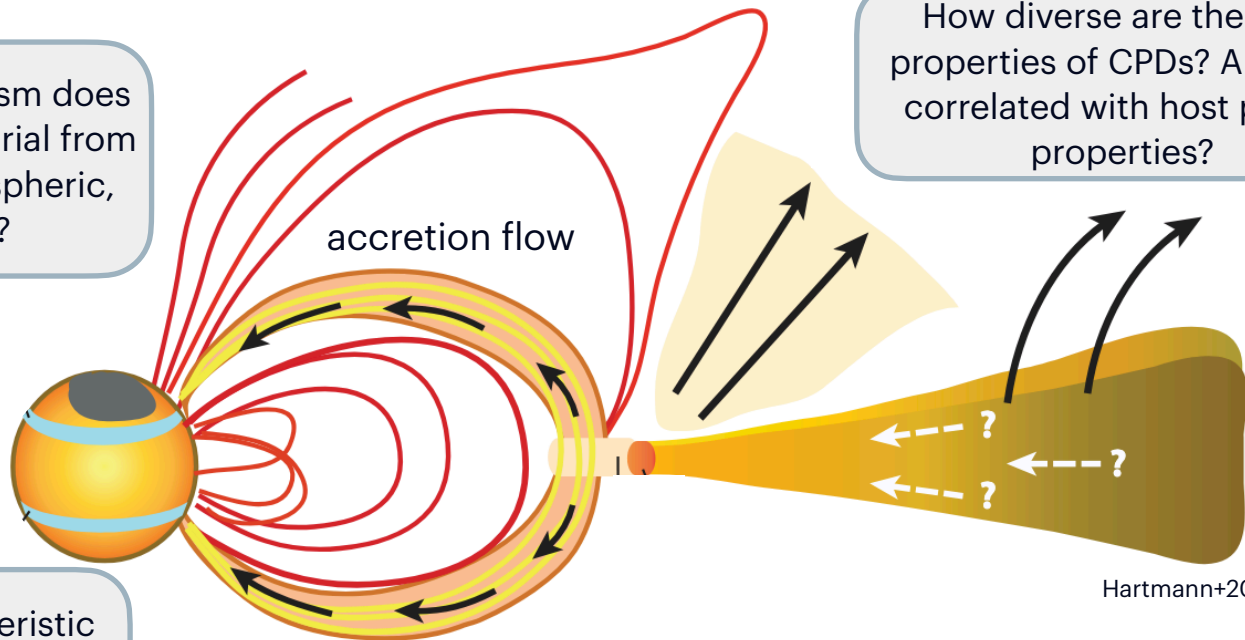


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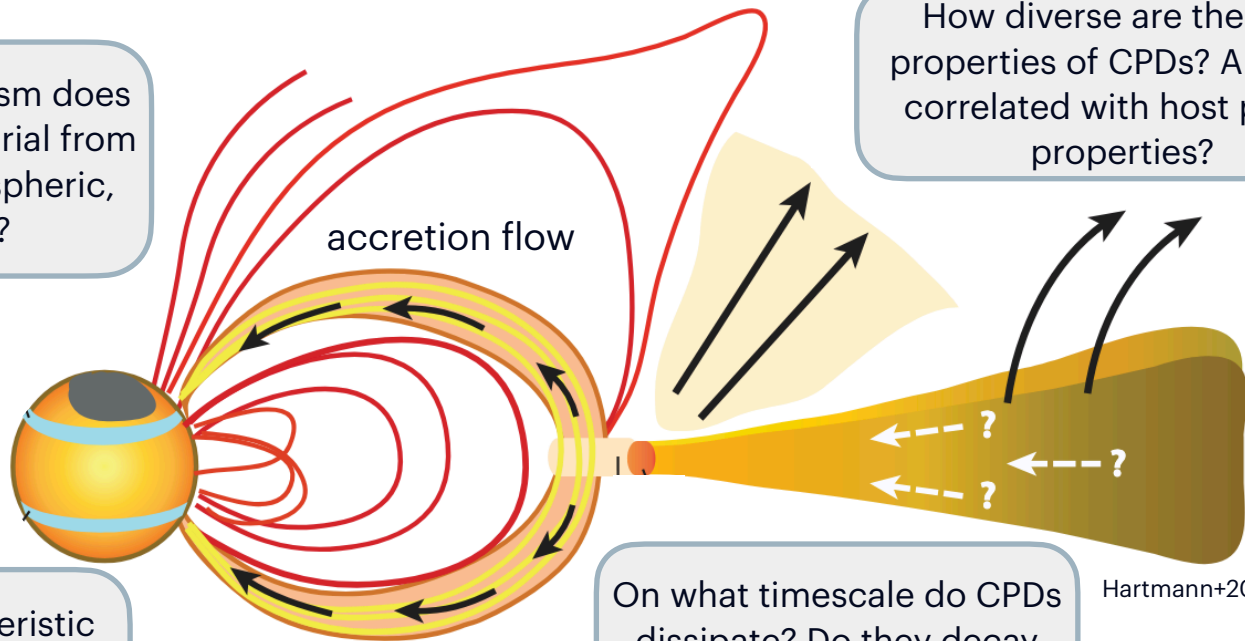
How diverse are the bulk properties of CPDs? Are they correlated with host planet properties?



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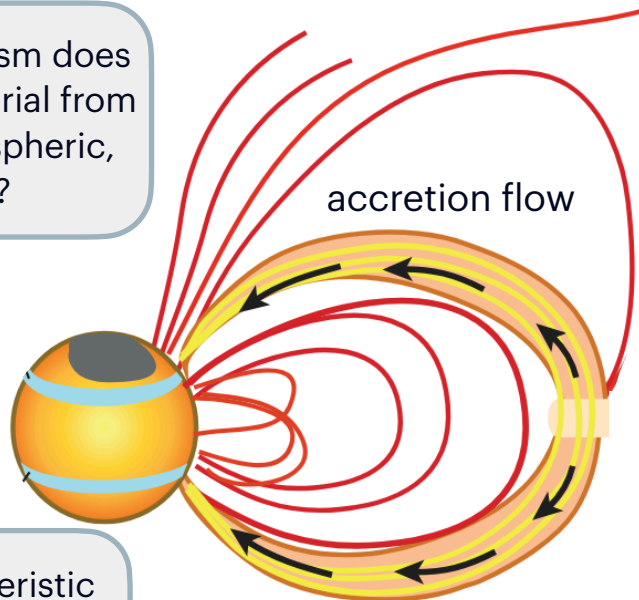
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On what timescale do CPDs dissipate? Do they decay similarly to stellar disks?

Hartmann+2016

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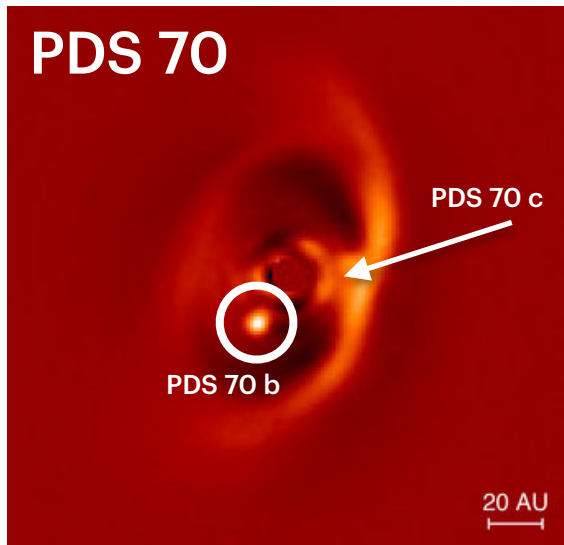
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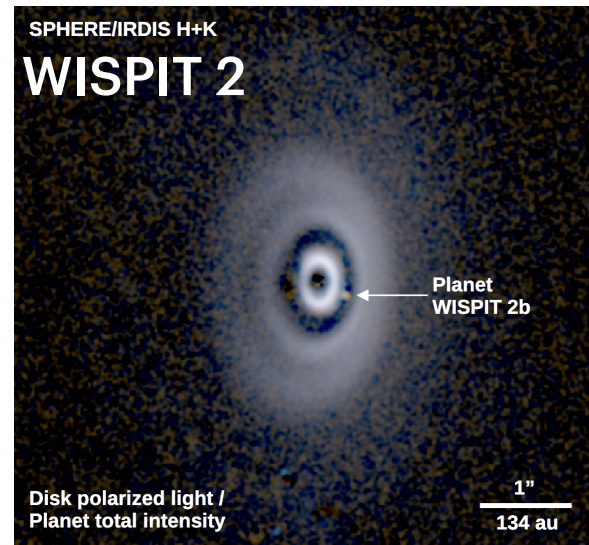
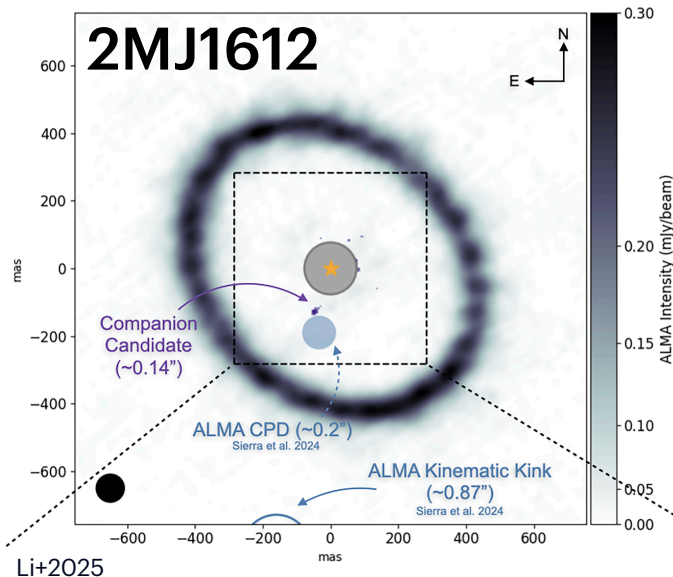
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Accreting protoplanets are windows into mass transfer during planet formation

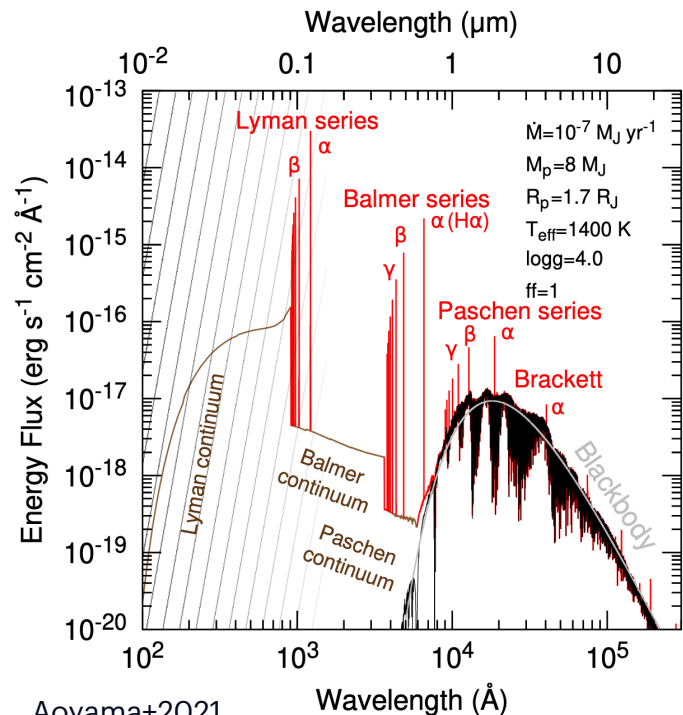


Credit: ESO/A. Müller, MPIA
Keppler+2018, Haffert+2019

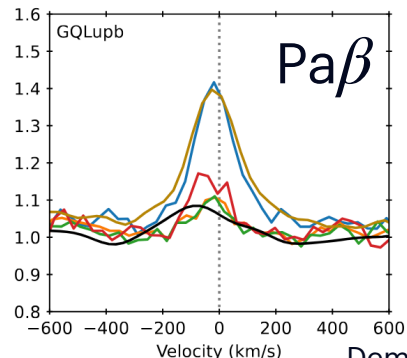


van Capelleveen+2025
Close+2025

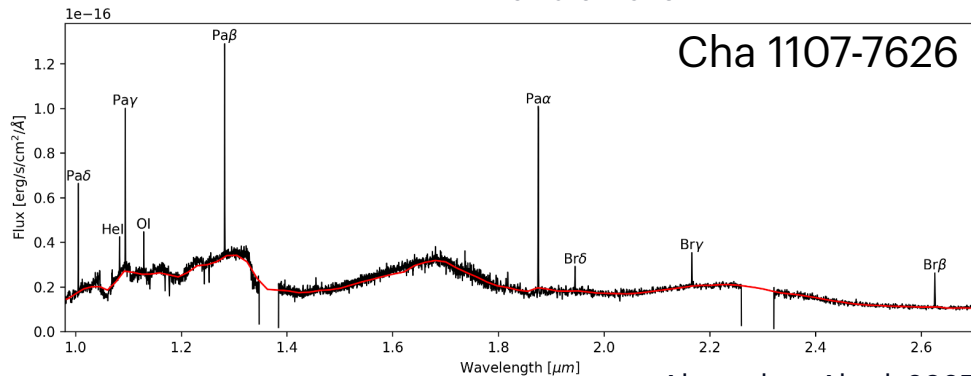
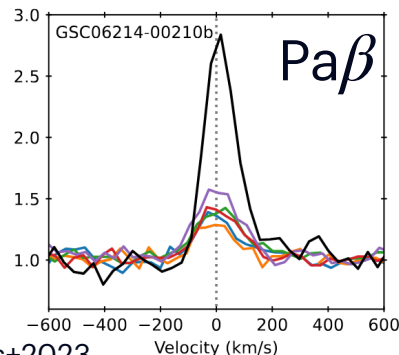
Accretion is traced by UV continuum excess and hydrogen emission lines



