Accretion disks around BDs: the variability perspective

Aleks Scholz (St. Andrews)
Ray Jayawardhana (Toronto)
Jochen Eislöffel (Tautenburg)
Beate Stelzer (Palermo)
Xiaoying Xu (Arizona)
Duy Cuong Nguyen (Toronto)
Alexis Brandeker (Stockholm)
Marten van Kerkwijk (Toronto)

Nébulosités de la ceinture d'Orion cliché Emmanuel MALLART 09/2001

T Tauri stars are variable

T TAURI VARIABLE STARS*

ALFRED H. JOY
Mount Wilson Observatory
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ABSTRACT

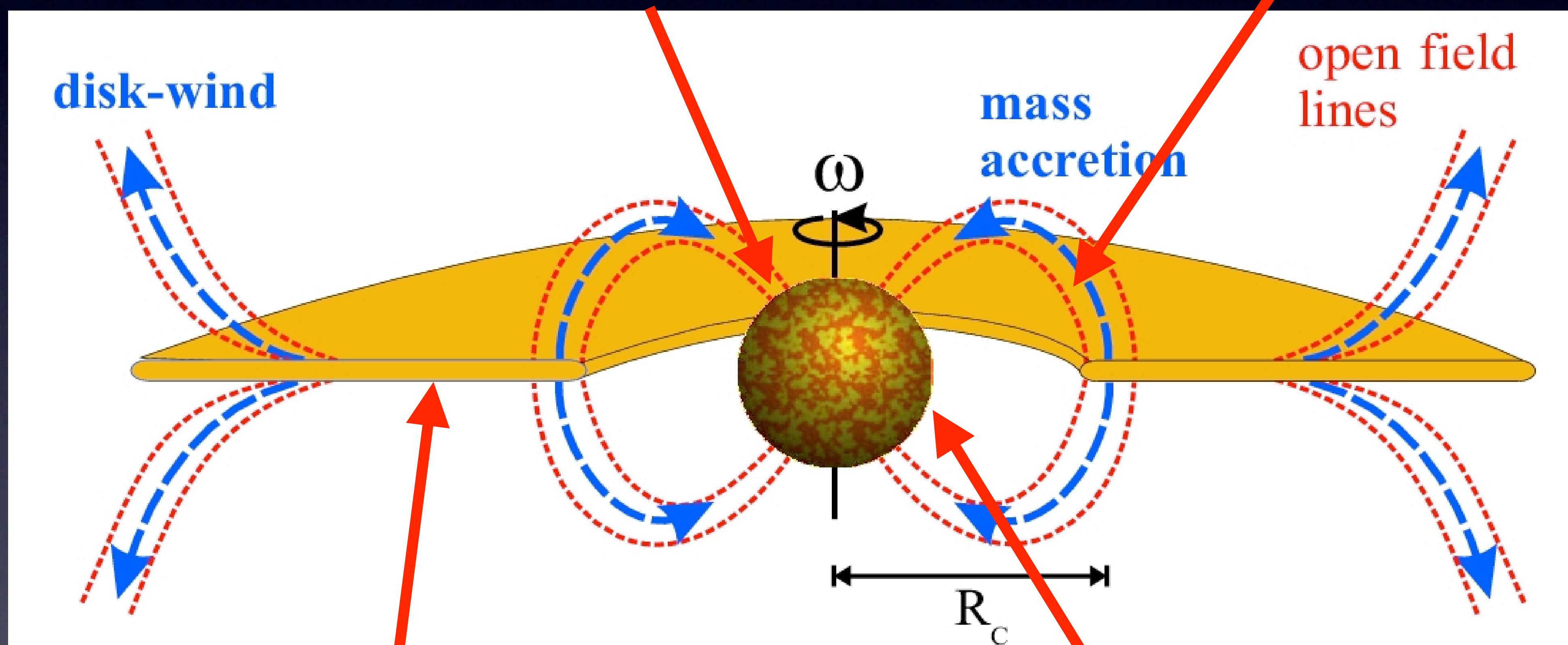
Eleven irregular variable stars have been observed whose physical characteristics seem much alike and yet are sufficiently different from other known classes of variables to warrant the recognition of a new type of variable stars whose prototype is T Tauri. The distinctive characteristics are: (1) irregular light-variations of about 3 mag., (2) spectral type F5–G5 with emission lines resembling the solar chromosphere, (3) low luminosity, and (4) association with dark or bright nebulosity. The stars included are RW Aur, UY Aur, R CrA, S CrA, RU Lup, R Mon, T Tau, RY Tau, UX Tau, UZ Tau, and XZ Tau.

