

Magnetic Protostars & Planets (MaPP)

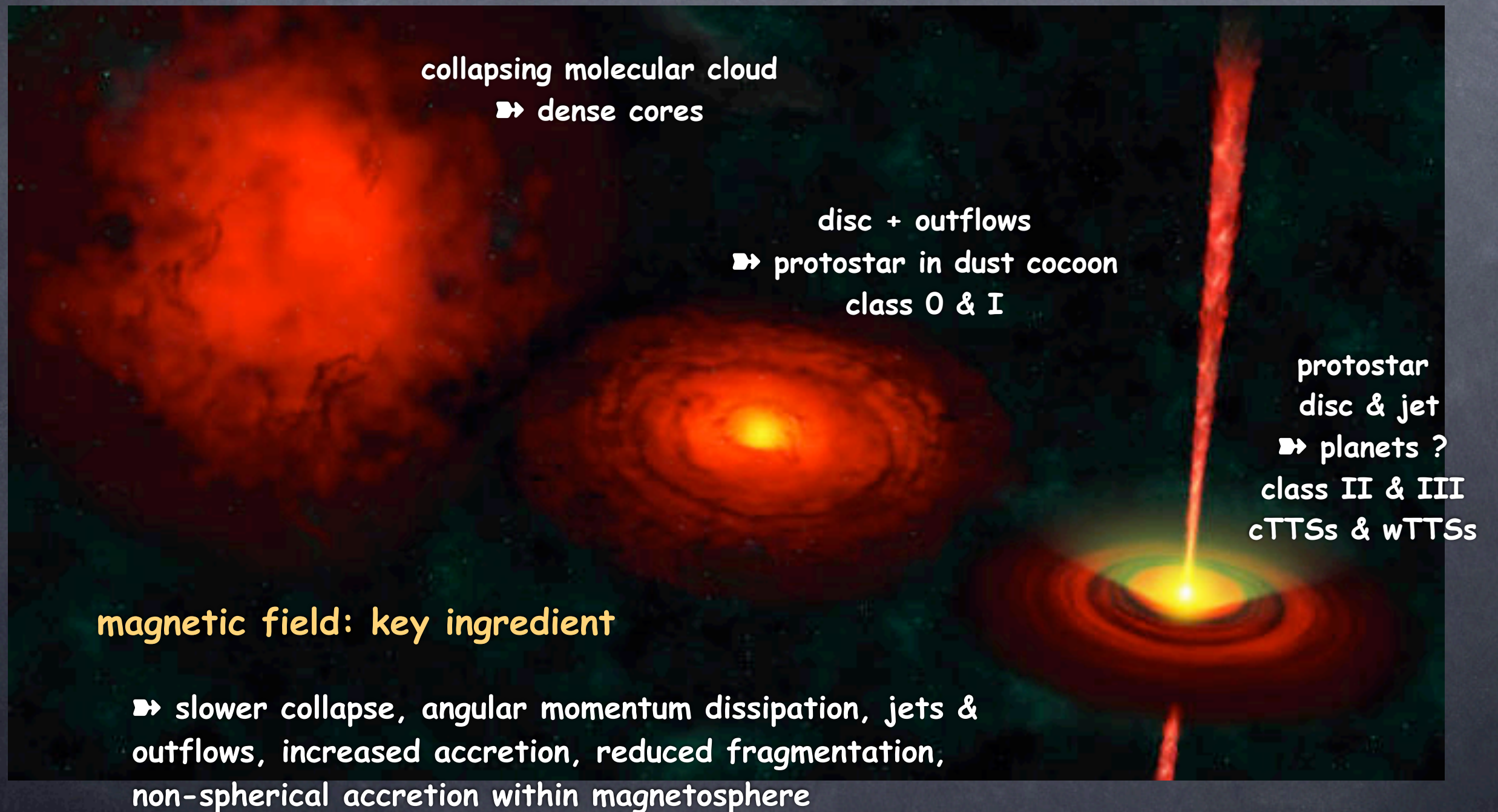
a Large Program with
ESPADONs @ CFHT

wiki : <http://lamwww.oamp.fr/magics/mapp>

JF Donati & the MaPP collaboration
~40 coIs from France, UK, Canada, USA, etc

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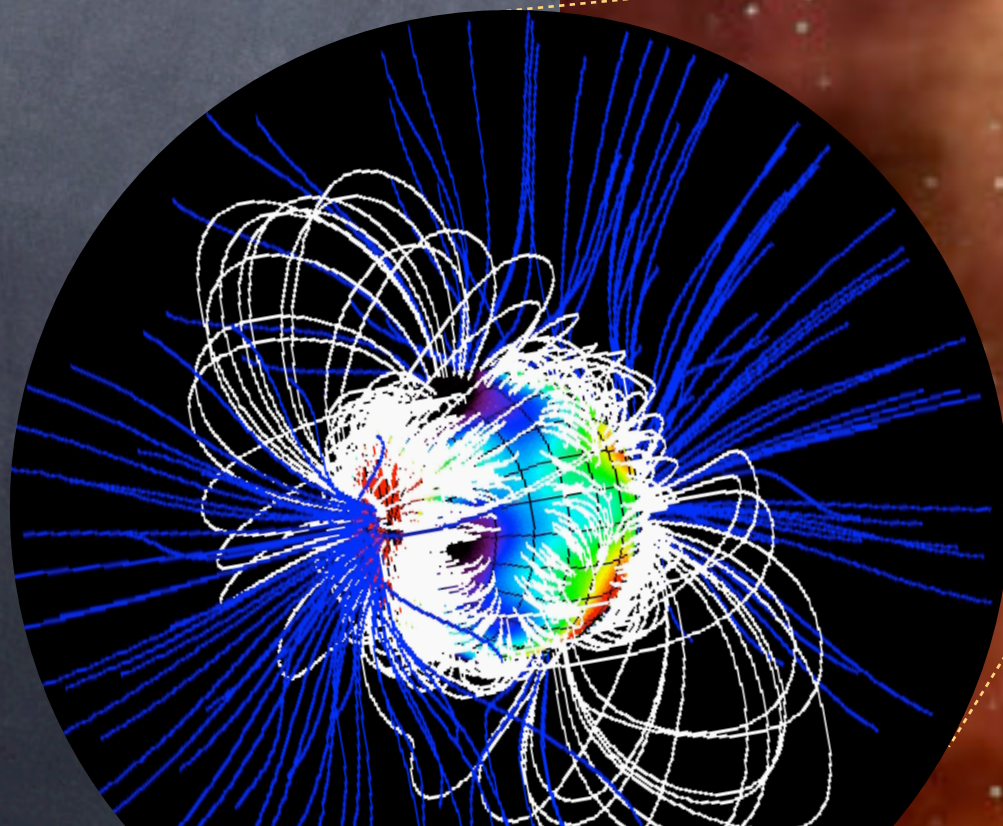
star & planet formation: the role of magnetic fields ?



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magnetospheric accretion on cTTSs: the central engine

- * inner disc regions disrupted by magnetosphere of protostar
 - ➔ magnetospheric gap w/ typical outer radius of ~ 0.1 AU
- * non-spherical star/disc accretion through discrete magnetic funnel
 - ➔ modified structure of protostar?
- * star/disc magnetic coupling & low protostar rotation rates
- * interrupting migration of giant protoplanets?
- * collimated jets from inner disc regions



not accessible to radio observations (eg ALMA)

➔ need ESPaDOnS@CFHT

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assessing the role of magnetic fields with ESPaDOnS@CFHT

tackle major unresolved issues:

- * origin of the disc field?
amount of angular & magnetic flux dissipated during collapse?
- * origin of protostar fields?
physics of magnetospheric accretion process?
angular momentum control & impact on stellar structure?
- * presence/absence of jets related to field properties?
- * formation/interrupted migration of close-in giant planets?

➔ MaPP : observe 15 cTTSs & 4 FUOrs at \neq epochs
awarded 690 hr w/ ESPaDOnS@CFHT from 2008b-2012b