Aoyama+2021
(model spectrum)



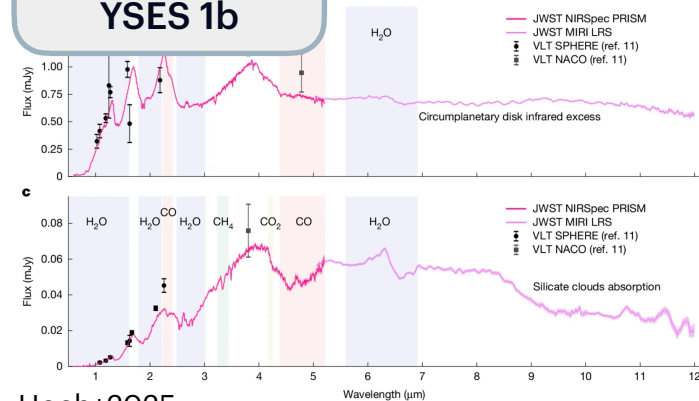
Demars+2023



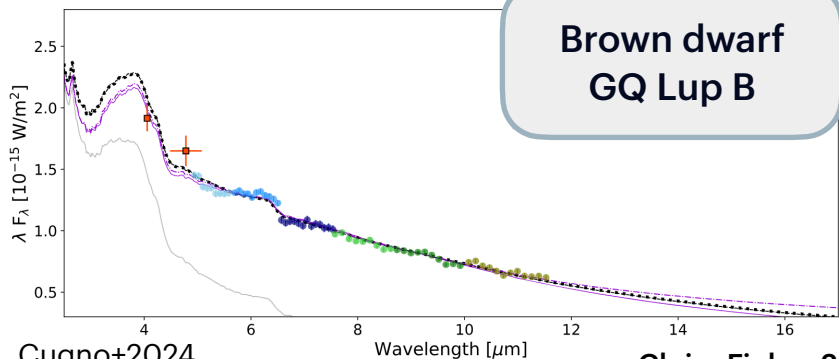
Almendros-Abad+2025

Mid-IR excess offers a way to study warm dust in circumplanetary disks

PMC
YSES 1b



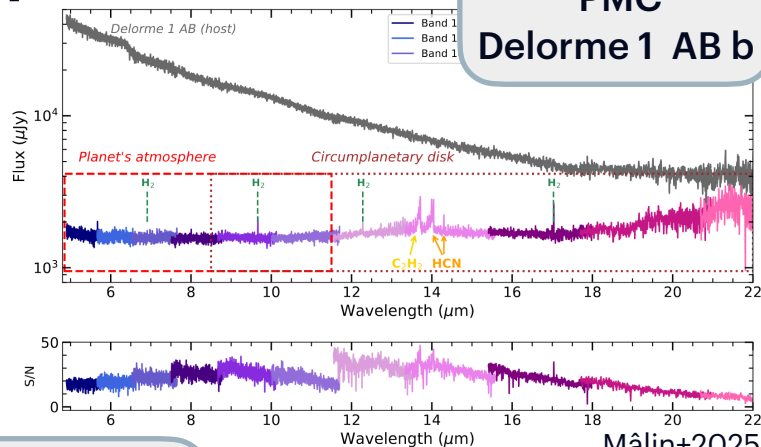
Hoch+2025



Brown dwarf
GQ Lup B

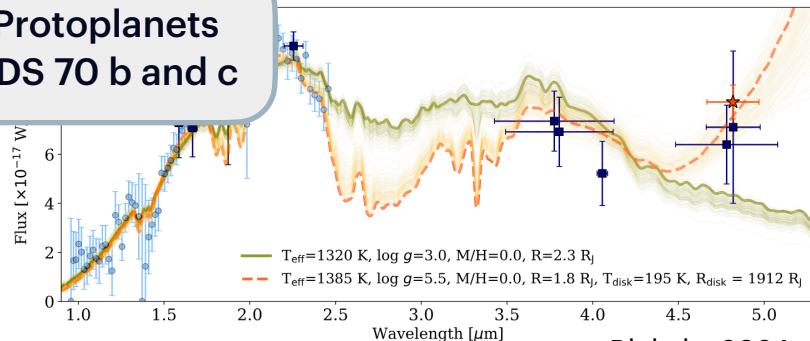
Cugno+2024

PMC
Delorme 1 AB b



Mâlin+2025

Protoplanets
PDS 70 b and c



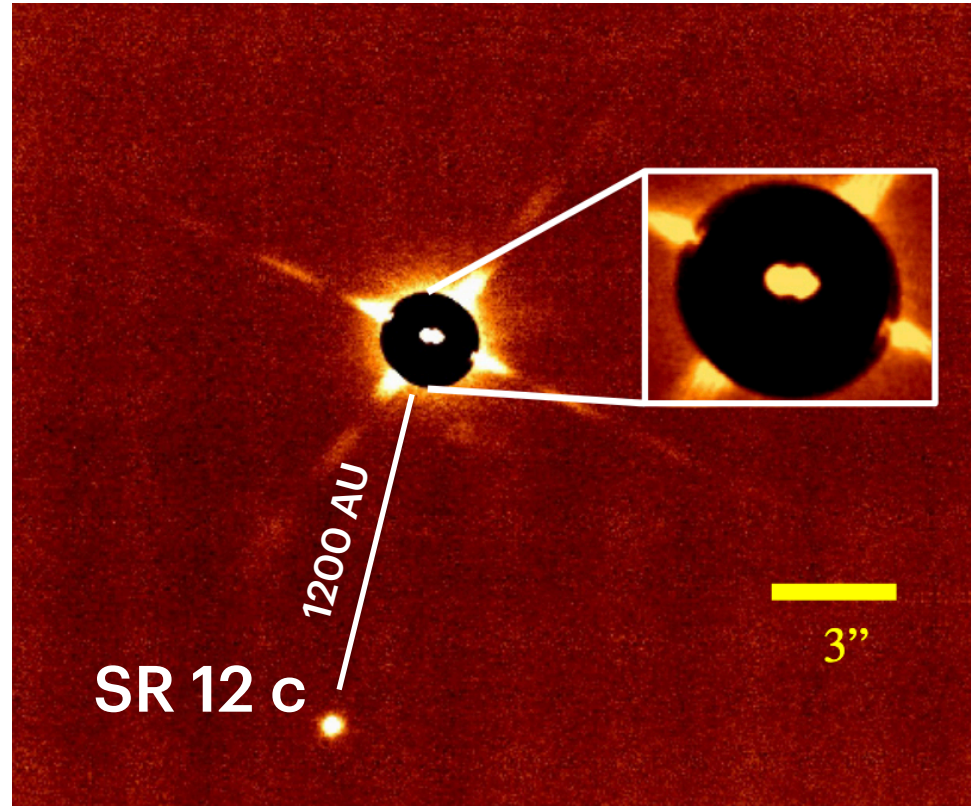
Blakely+2024 7

SR 12 c is a young, accreting, planetary-mass companion

System properties

Age: ~2 Myr

Kuzuhara+2011 Ortiz-León+2017, Wu+2022, Santamaría-Miranda+2018, Bowler+2014, Wilking+2005, Pecault & Mamajek (2013)



Kuzuhara et al. (2011)

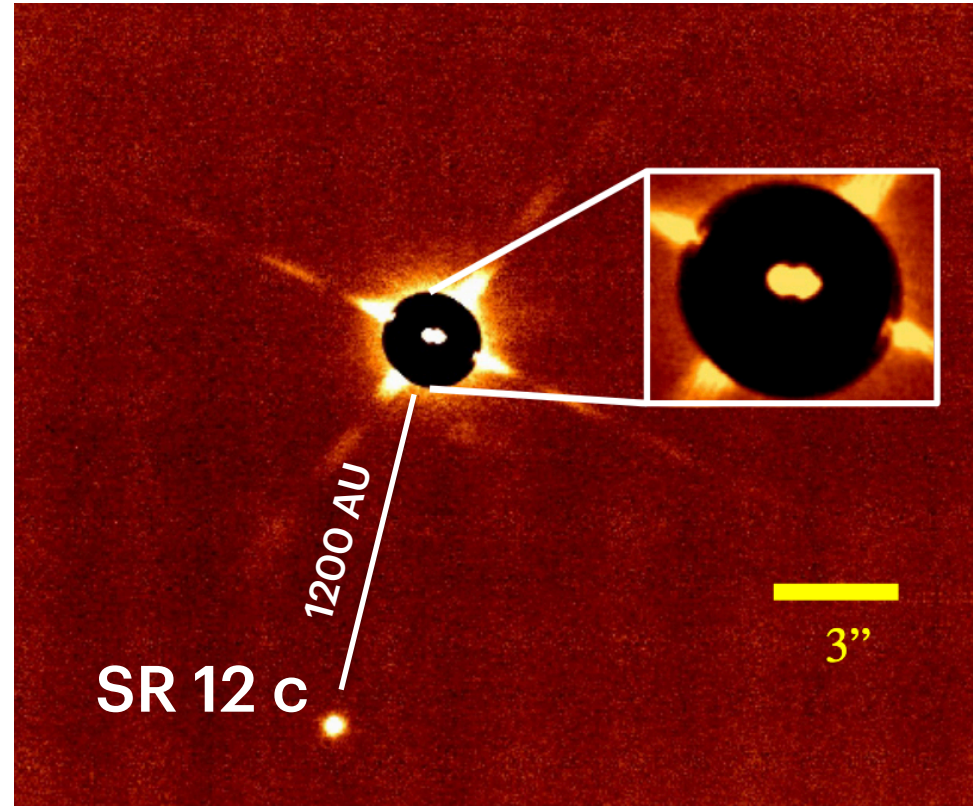
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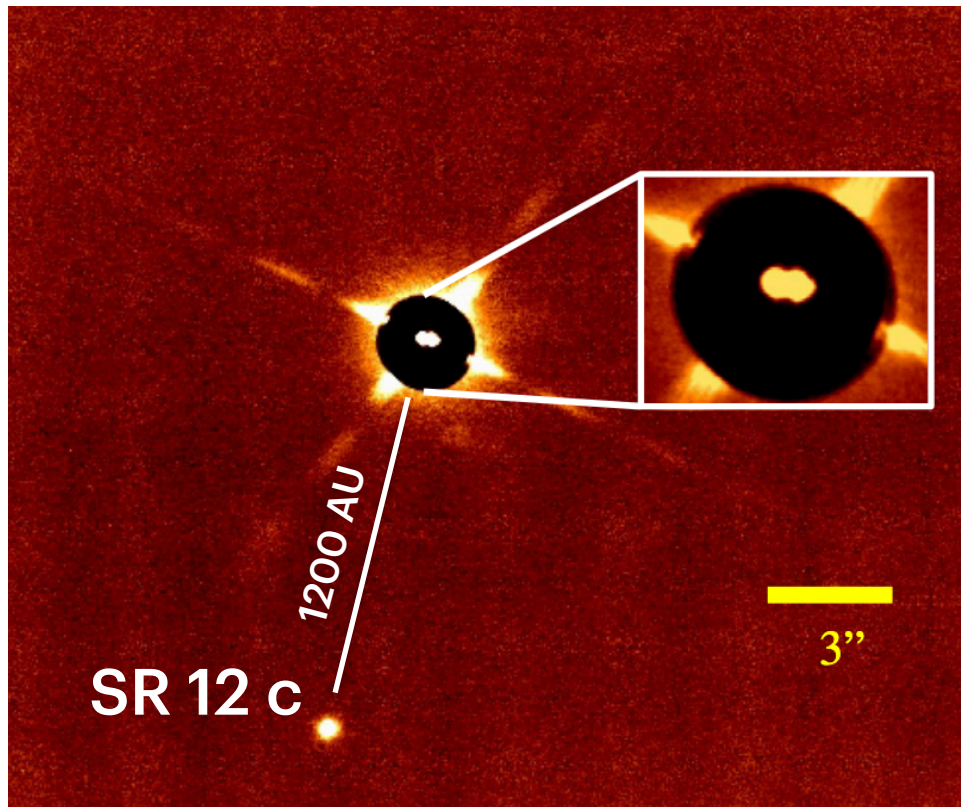
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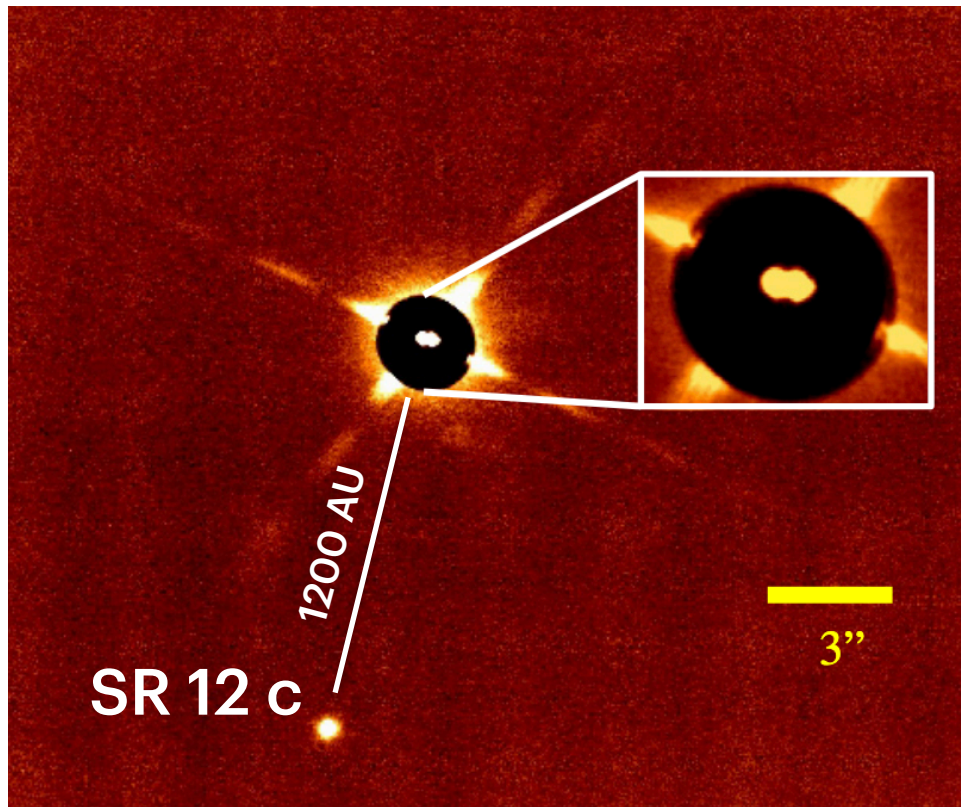
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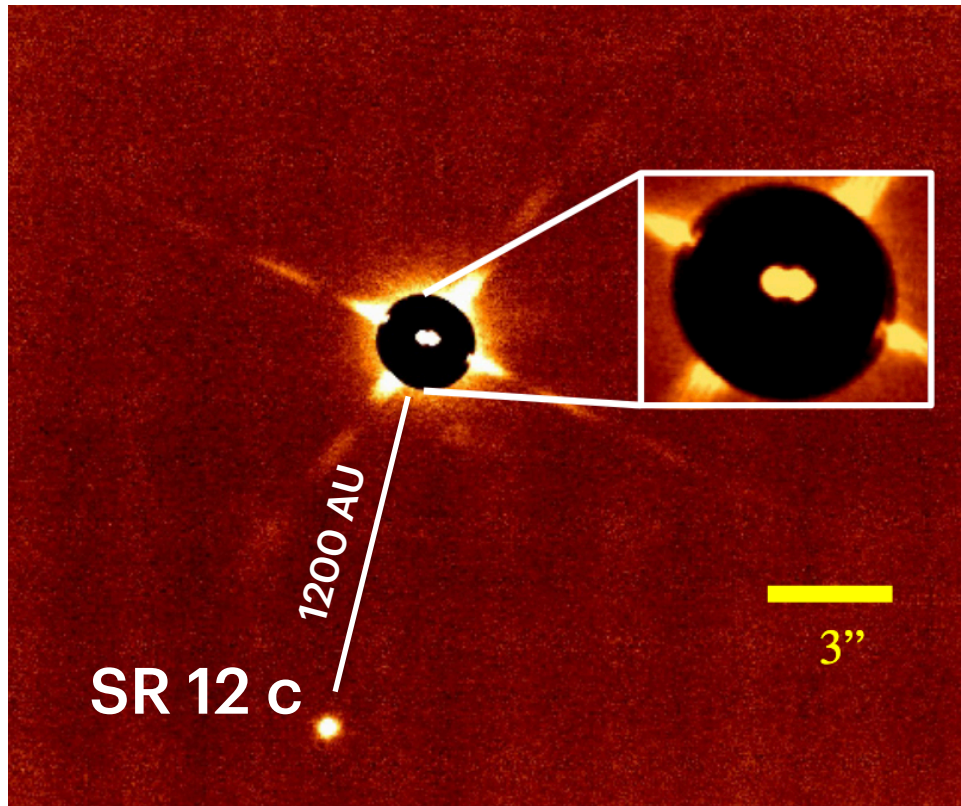
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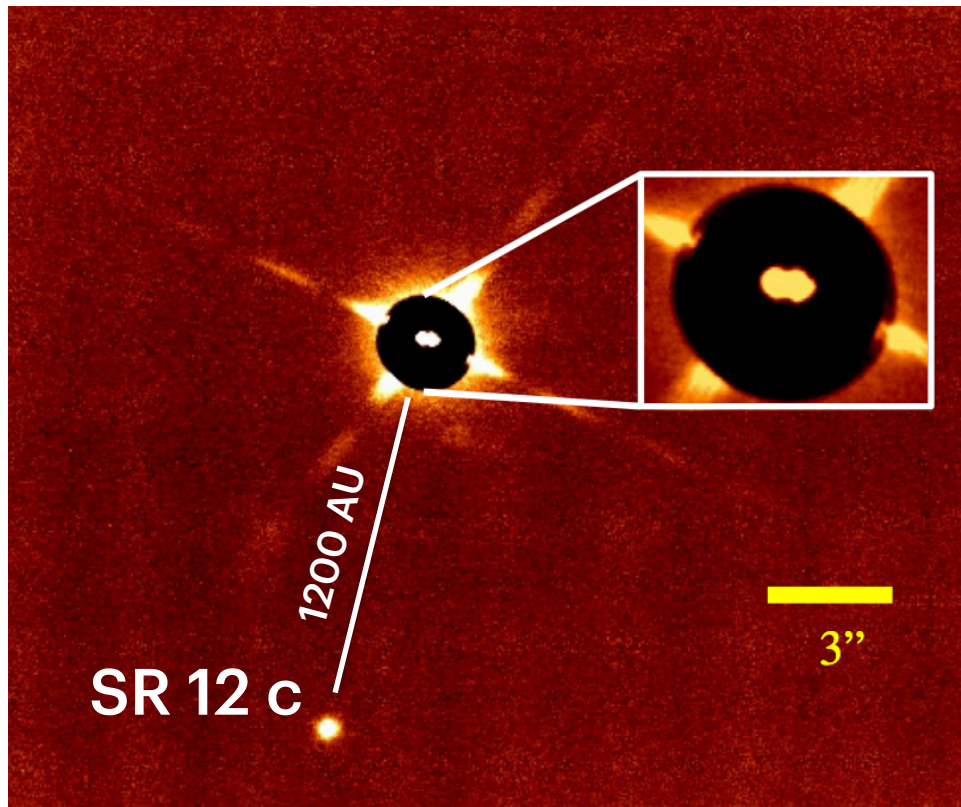
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M_* : ~1.0 and $0.5 M_{\odot}$