T Tauri has a magnitude range of from 9.4 to 13.5 or 14, but no regular period has as yet been detected. I have had it under observation (...) for the past 27 years (...) and can only describe its changes as "irregular".
(George Knott from Cuckfield, 1891, The Observatory, 3 citations)

Origin

accretion shock
(hot spots)

accretion rate

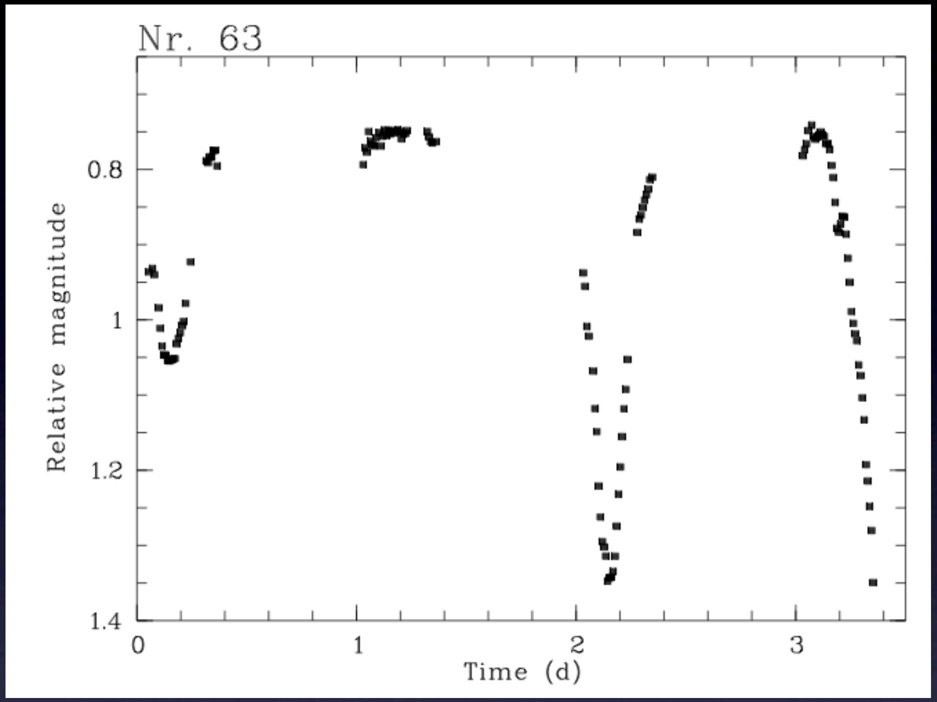


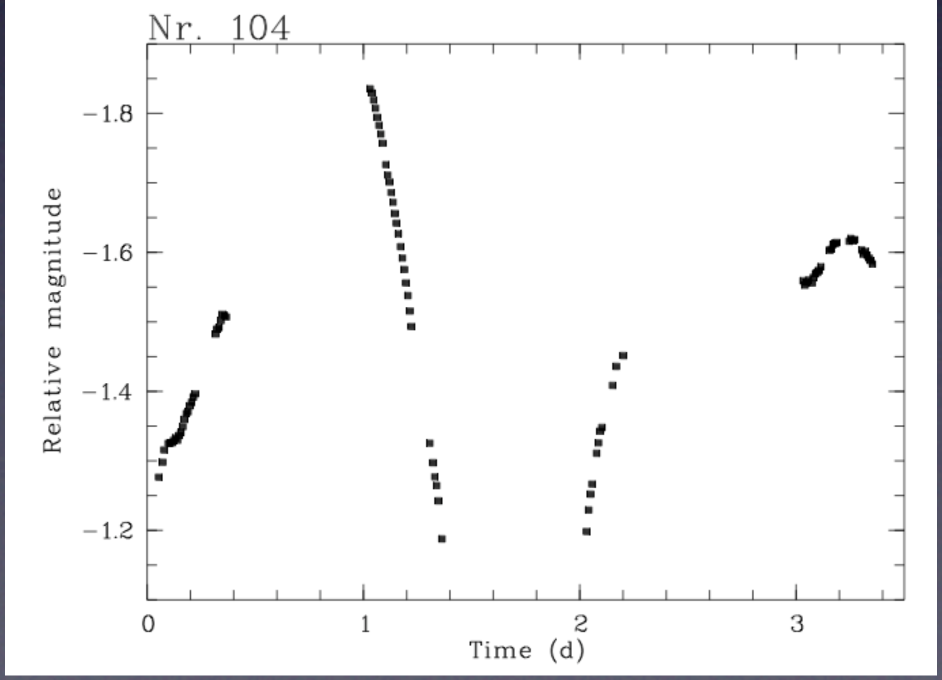
disk inhomogenities
(clumps, walls, spiral
arms, gaps, planets?)