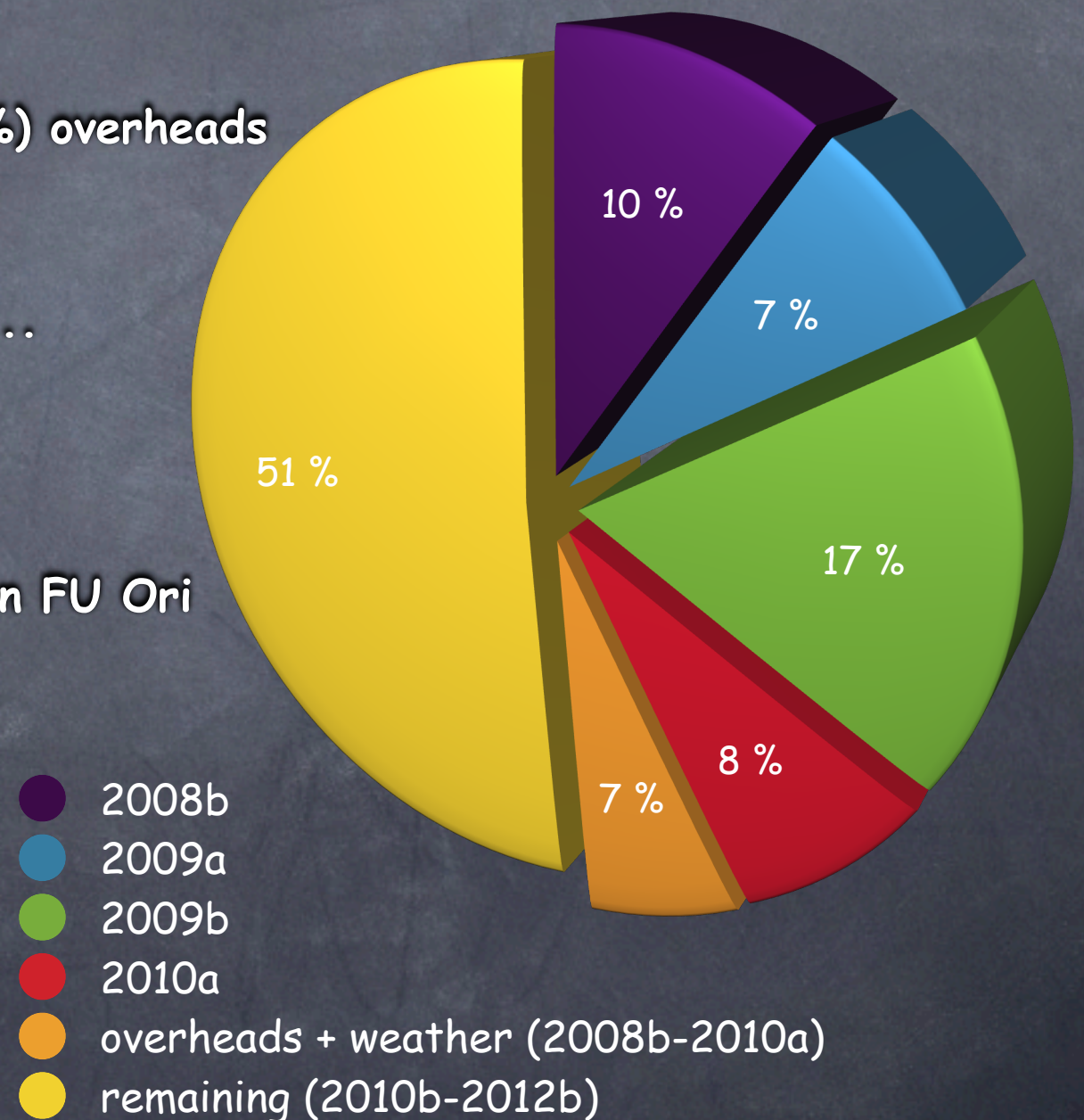


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observations: 2008b - 2010a statistics

* 336 hr = 91 hr (42%) on sky + 45 hr (7%) overheads
additional NARVAL@TBL observations
(LP status obtained in 2010b)
HETG@Chandra, HARPS@ESO, SMARTS...
observed 9 cTTSS & 4 FUOrs
multisite multi- λ campaign on 2 targets

* field detected on all cTTSS & confirmed on FU Ori
full analysis published for 2 stars
more papers to come soon



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an illustrative example: the cTTS V2129 Oph

* V2129 Oph : brightest cTTS in ρ Oph

* $M_{\star} \sim 1.35 M_{\odot}$ - $R_{\star} \sim 2.1 R_{\odot}$ - age $\sim 2-3$ Myr
 $P_{\text{rot}} \sim 6.5$ d - $\log M_{\text{acc}} \sim -9.2$ (M_{\odot}/yr)