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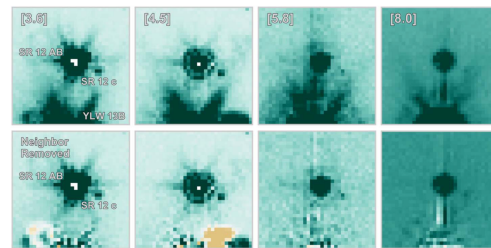
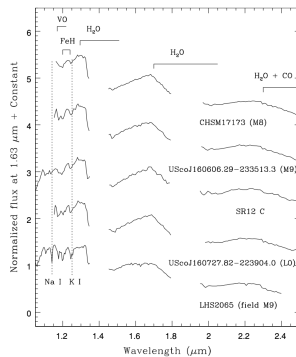
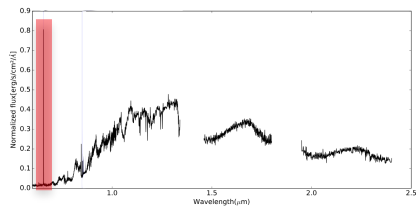
Previous imaging and spectroscopy of SR 12 c



UV

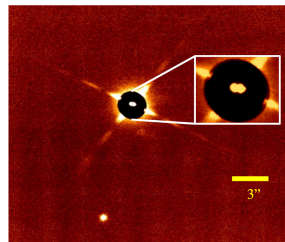
MIR

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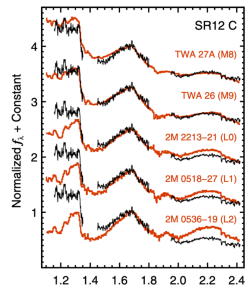


IRSF/Sirius
Kuzuhara+2011

Spitzer/IRAC
Martinez+2022



Subaru/CISCO
Kuzuhara+2011



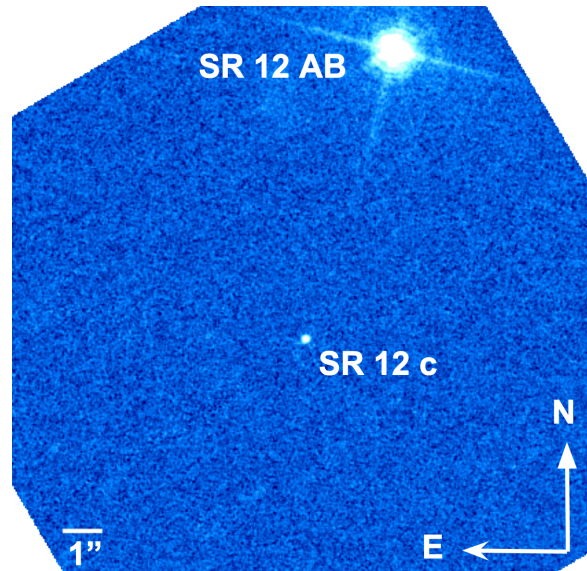
IRTF/Spex
Bowler+2014

VLT/X-shooter
Santamaria-Miranda+2018

UV

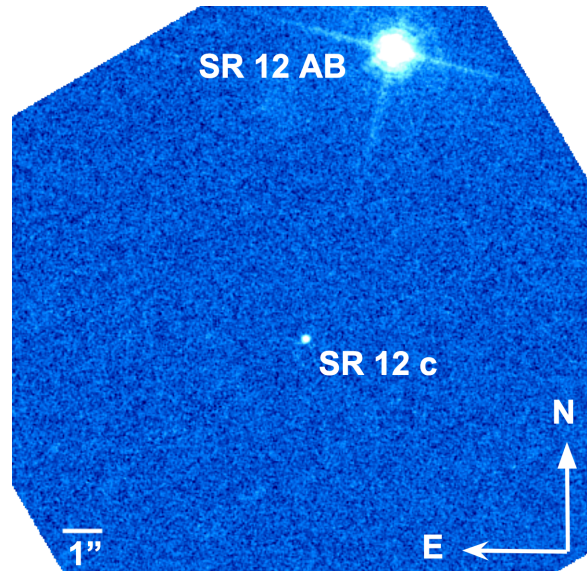
MIR

**New HST/WFC3 imaging from
2200-6600 Å shows
continuum and emission line
accretion signatures**

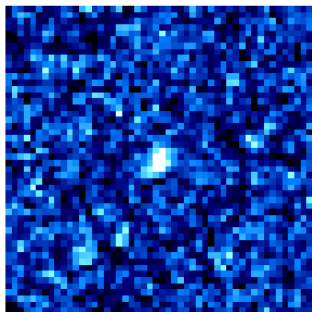


New HST/WFC3 imaging from 2200-6600 Å shows continuum and emission line accretion signatures

Finley+(in prep.)

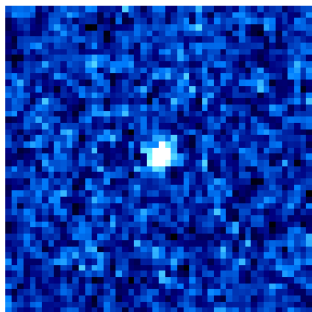


F225W

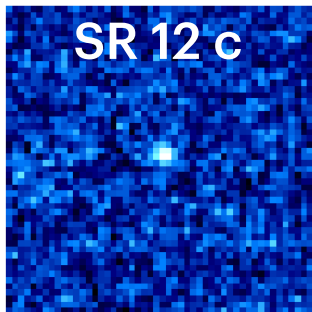


GO 16203

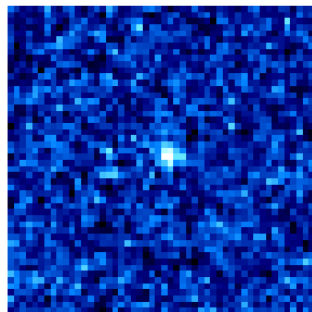
F336W



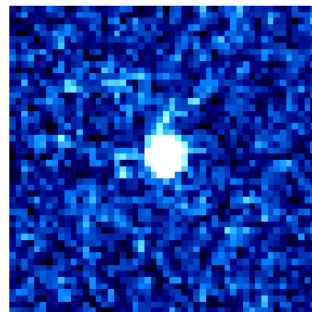
F438W



F555W

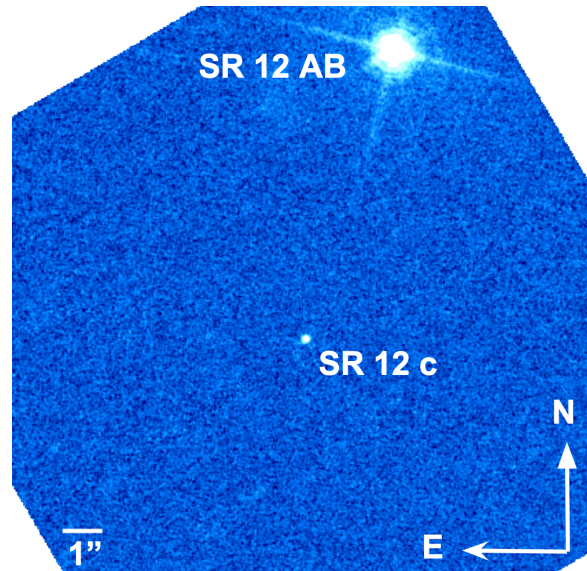


F656N

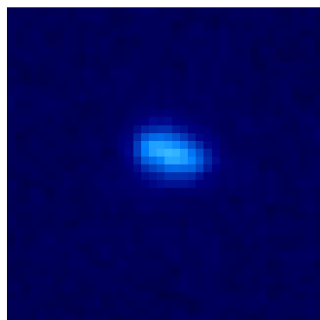


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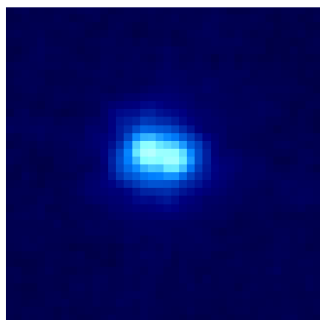