stellar activity
(cool spots, flares)

The first T Tauri BDs

- 12 highly variable VLMS and BDs in σOri and εOri (3-5 Myr) from monitoring in 2001/2
- T Tauri lightcurves: high amplitude, irregular
- accretion+disks confirmed with IR excess and emission lines

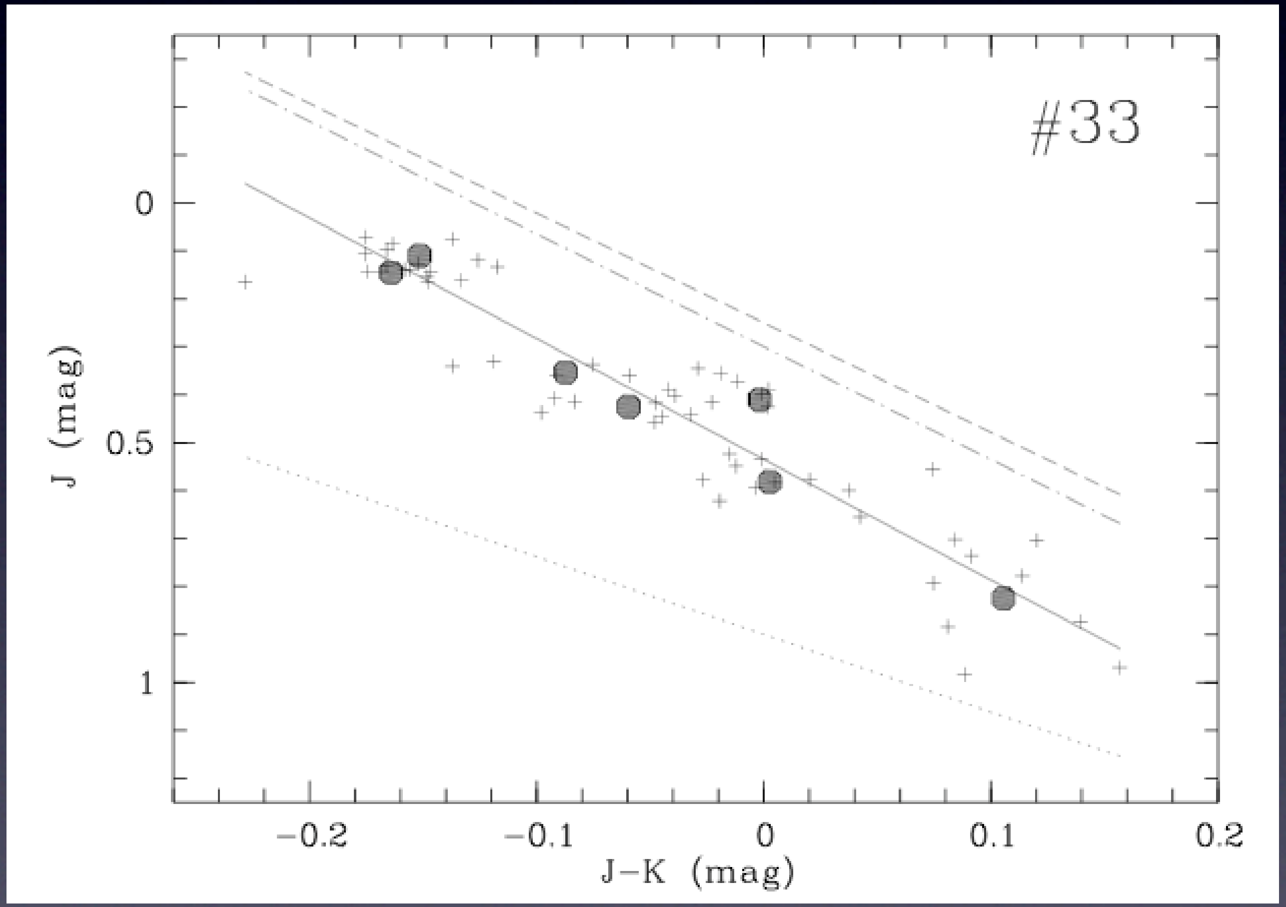