corotation radius $R_{\text{cor}} \sim 7.7 R_{\star} \sim 0.08$ AU

protostar spins up if $R_{\text{mag}} < R_{\text{cor}}$

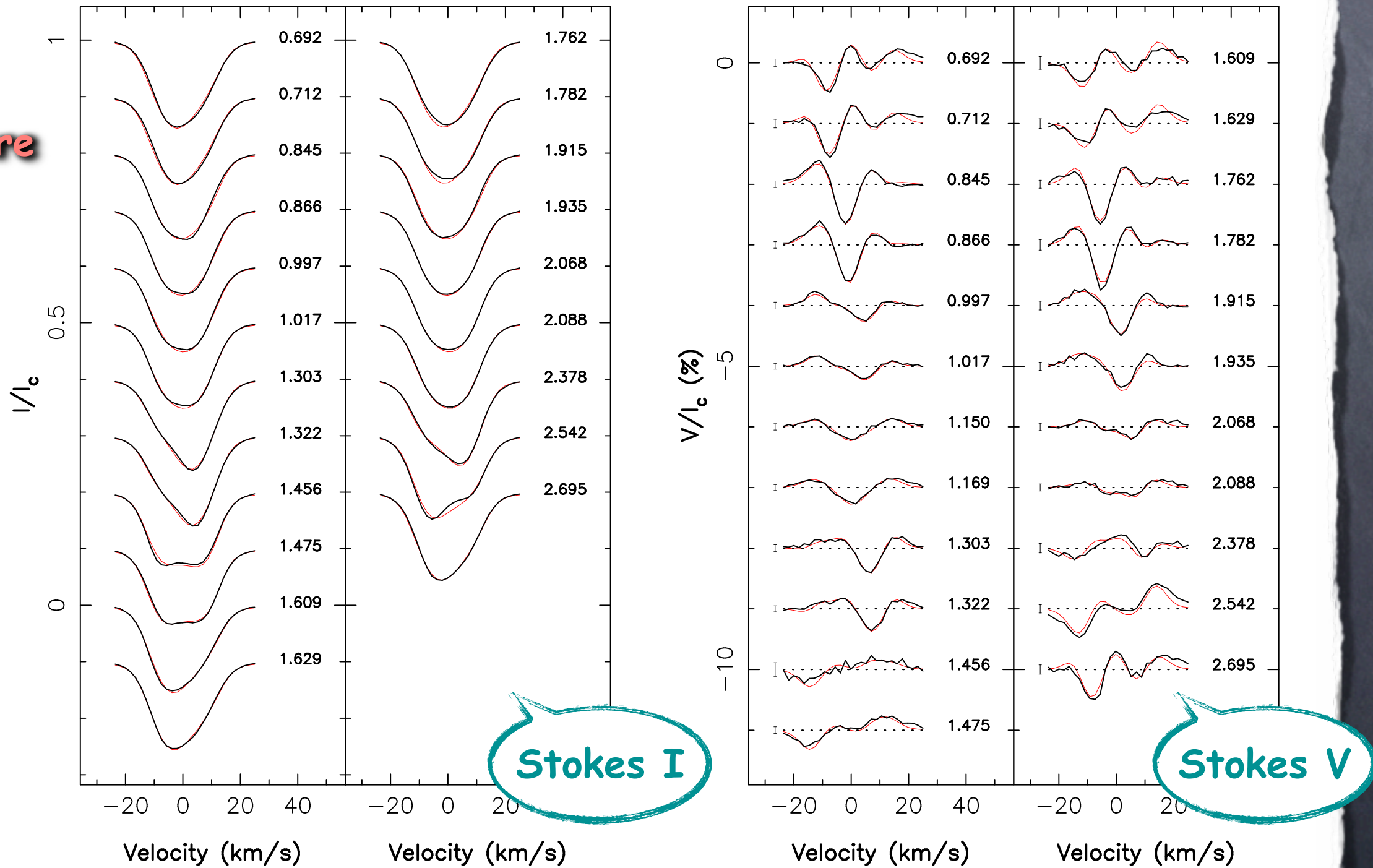
protostar spins down otherwise

* 23 spectra collected over 15n in 2009a
simultaneous data from HETG@Chandra, HARPS@ESO, SMARTS