F225W

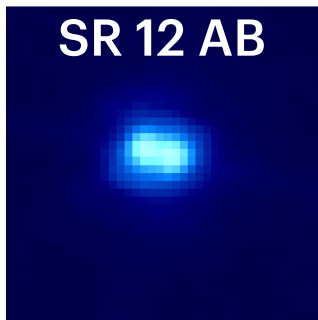


GO 16203

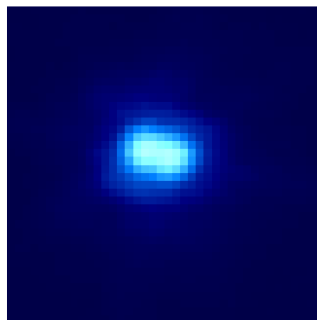
F336W



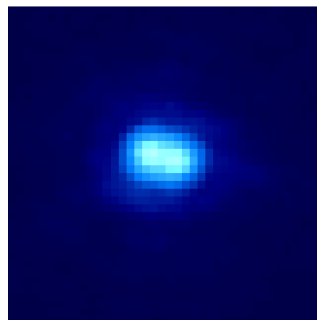
F438W



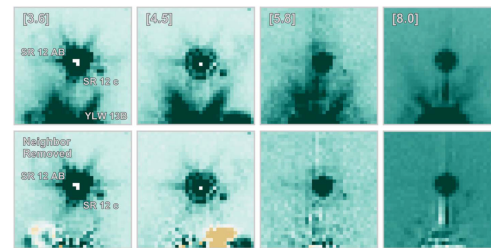
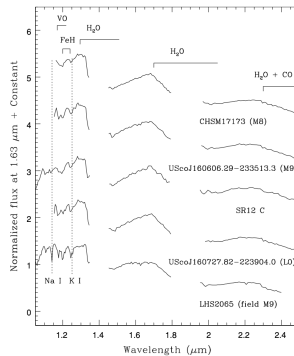
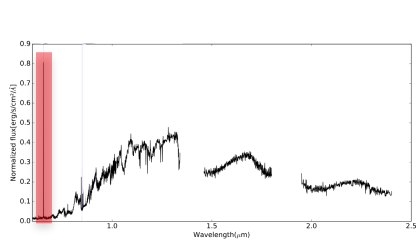
F555W



F656N



Previous imaging and spectroscopy of SR 12 c



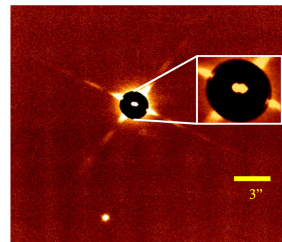
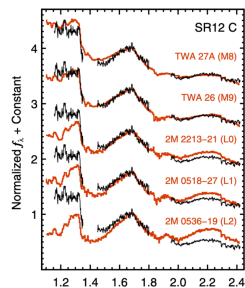
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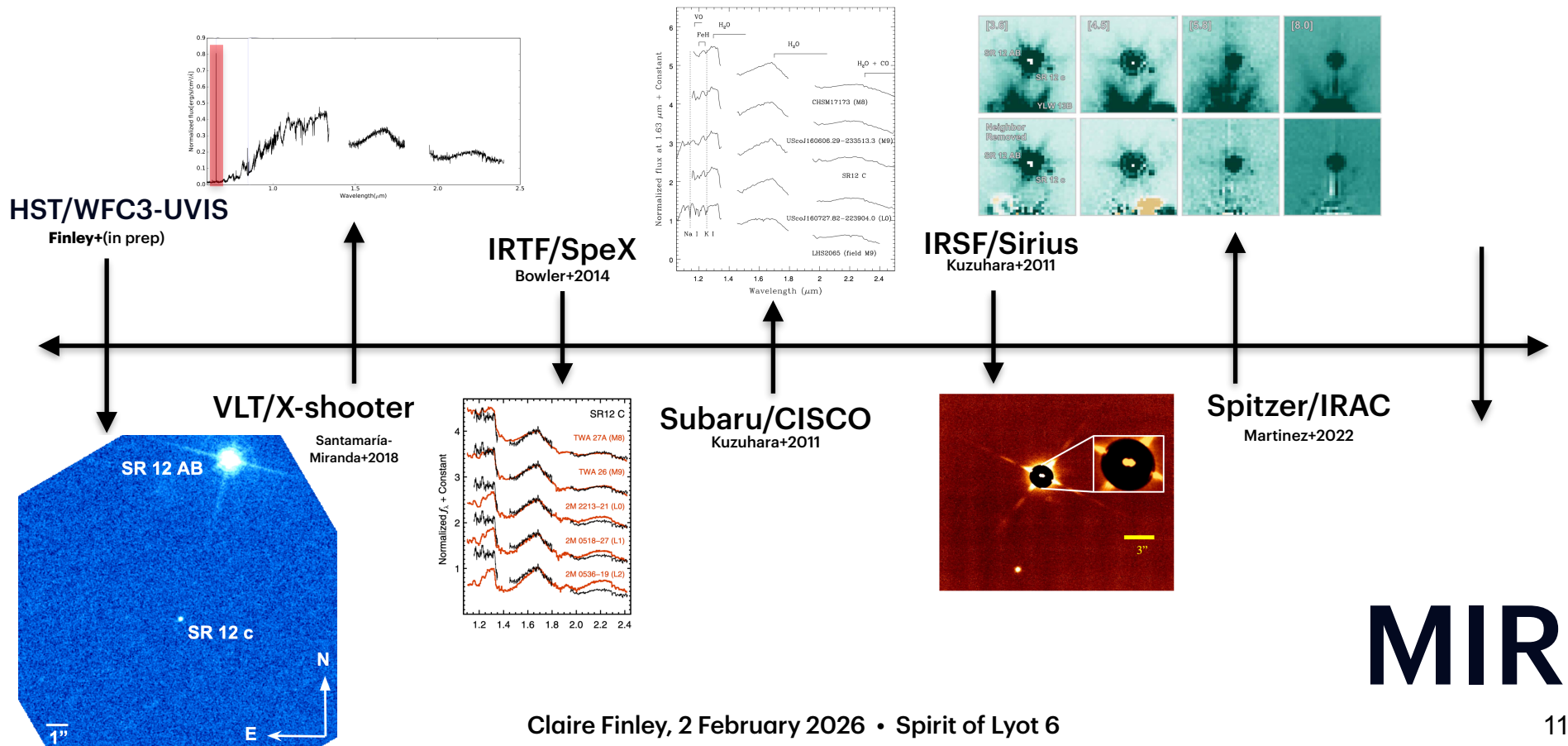
Spitzer/IRAC
Martinez+2022



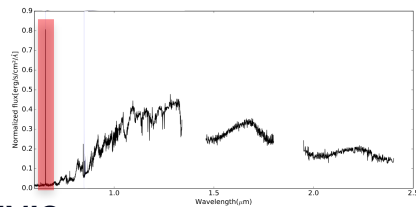
UV

MIR

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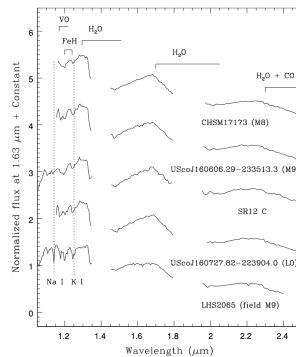


Previous imaging and spectroscopy of SR 12 c



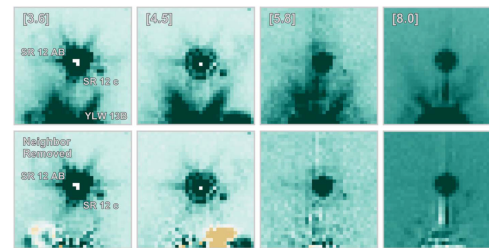
HST/WFC3-UVIS

Finley+(in prep)



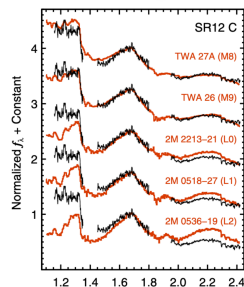
IRTF/SpeX

Bowler+2014



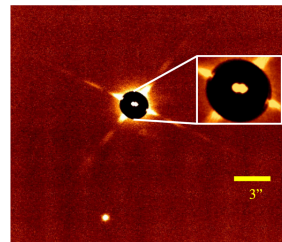
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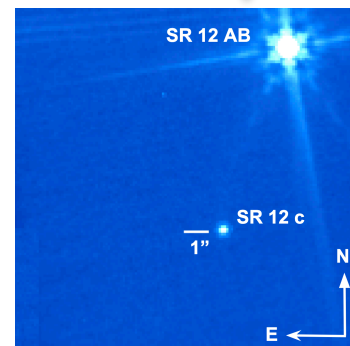


Subaru/CISCO

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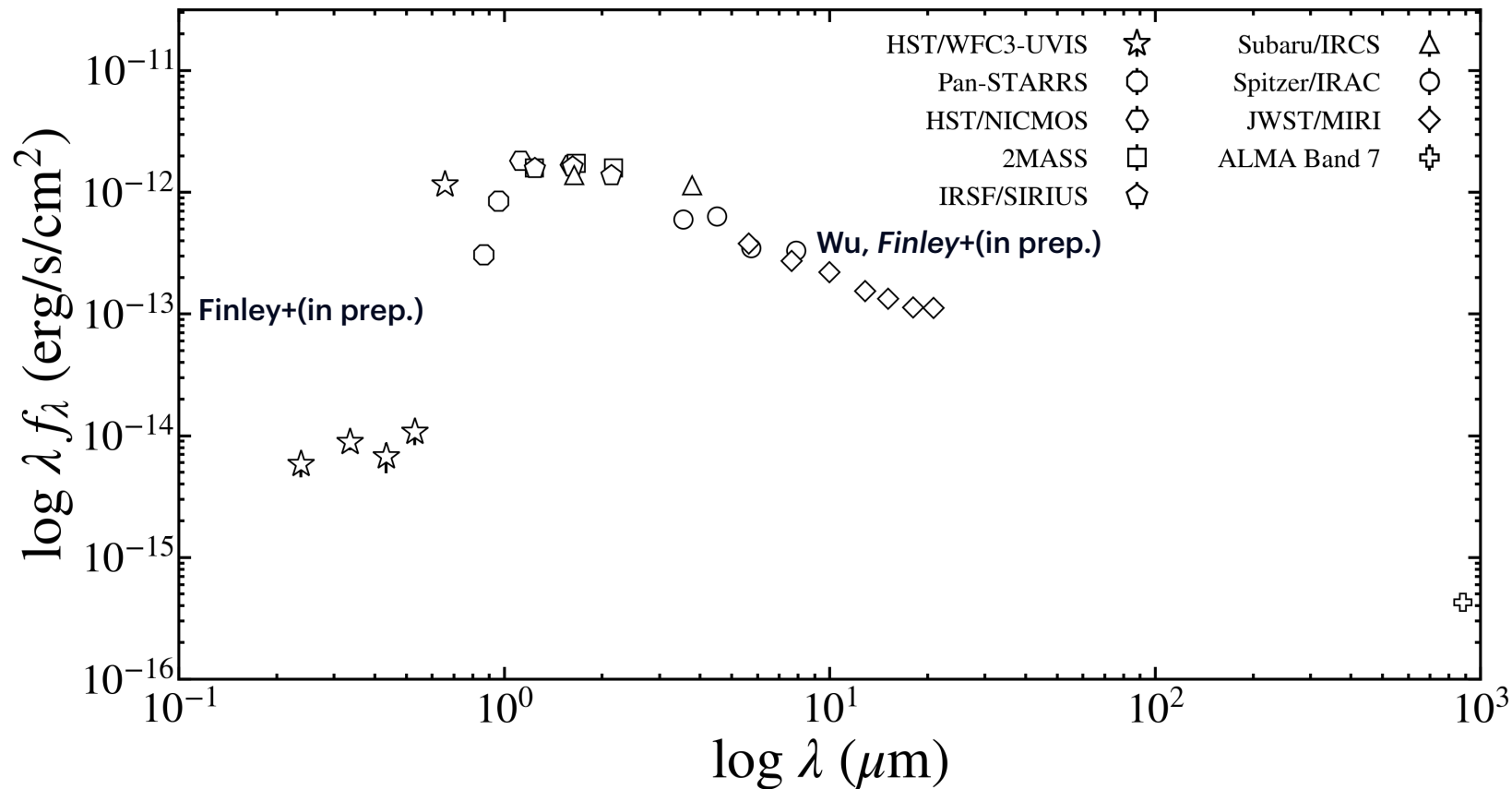
Spitzer/IRAC