Scholz & Eislöffel 2004, 2005

Origin: hot spots

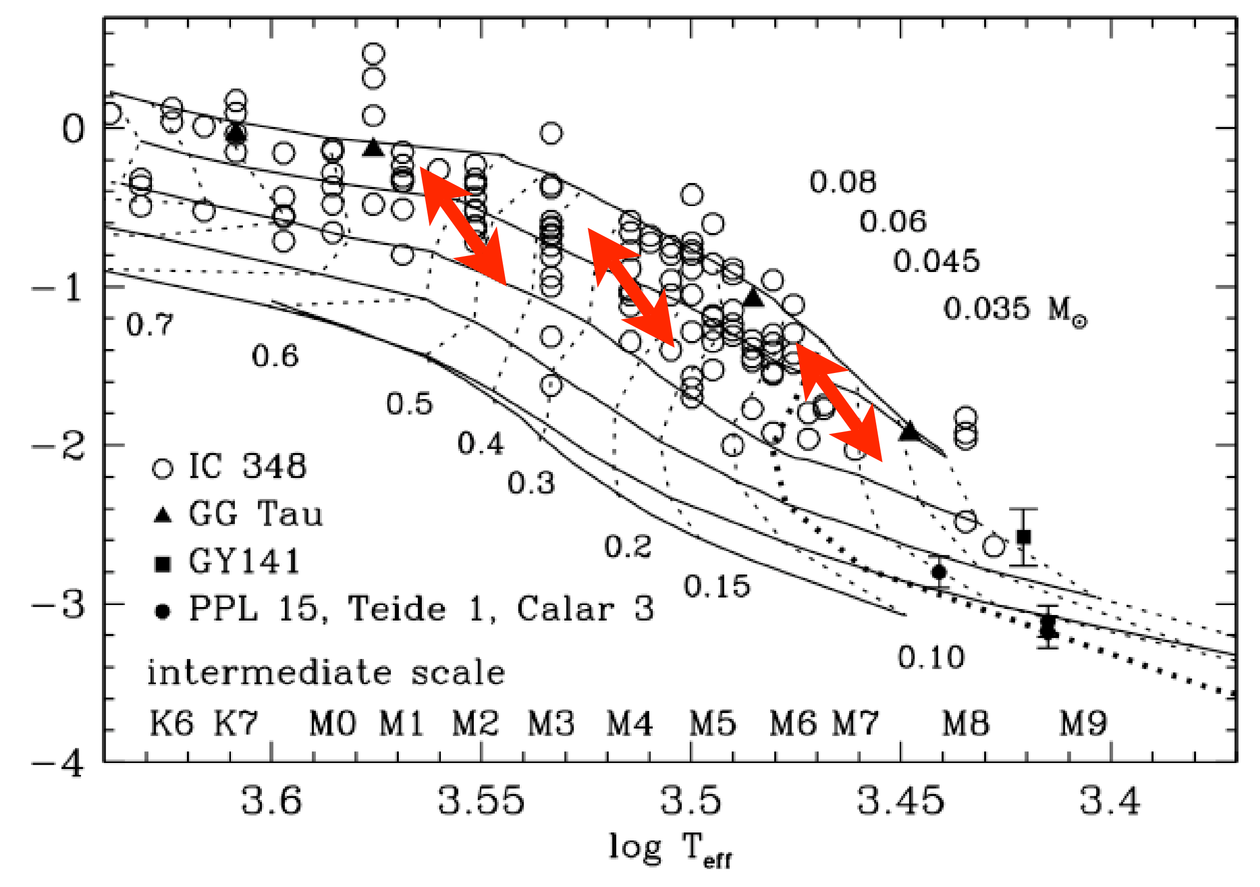
- hot spots with temperature of 6000-7000K (similar to 2M1207, Koen et al.)
- no clear period yet found, but P=35-45 h seen in 4 seasons
- accretion flow is funnelled, variable, and asymmetric