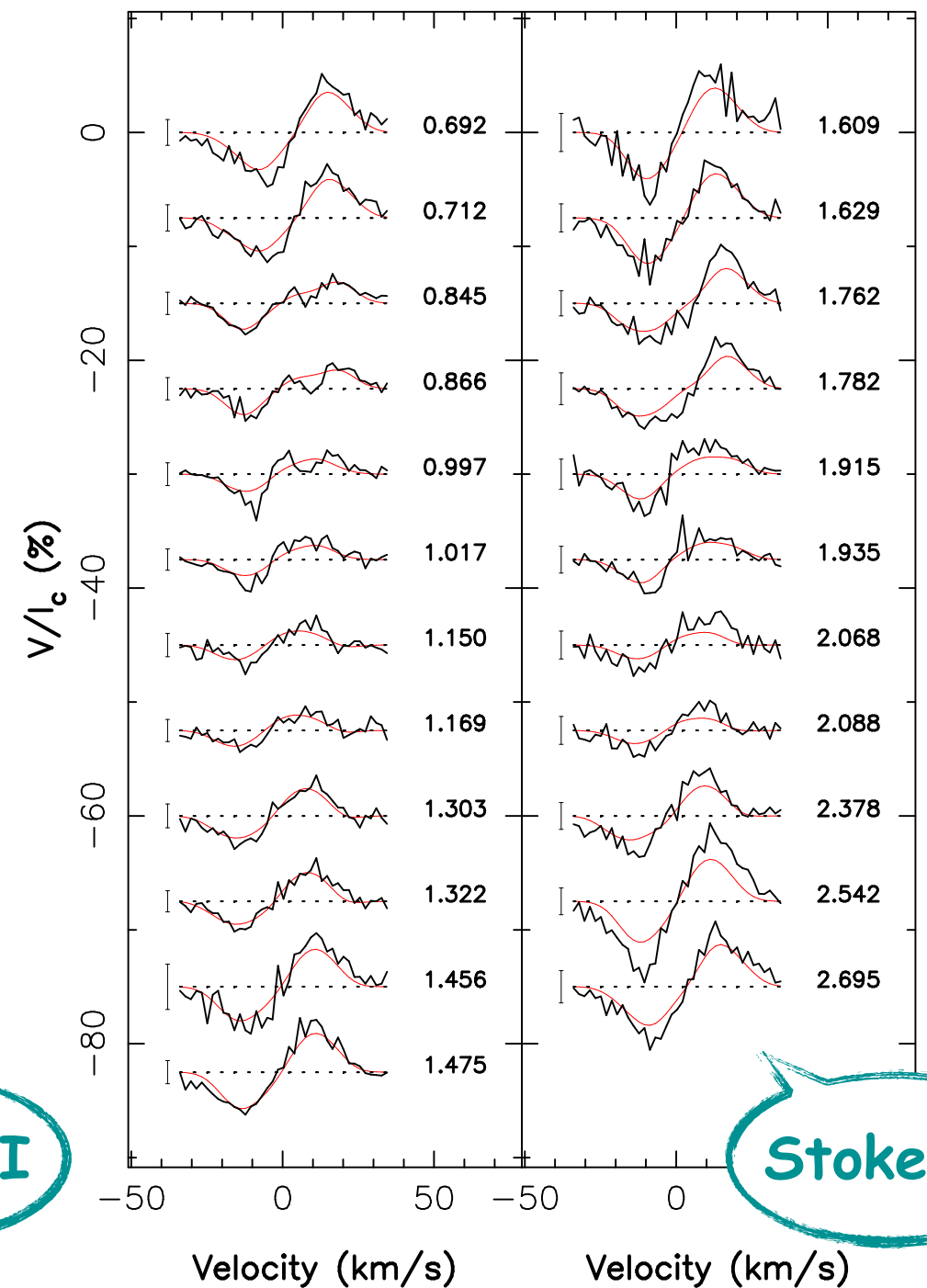
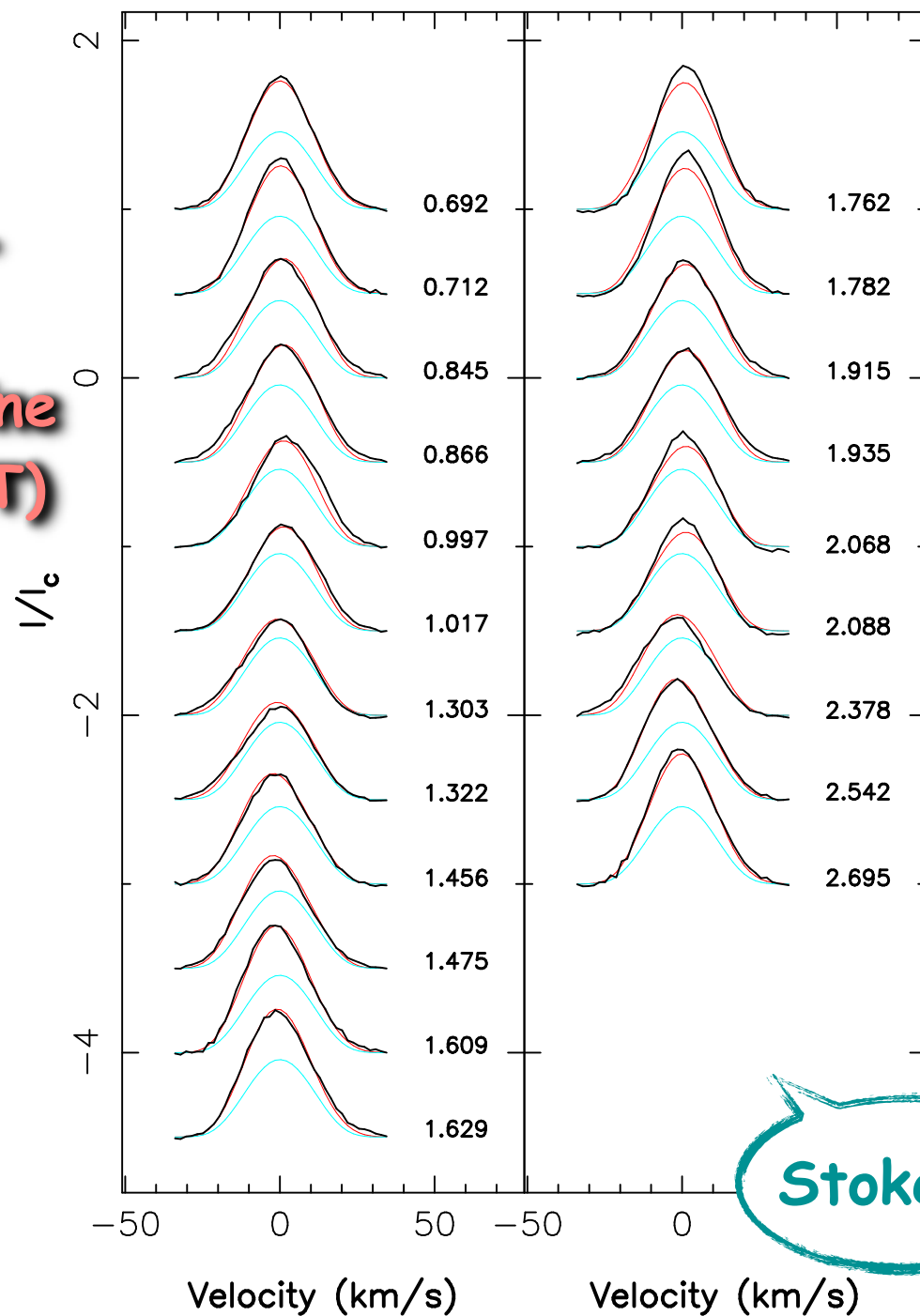
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photosphere
(LSD
profiles)