Martinez+
2022

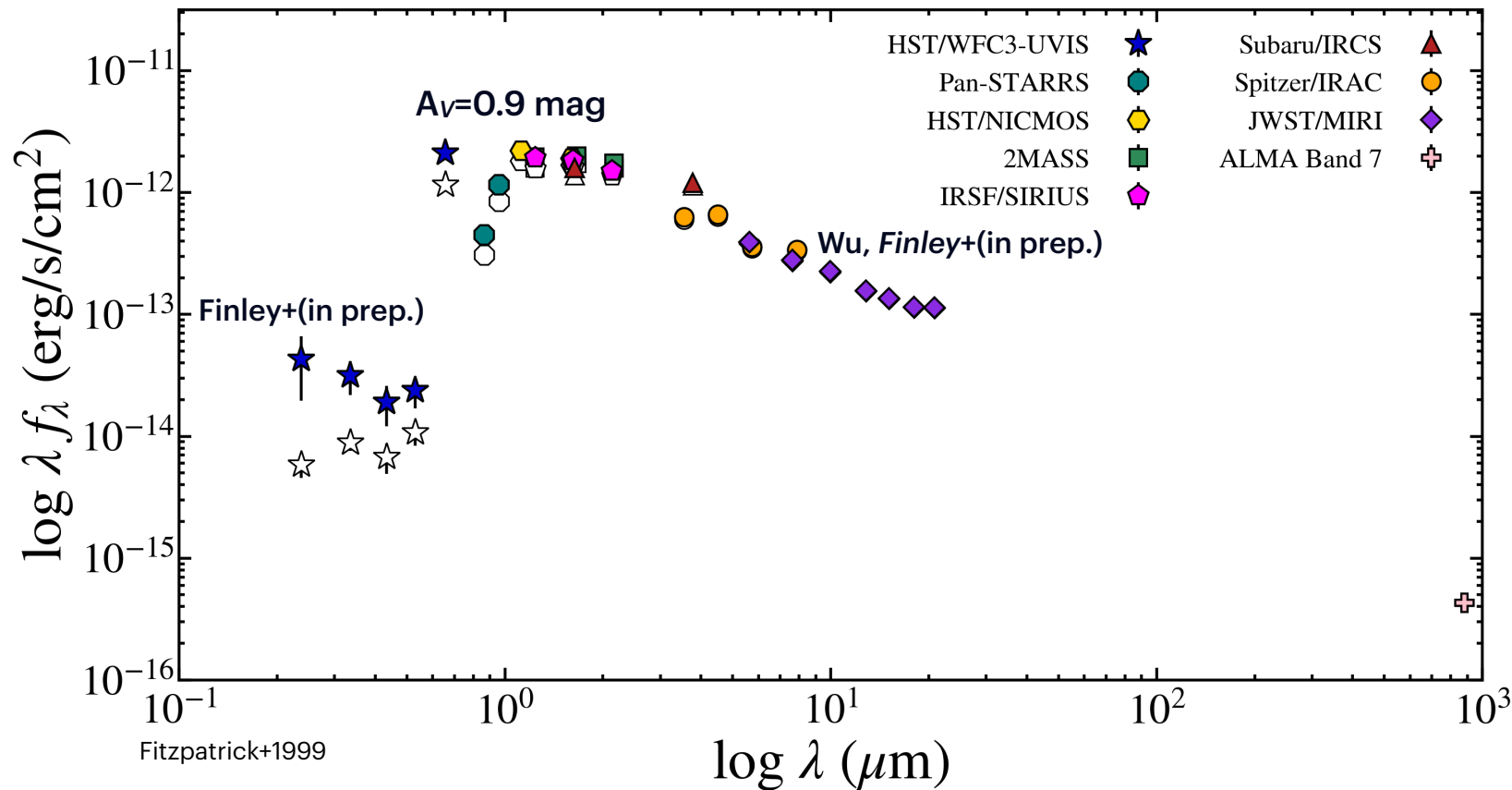
JWST/MIRI

Wu, Finley+(in prep)

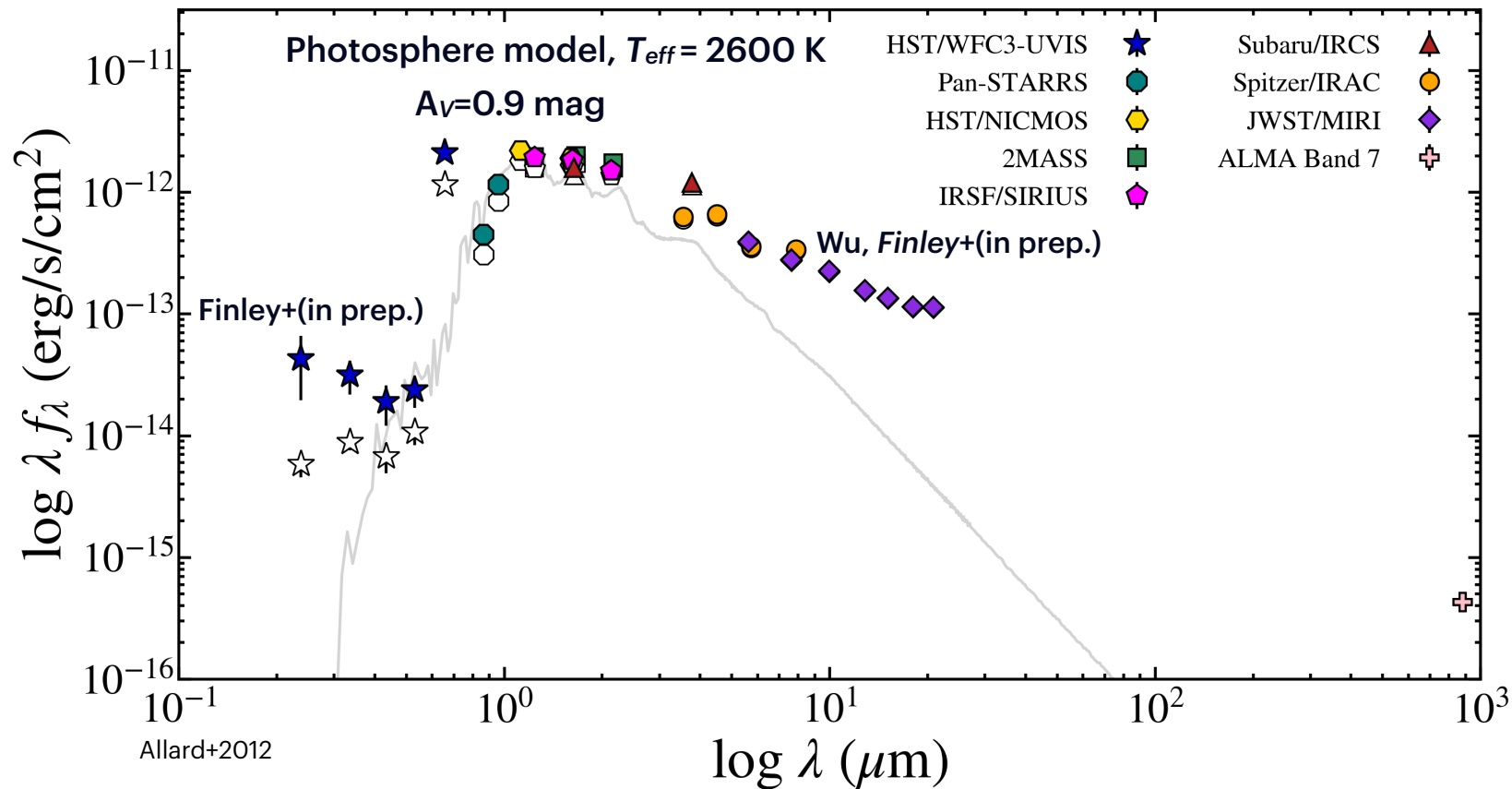
The UV through sub-mm SED of SR 12 c



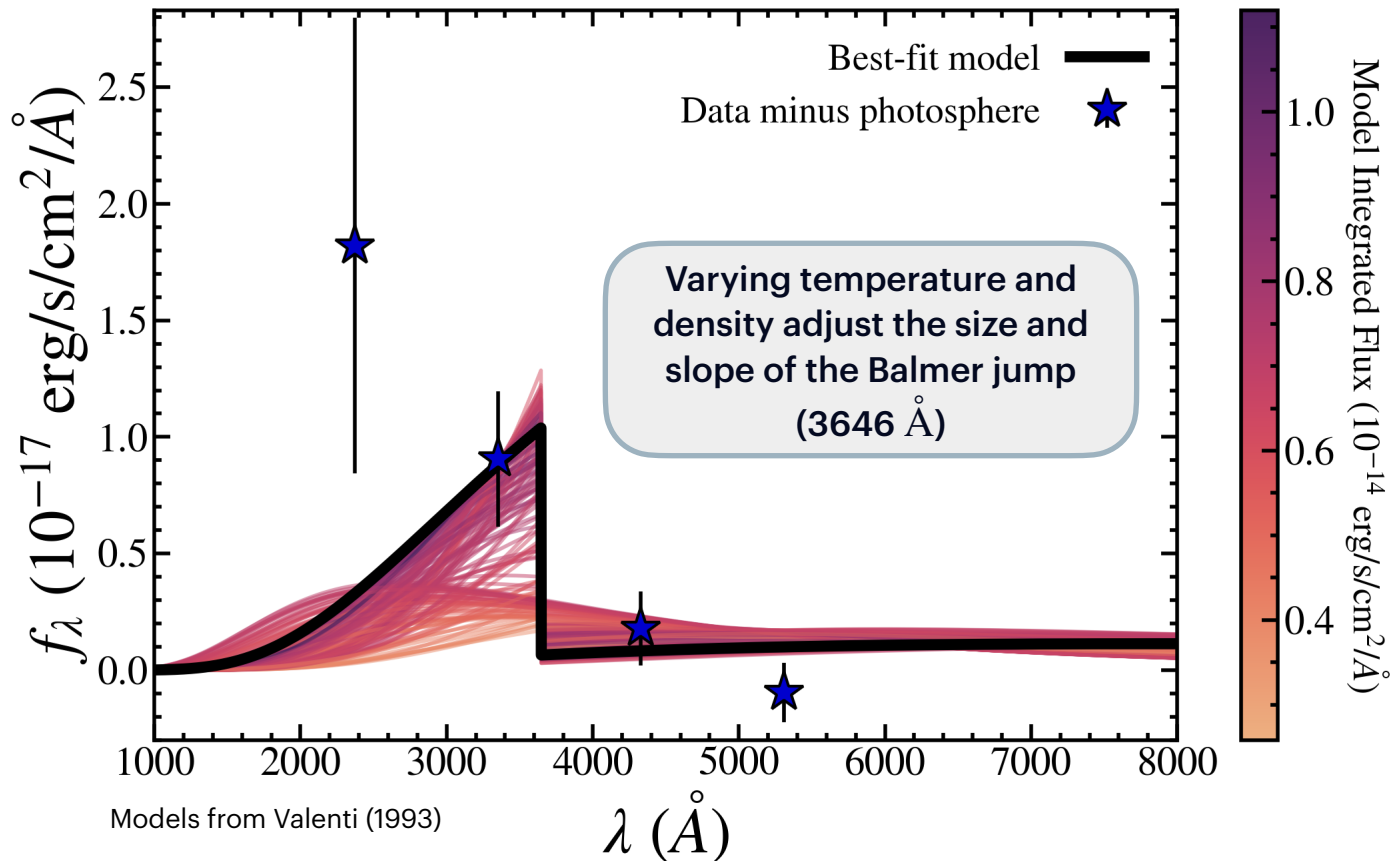
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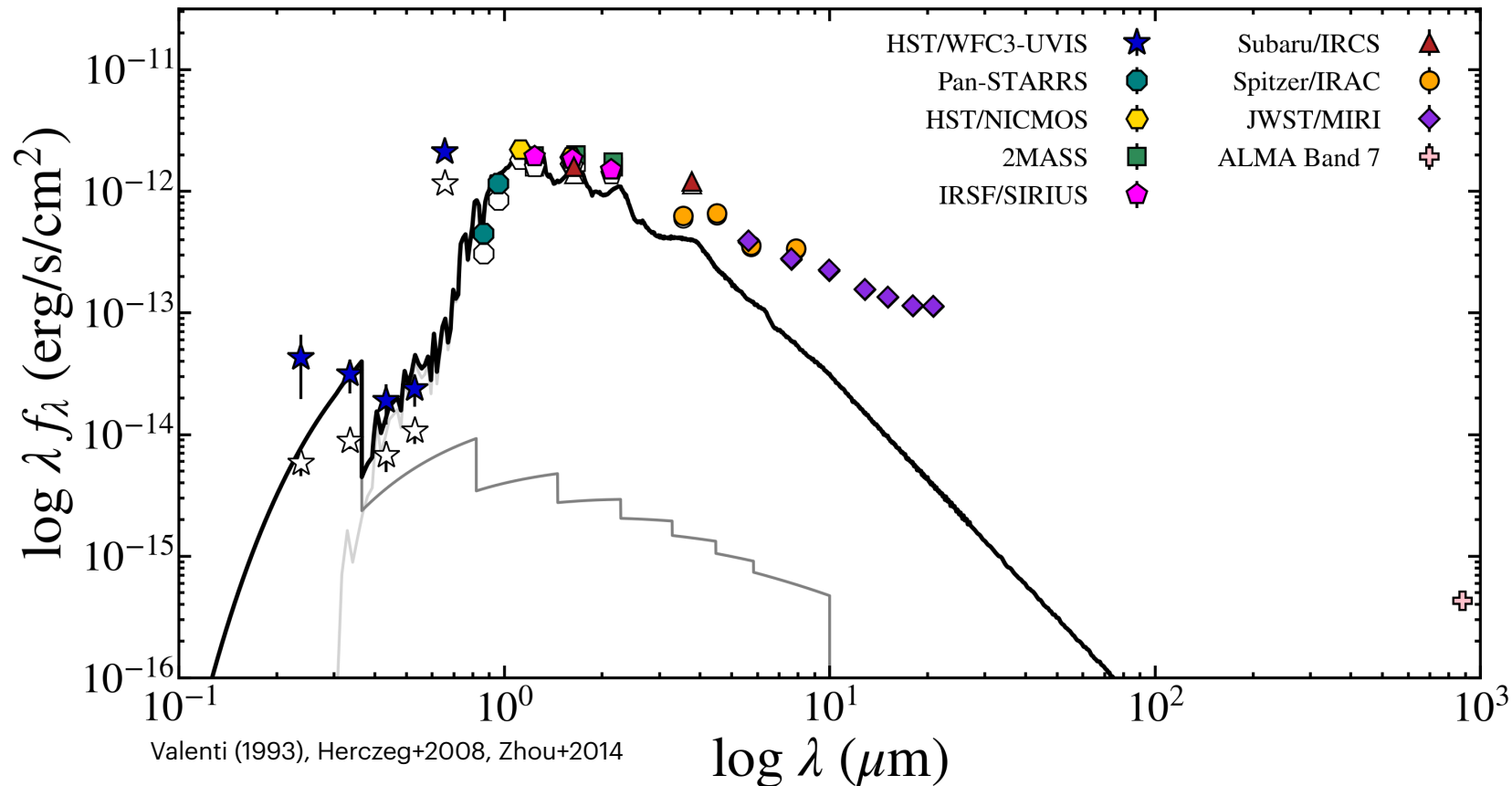
The UV through sub-mm SED of SR 12 c