Scholz, Xu, Jayawardhana, et al., 2009

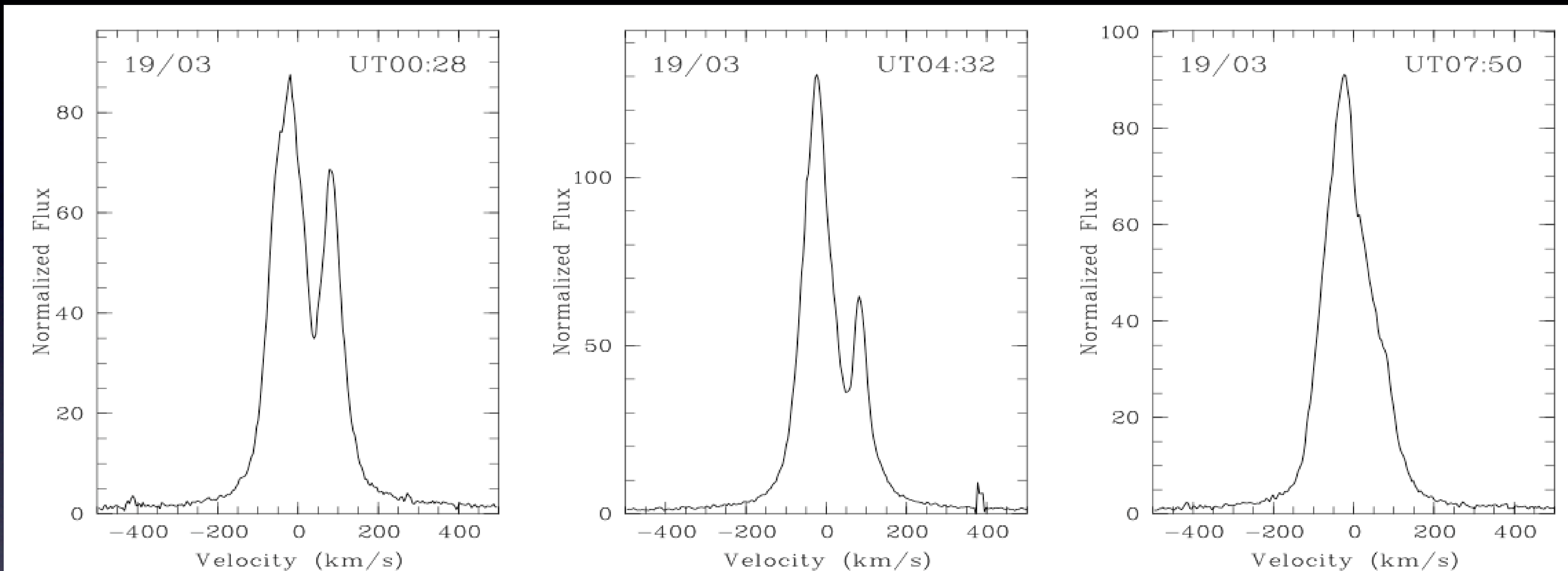
Variability and HR diagram

- ~20% of all accreting VLMOs show strong variability; affected are I- and J-band
- for such objects, higher uncertainties are expected when deriving L, Teff, M, age
- disentangling the origin of the variation helps



Luhman 1999, HR diagram in IC348 and BCAH98

The case of 2M1207



- red-shifted absorption features strongly variable on 1d timescale
- accretion column + edge-on view + rotation (a mini AA Tau)
- structured flow, magnetic funneling