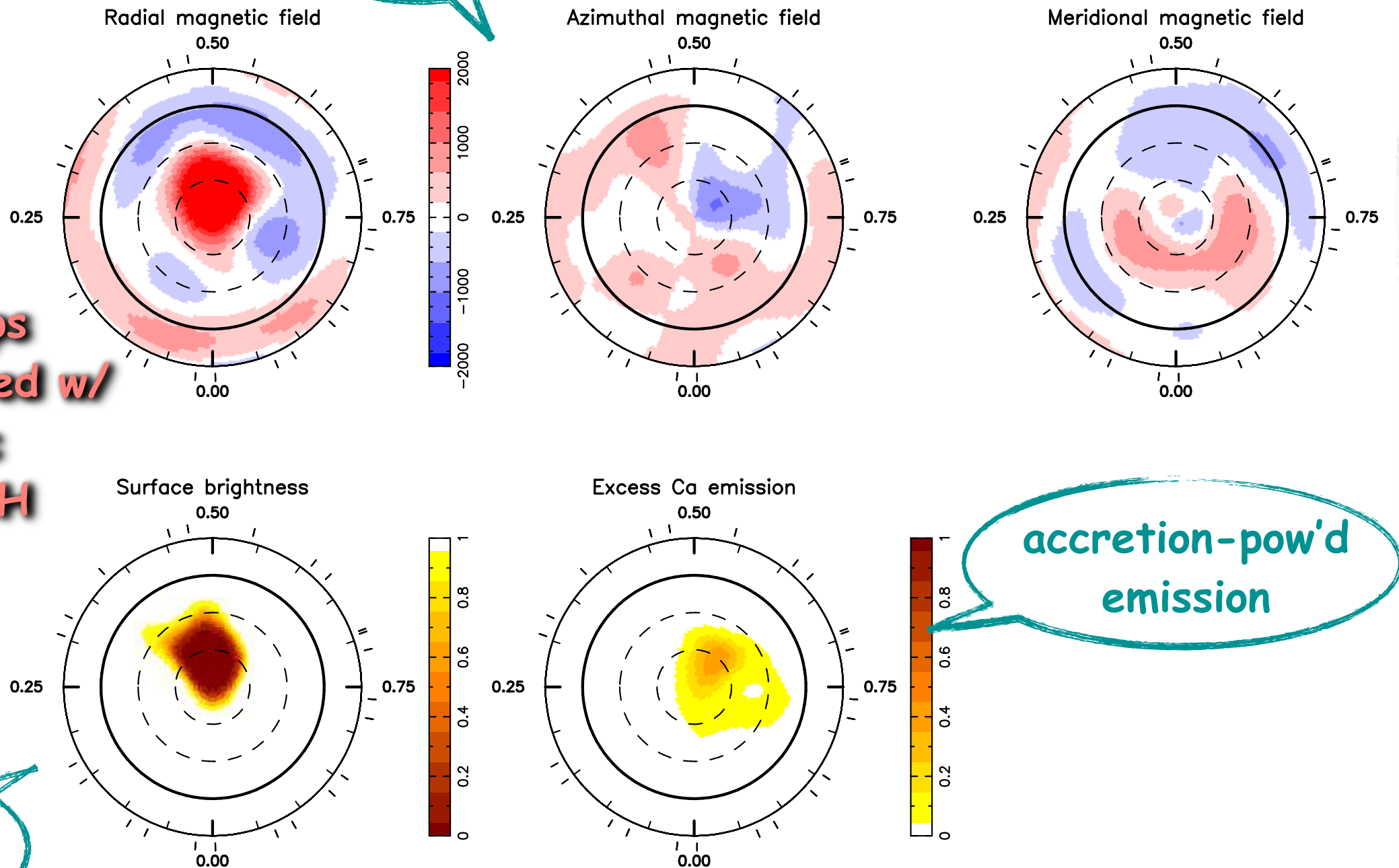
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accretion-
powered
emission line
(Ca II IRT)