Fitting hydrogen slab models to the Balmer break



Slab+photosphere models quantify accretion properties



From UV excess to mass accretion rate

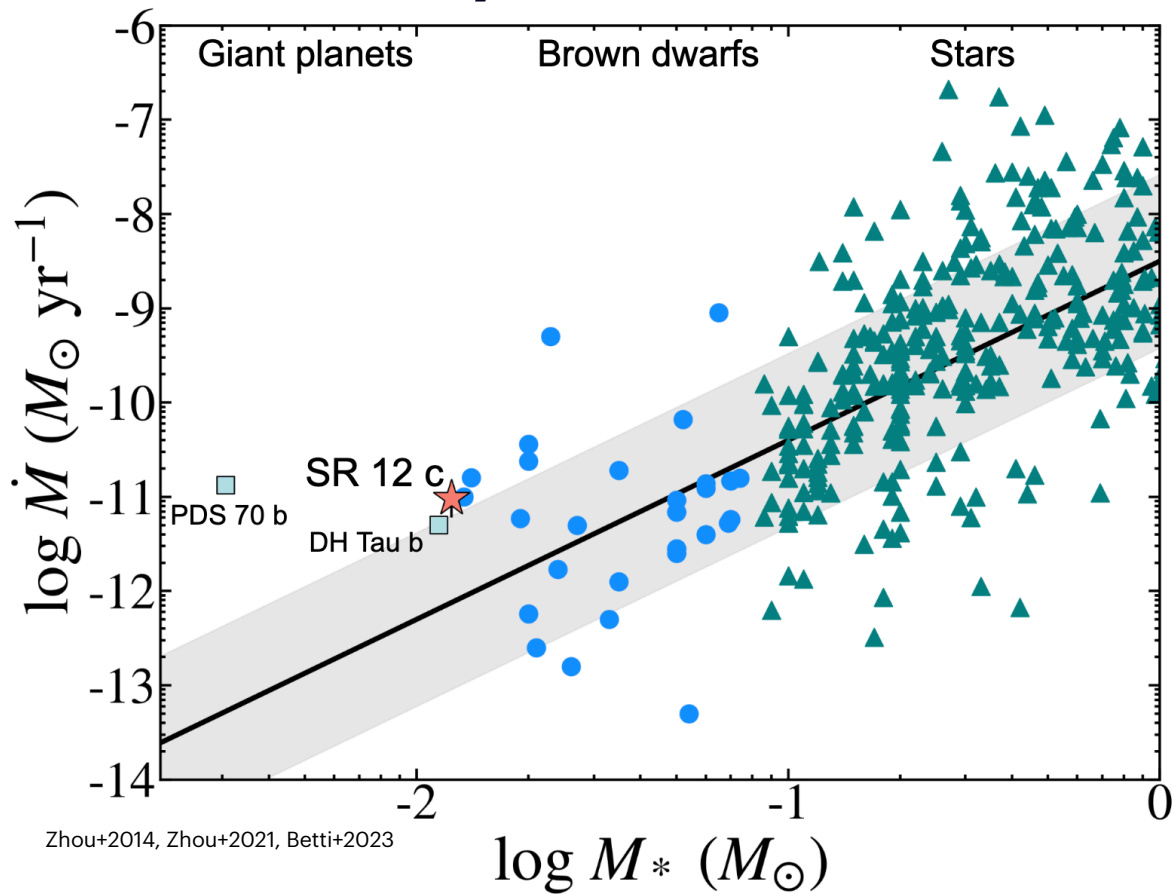
<i>Continuum accretion luminosity ($L_{\odot}$)</i>	<i>$H\alpha$ line accretion luminosity ($L_{\odot}$)</i>	<i>Total accretion luminosity ($L_{\odot}$)</i>	<i>Mass accretion rate ($M_{\odot} \text{ yr}^{-1}$)</i>
1.3×10^{-5}	3.3×10^{-6}	1.7×10^{-5}	1.0×10^{-11}

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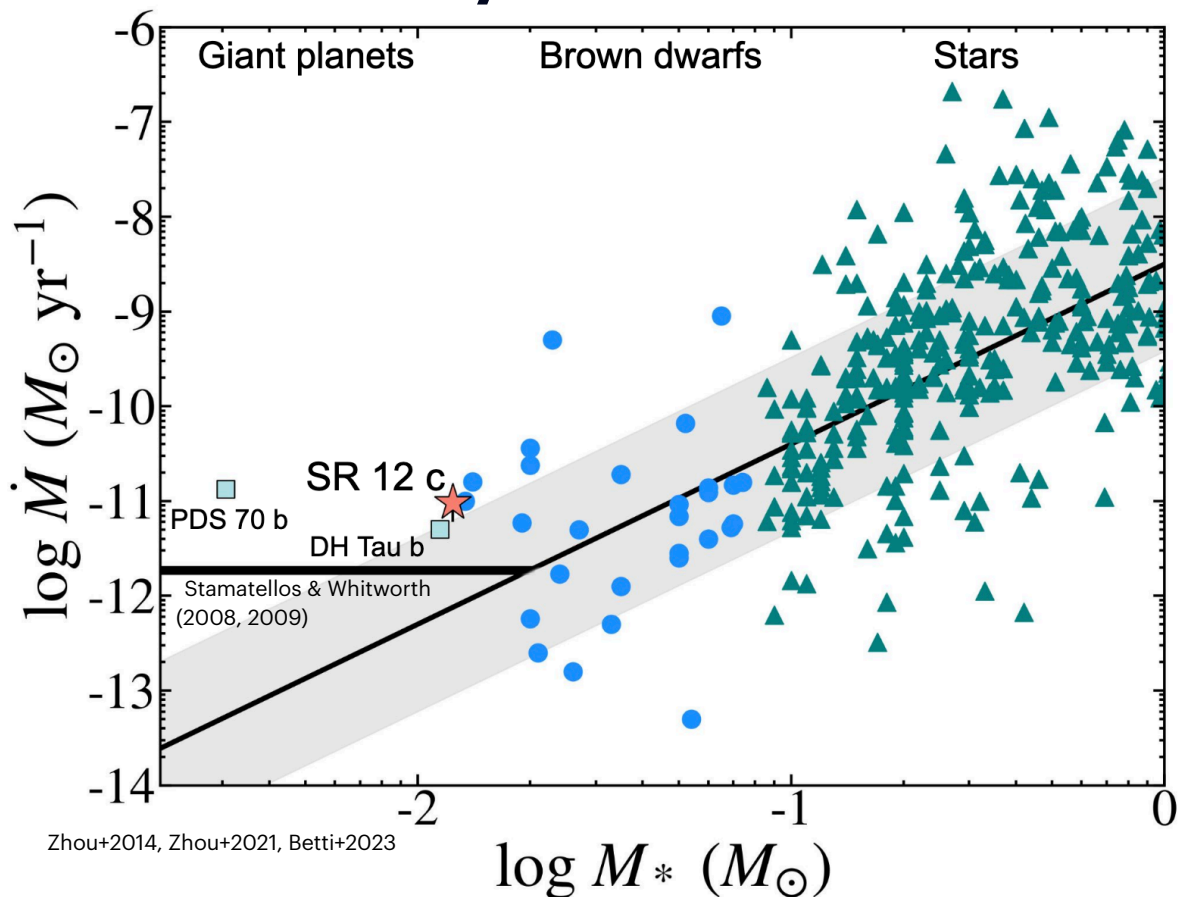
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***Over the next Myr, at this rate, it will only accrete another $0.01 M_{Jup}$ —
SR 12 c formed all $13 M_{Jup}$ in just 2 Myr***

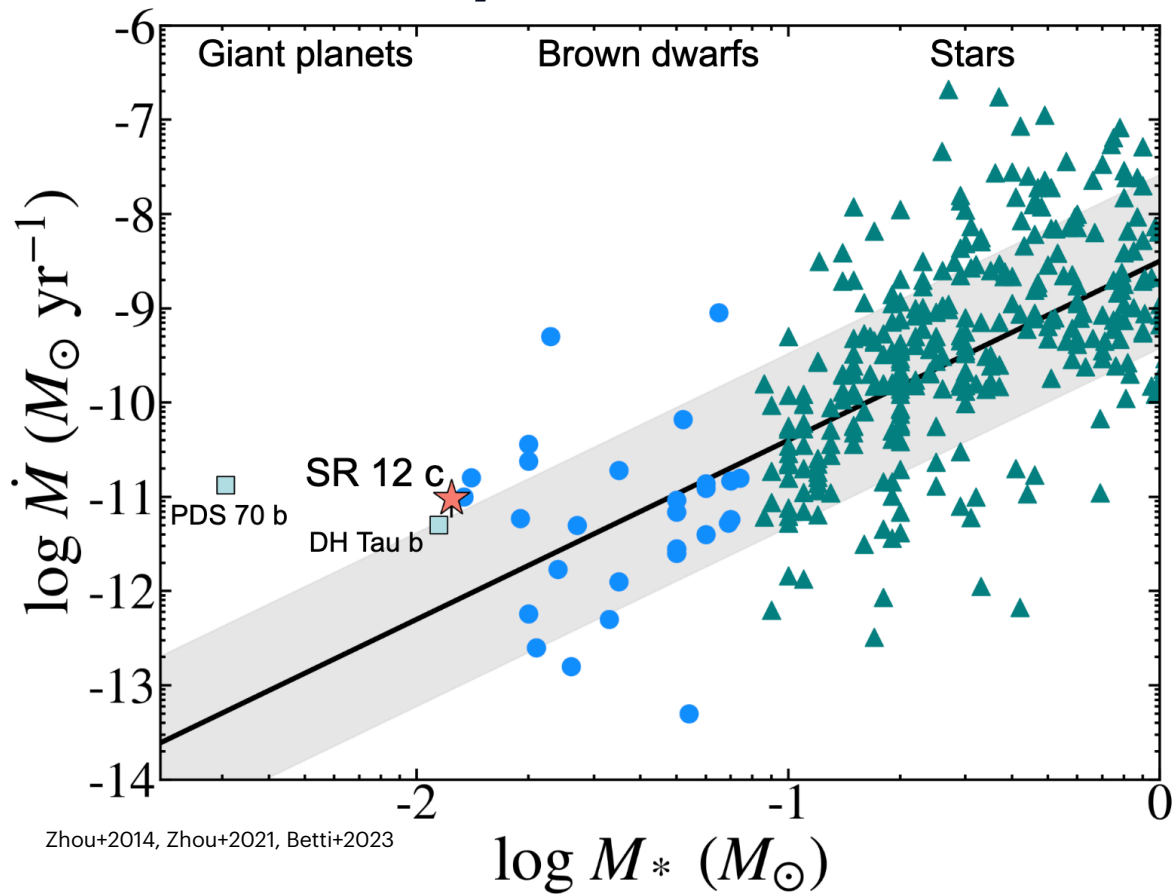
Accretion rate may trace formation history