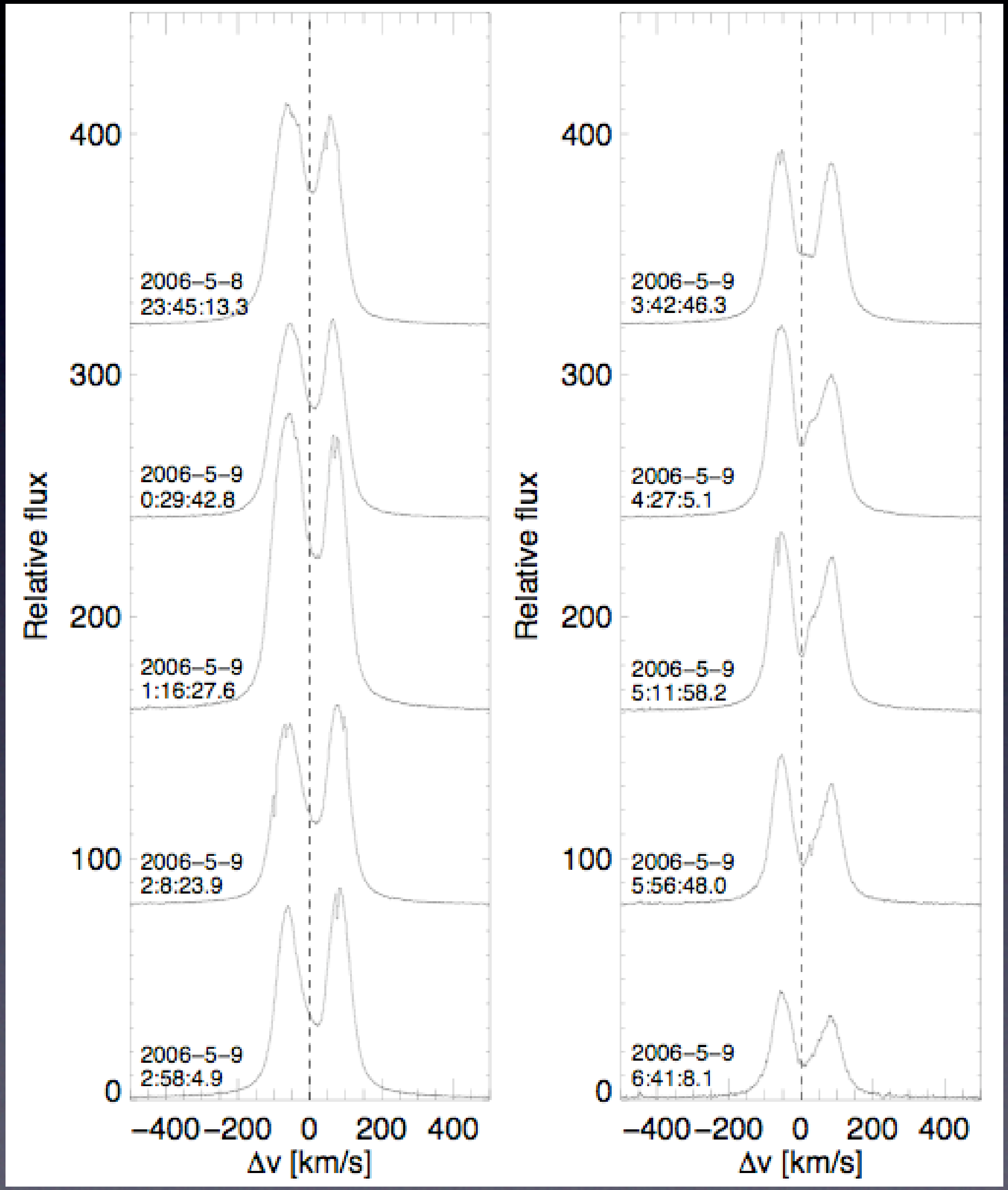
Scholz, Jayawardhana, Brandeker 2005

The 1st brown dwarf stamp

The case of 2M1207

- follow-up confirms broad, asymmetric profiles, but not the strong changes
- absorption feature is always visible
- changes in the flow (wind?) structure on timescales of months and years