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B field



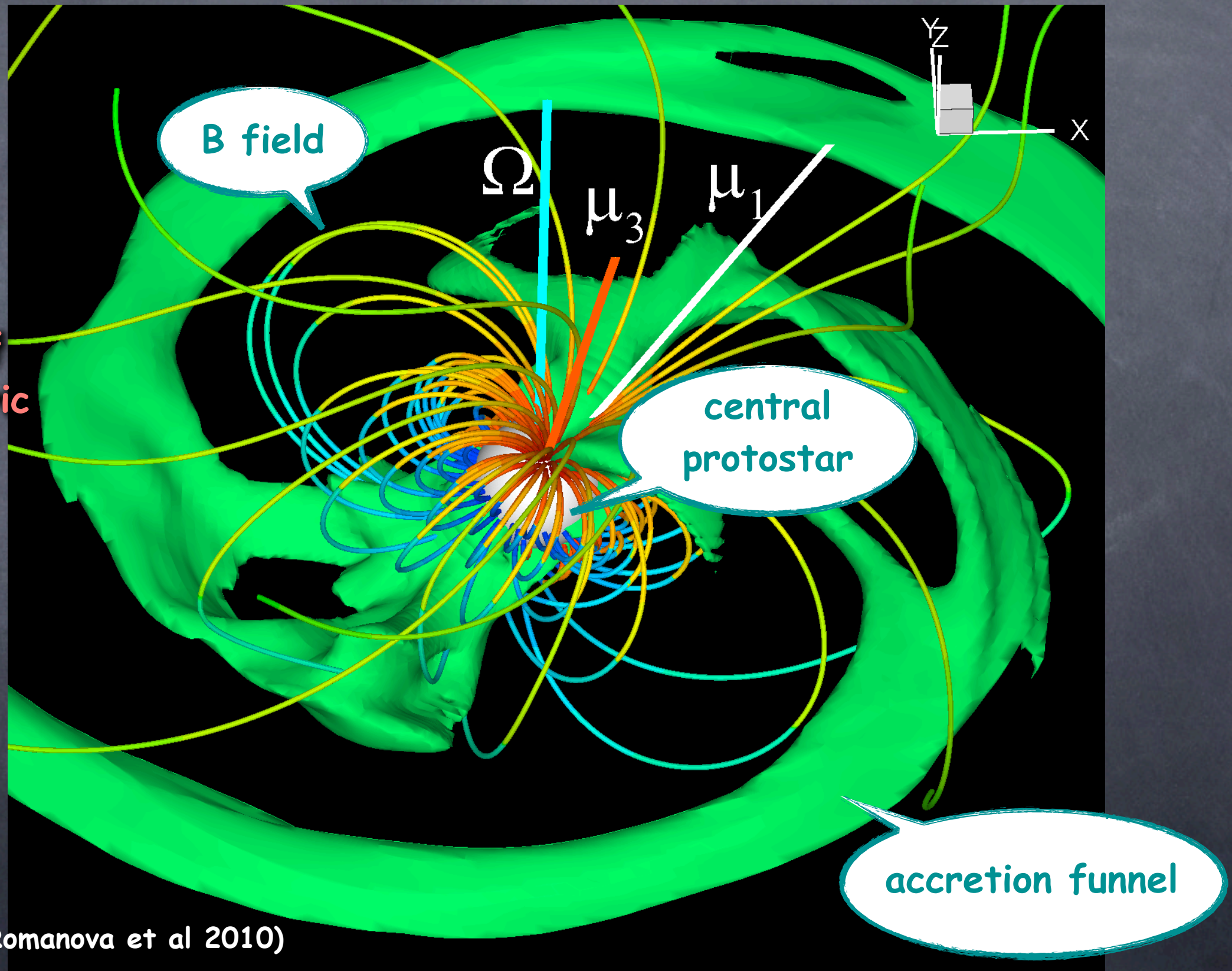
surface maps
reconstructed w/
tomographic
imaging & SH
expansions

photospheric
brightness

accretion-pow'd
emission

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3D numerical simulations of magnetospheric accretion