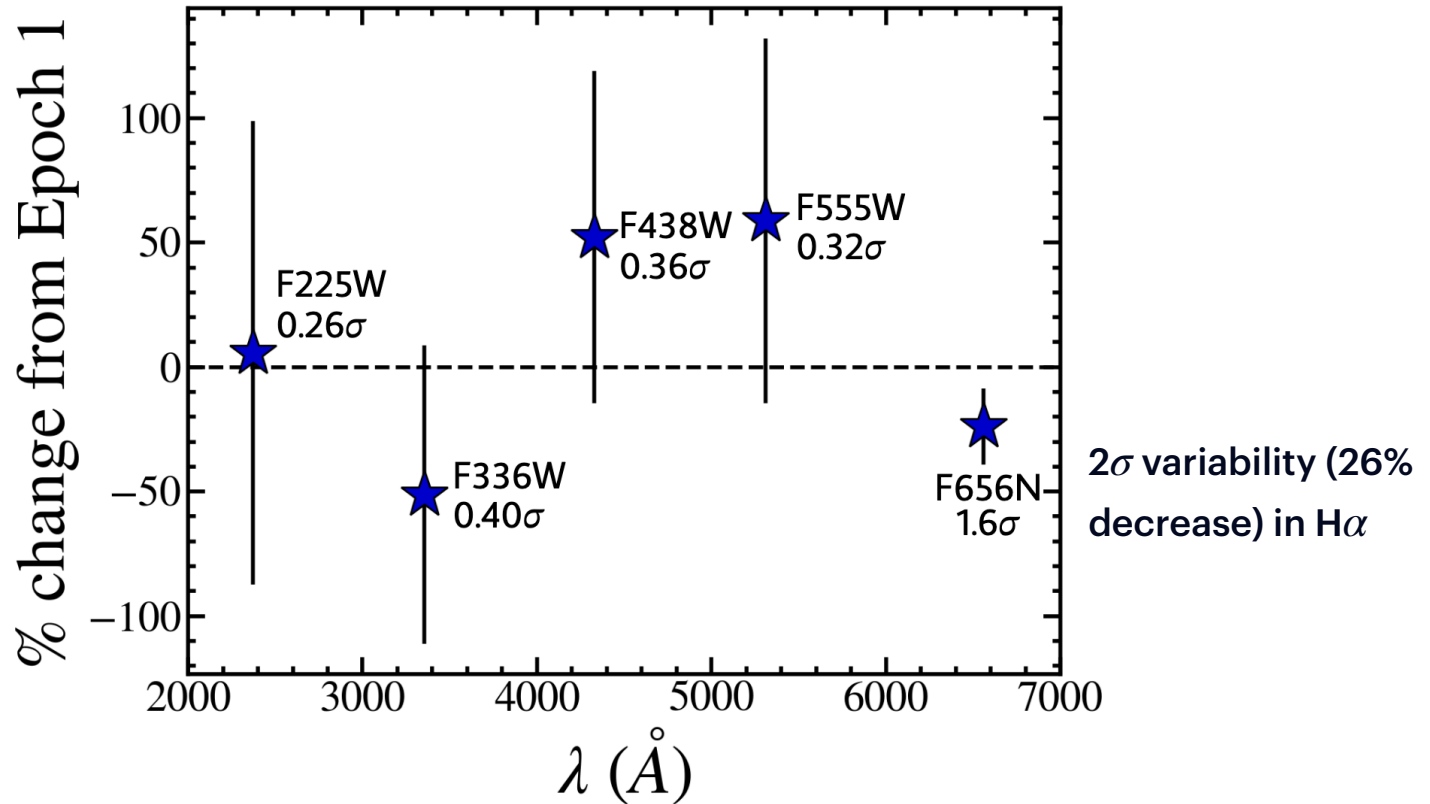
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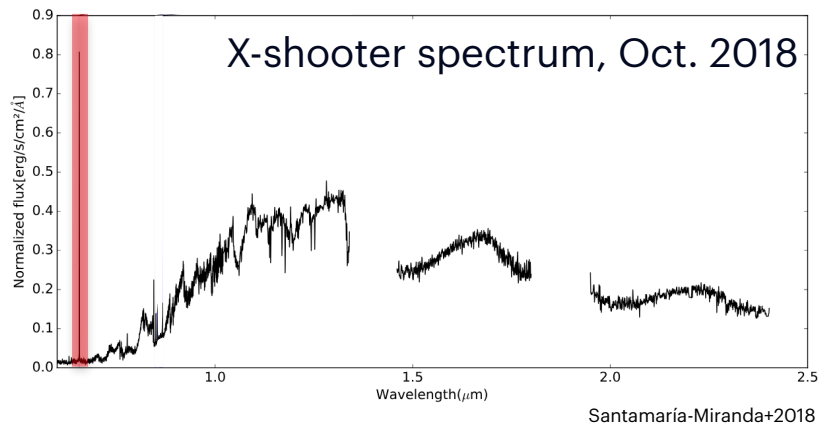
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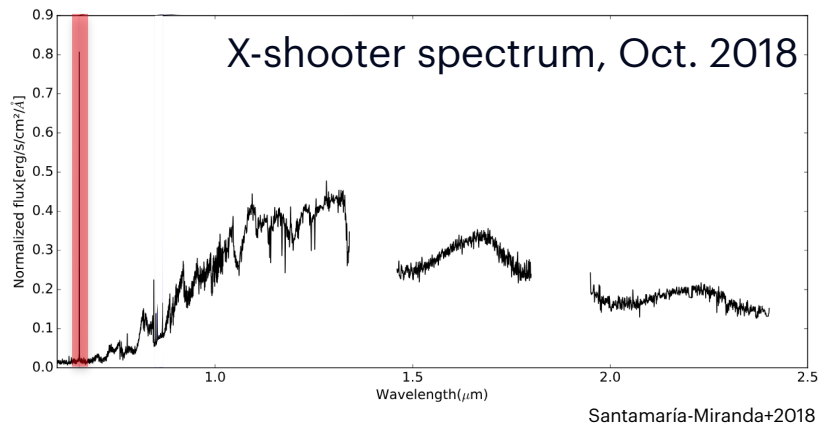
H α is not significantly variable over a short baseline



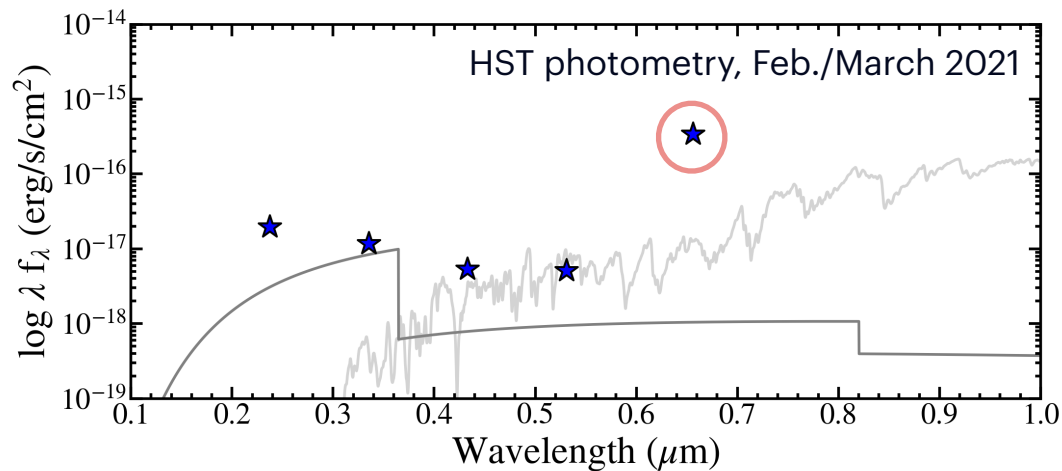
Accretion variability implies dynamic mass transfer



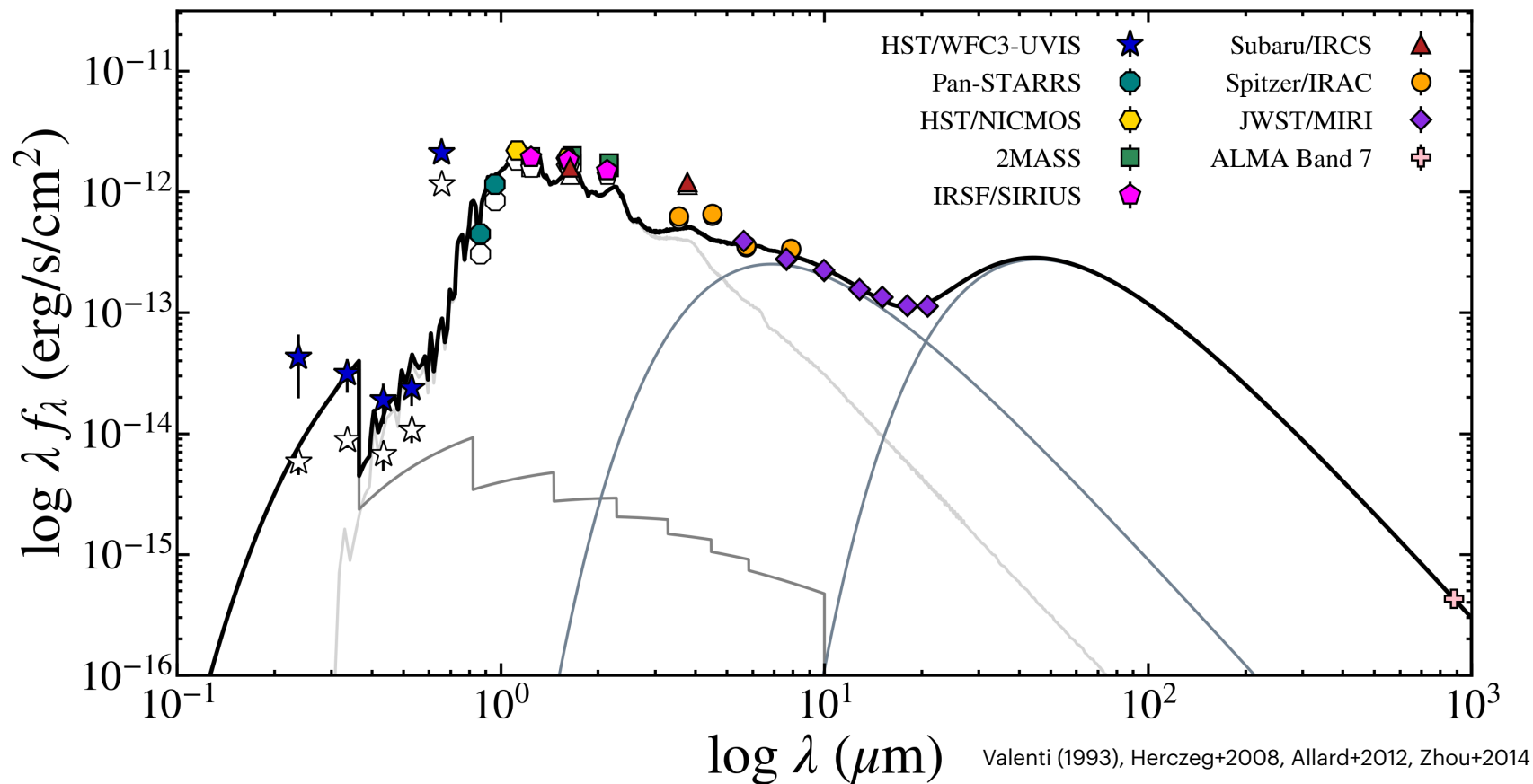
Accretion variability implies dynamic mass transfer