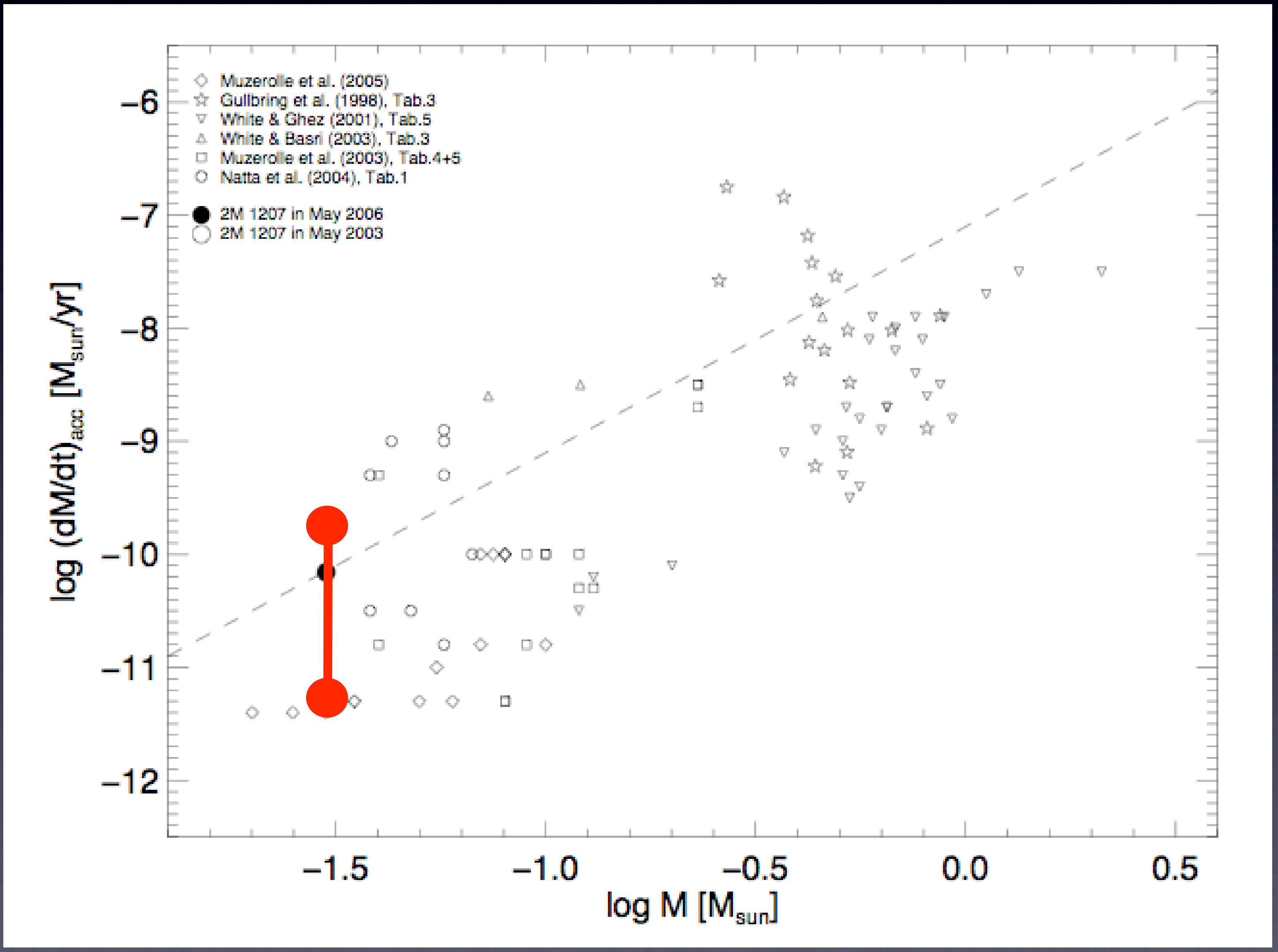
Stelzer, Scholz, Jayawardhana 2007
see Herczeg & Hillenbrand 2007



Mdot variability?