(Romanova et al 2010)

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results obtained to date & expected soon

- * large-scale B fields of cTTSs variable on timescales of a few years
 - ➔ produced by a non-stationary dynamo
- * large-scale B field of fully-convective (AA Tau-like) cTTSs
 - ➔ strong enough to slow-down rotation (propeller)
- * more to come (COUP 932, TW Hya, DG Tau)
 - ➔ extend parameter space
- * no detection on V1515 Cyg, V1057 Cyg & Z CMa but dense coverage of FU Ori
 - ➔ study disc field in more details
 - ➔ revised schedule for 2010b-2012b

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revised MaPP schedule proposed for 2010b-2012b

semester	stars	allocated (hr)	comments / changes
2010b	AA Tau, DN Tau, DK Tau	72	coordinate w/ COS@HST
2011a	V2247 Oph, GQ Lup, RU Lup	64	in place of V1515 Cyg / V1057 Cyg (-64 hr wrt old schedule)
2011b	BP Tau, SU Aur, DF Tau	55	adding in DF Tau (+13 hr)
2012a	TW Hya, V2129 Oph, RY Lup	39	adding in RY Lup (+13 hr)
2012b	COUP 932, DG Tau, AA Tau, DN Tau, DK Tau	124	replacing T Tau & RY Tau w/ DN Tau & DK Tau; more time on COUP 932 to estimate nebular contribution to emission lines (+28 hr)
		354	ie 690 - 336 hr

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potential extensions to MaPP

- * extend B monitoring of 4 prototypical cTTSSs from 2013a to 2014b (AA Tau, BP Tau, V2129 Oph, V2247 Oph, 1 star per semester) by 2yr yielding baselines of 5-9yr
 - ➔ better characterize long-term B fluctuations & associated impact on angular momentum evolution
 - ➔ requires 85 hr on 4 semesters (12% of MaPP alloc)
- * small survey of large-scale B fields of wTTSSs w/ \neq masses & rotation rates using both ESPaDOnS@CFHT & NARVAL@TBL
 - ➔ missing link between MaPP & existing MS survey
 - ➔ requires 98 hr on 4 semesters (14% of MaPP alloc)

Magnetic Protostars & Planets

MaPP-related studies & reviews based on CFHT data:

refereed

MaPP

publications

2008-2010

- * Donati JF, Jardine MM, Gregory SG et al, 2008, MNRAS 386, 1234
- * Donati & Landstreet 2009, ARA&A 47, 333
- * Donati JF, Skelly MB, Bouvier J, et al 2010a, MNRAS 402, 1426
- * Donati JF, Skelly MB, Bouvier J, et al 2010b, MNRAS in press, [astro-ph:1007.4407](#)
- * Donati JF, Bouvier J, Walter FM, et al, 2010c, MNRAS submitted
- * Skelly MB, Donati JF, Bouvier J, et al, 2010b, MNRAS to be submitted soon

MaPP-related studies based on complementary data:

- * Hussain GAJ, Cameron AC, Jardine MM, et al, 2009, MNRAS 398, 189
- * Skelly MB, Donati JF, Bouvier J, et al, 2010a, MNRAS 403, 159
- * Argiroffi C, Flaccomio E, et al, 2010, A&A to be submitted soon

Theoretical modeling, numerical simulations & reviews based on MaPP studies:

- * Jardine MM, Gregory SG, Donati JF, 2008, MNRAS 386, 688
- * Gregory SG, Matt SP, Donati JF, Jardine MM, 2008, MNRAS 389, 1839
- * Mohanty S, Shu FH, 2008, ApJ 687, 1323
- * Gregory SG, Jardine MM, Gray CG, Donati JF, 2010, RPP in press, [astro-ph/1008.1883](#)
- * Romanova MM, Long M, Lamb FK, et al., 2010, MNRAS in press, [astro-ph:0912.1681](#)
- * Long M, Romanova MM, Kulkarni AK, Donati JF, 2010, MNRAS submitted, [astro-ph:1009.3300](#)