**90% decrease in H α flux over 4 years →
variability is more significant over
longer baselines**



Jointly modeling accretion, photosphere, and CPD emission



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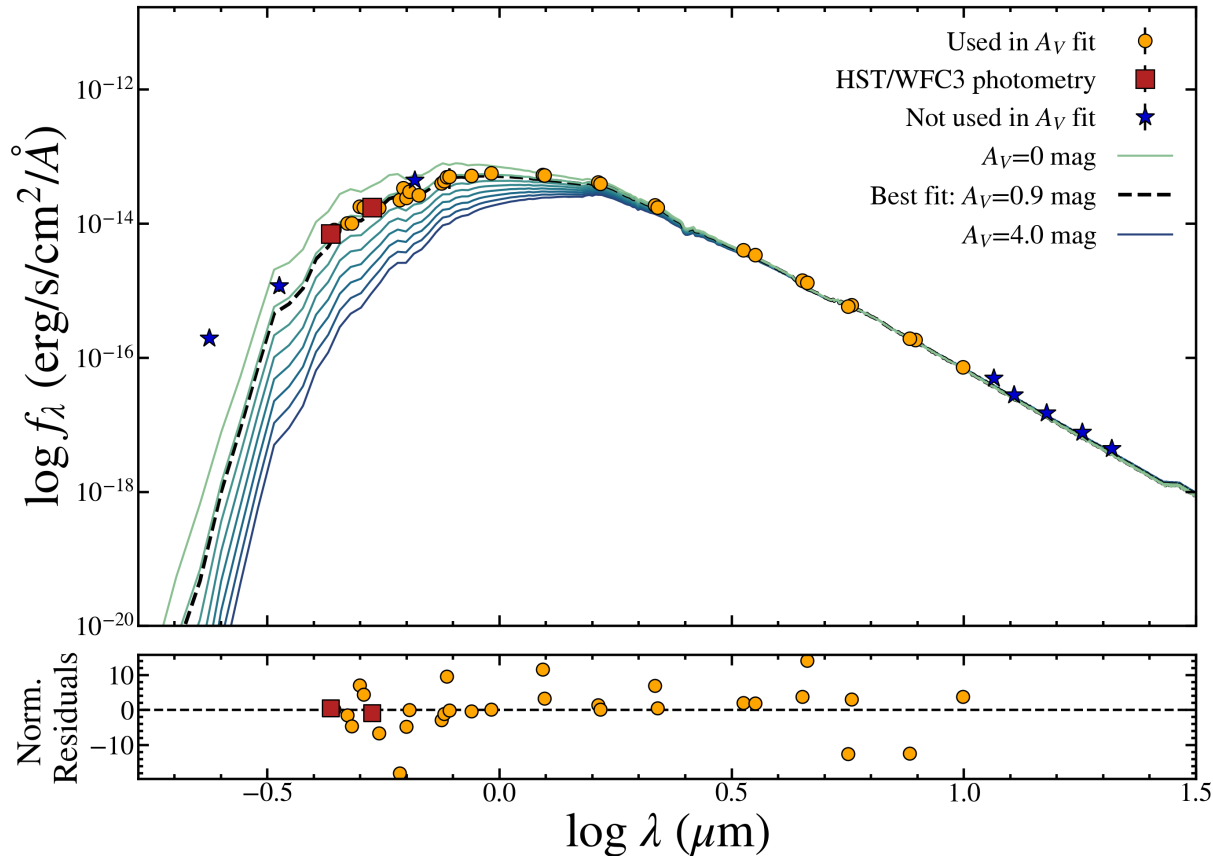
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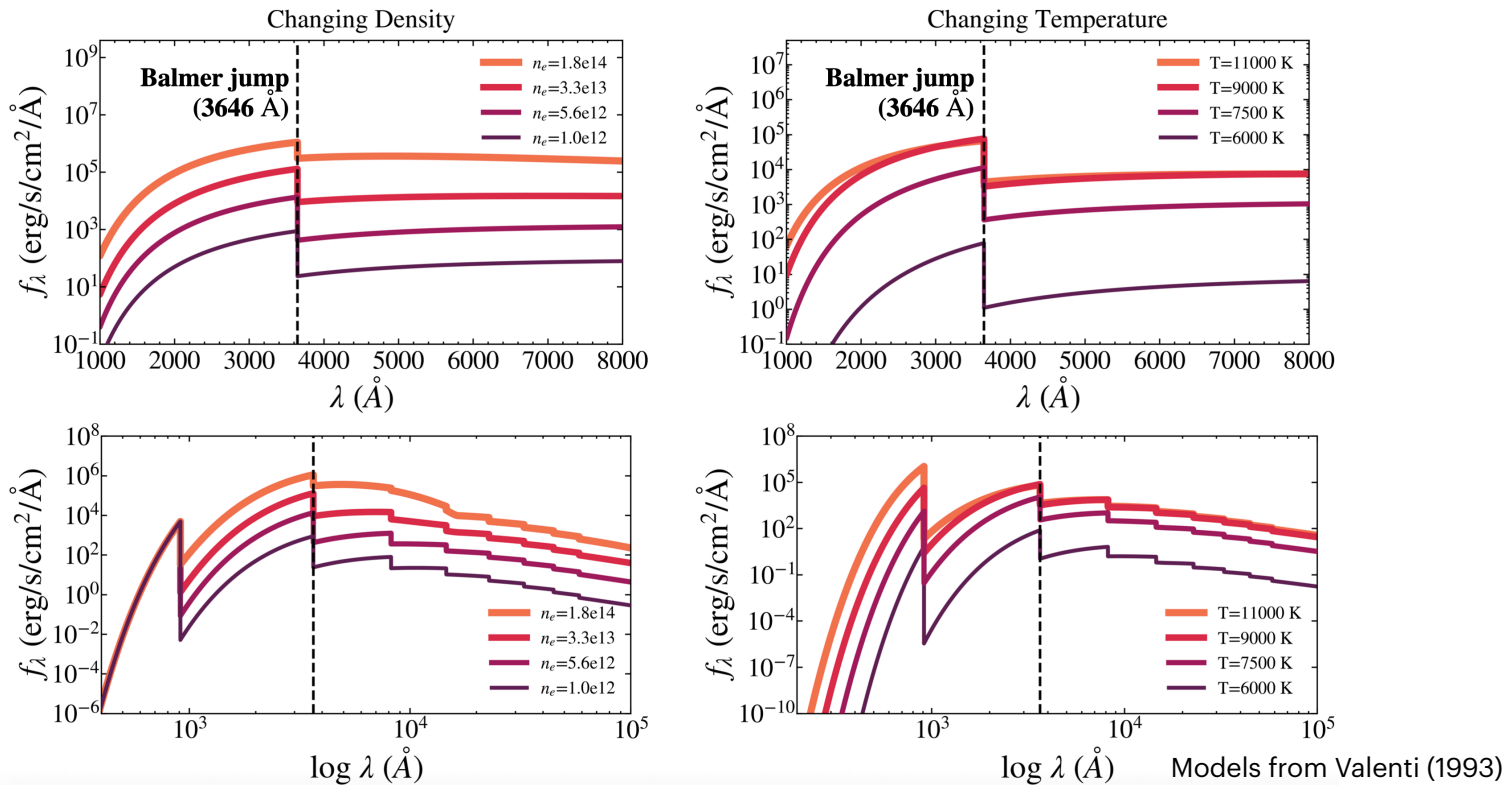
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Supplemental slides

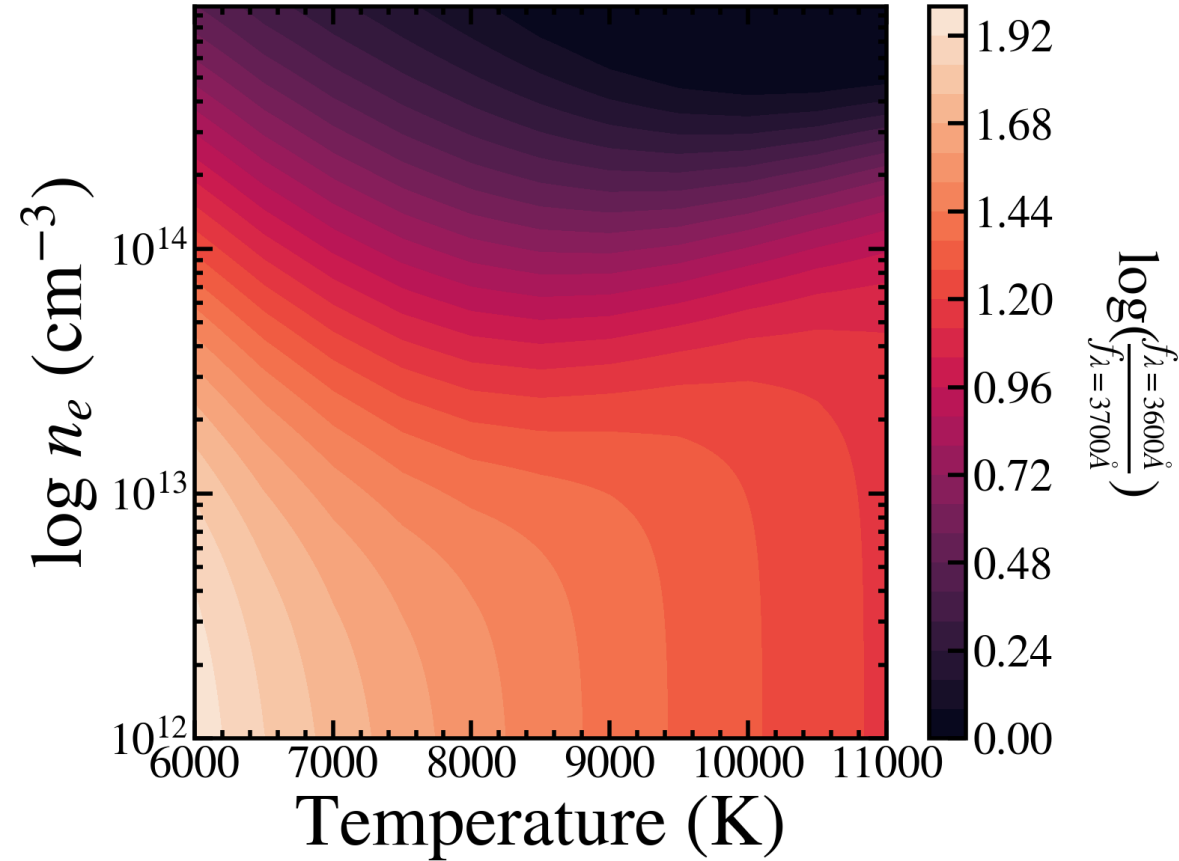
Extinction is estimated using the host binary

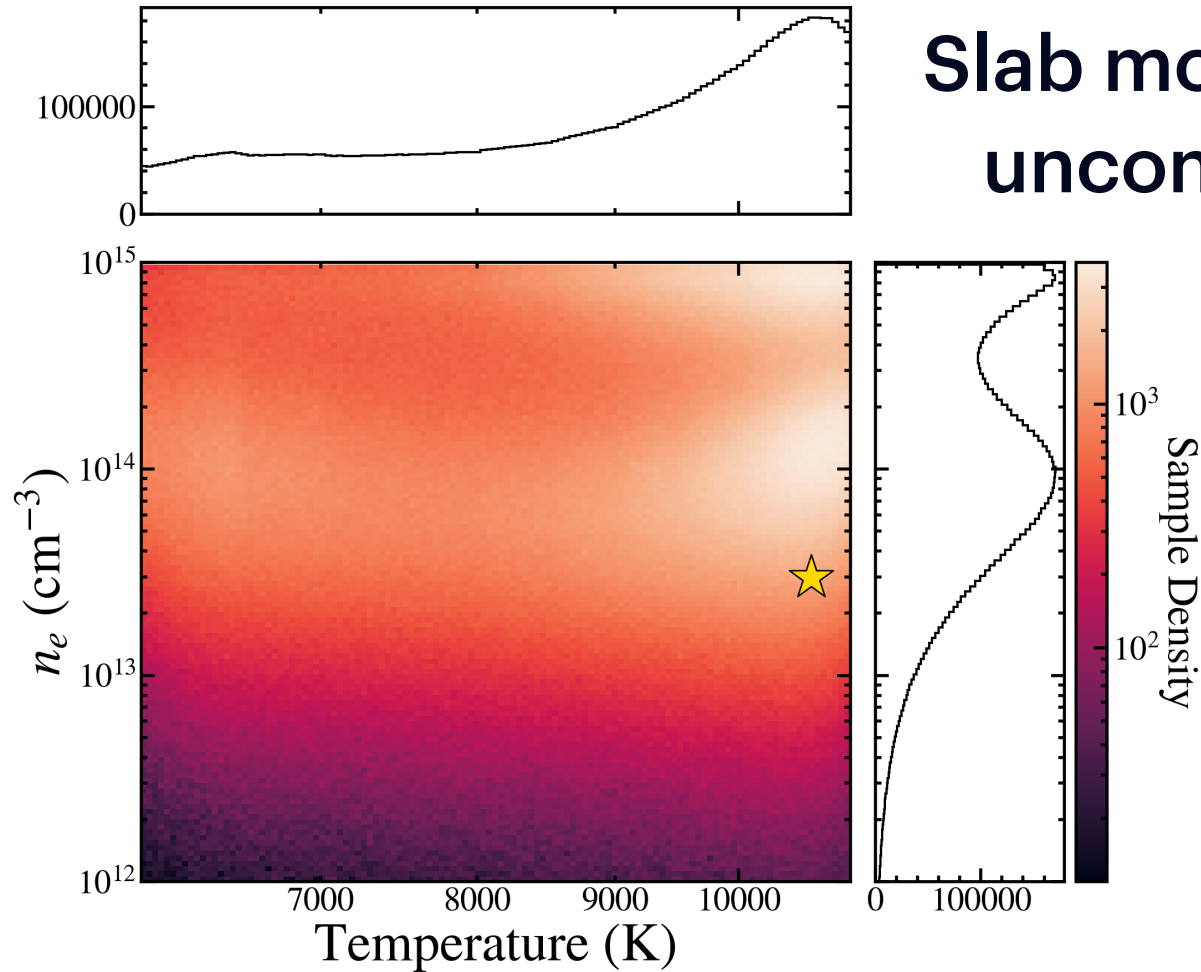


Hydrogen slab models approximate accretion properties without knowing shock geometry



Strength of the Balmer jump with varying temperature and density

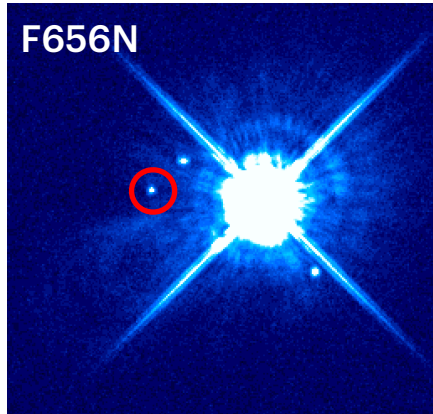




**Slab model temperature is
unconstrained, while the
density is slightly
more precise**

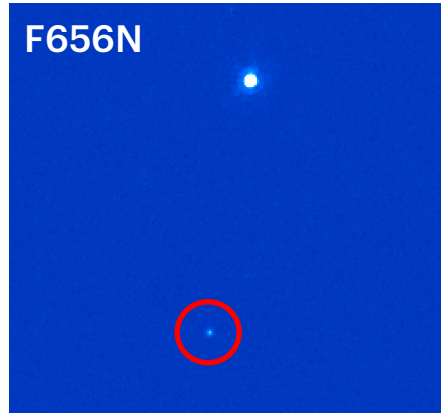
The rest of this program will double the current census of PMC continuum accretion studies

CT Cha b



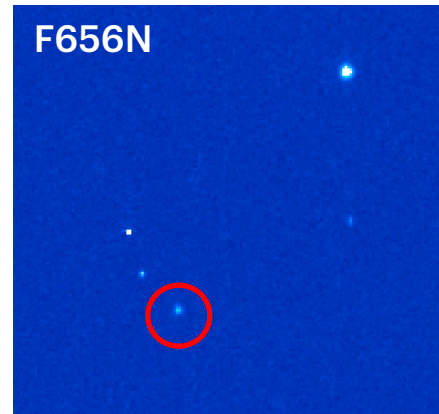
$M=17\pm5 M_{\text{Jup}}$

FU Tau b



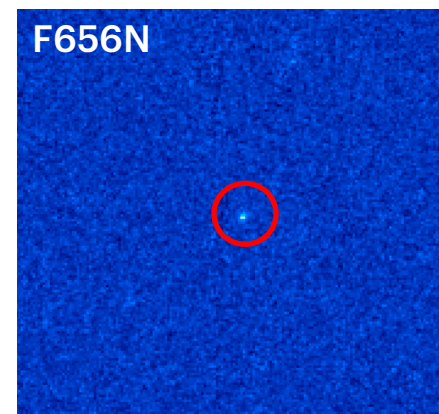
$M=19\pm4 M_{\text{Jup}}$

SCH06-J0359+2009 b



$M=15\pm1 M_{\text{Jup}}$

OTS-44 (free floating)



$M\sim12 M_{\text{Jup}}$