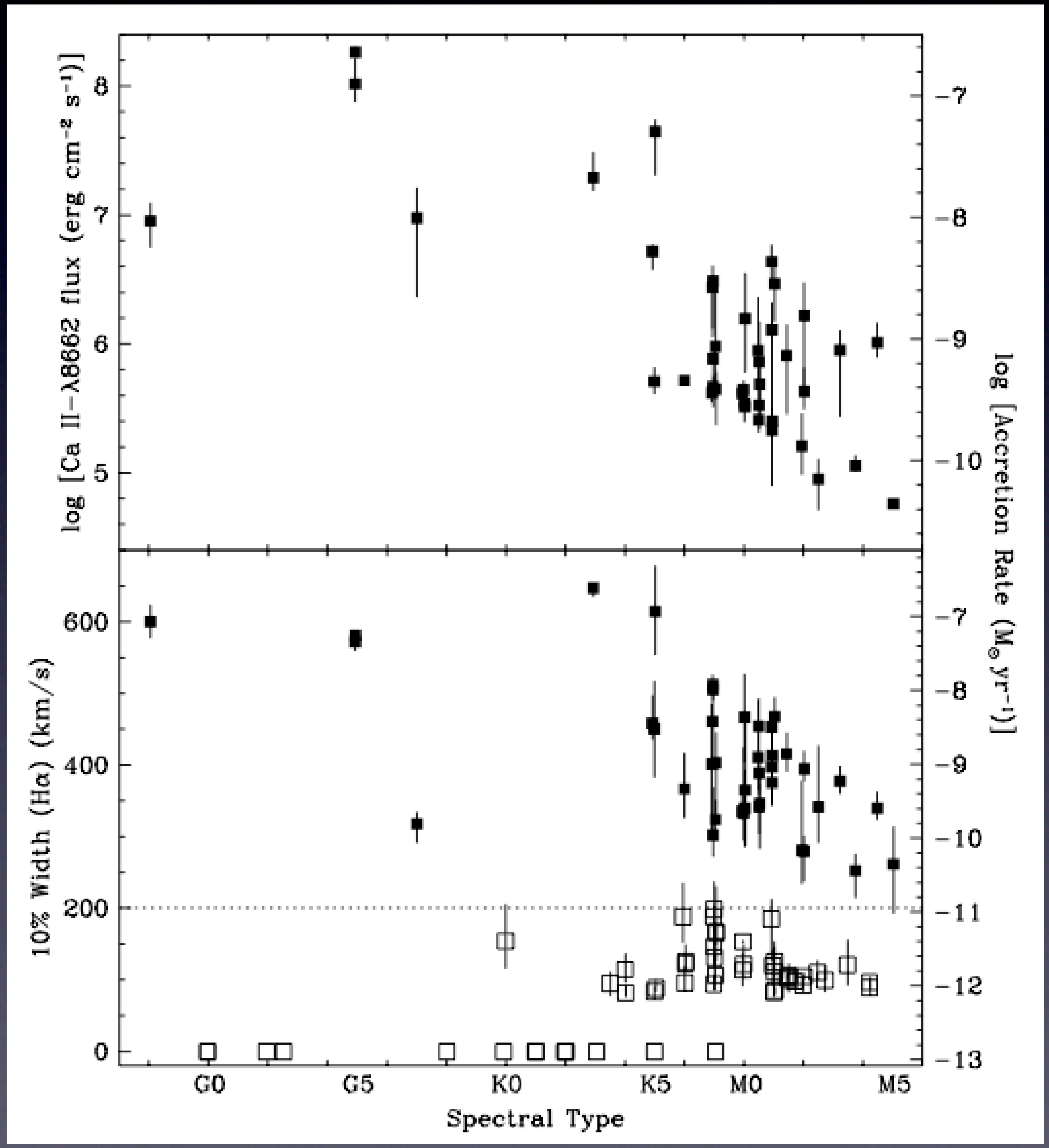
Date	$W_{10\,\%}$ [km/s]
Apr 2002	$\sim 300^{\dagger}$
May 8, 2003	170...200
Jan 29 - Feb 1, 2005	209...215
Mar 17 - 19, 2005	253...308
Mar 27 - 30, 2005	279...304
Feb 21 - 22, 2006	261...281
Apr 11, 2006	253
May 8 - 9, 2006	281...322
May 16, 2006	320

Gizis 2002, Mohanty et al. 2003, Scholz et al. 2005, Stelzer et al. 2007, Whelan et al. 2007



Mdot variability? Not much.

- in a large sample of stars typical Mdot changes are 0.35dex, with 32% exceeding 0.5dex
- not enough to explain spread in Mdot-M diagram
- timescales: days to weeks, longer timespans not tested yet



Nguyen, Scholz, van Kerkwijk, et al., 2009

Four conclusions

- T Tauri like variability extends down into the substellar regime.
- Brown dwarfs have asymmetric accretion flows, as expected for magnetospheric accretion.
- Variability information relevant for constraining fundamental parameters of accretors.
- Accreting stars/BDs are variable, but accretion itself is mostly stable within 0.5dex.