The pre-main sequence evolution (1Myr -> 1Gyr) of Solar System precursors: an UV view.

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MENU

UV excess

Decreases towards MS

Accretion UV emision redshifted

Wind unresolved, Stellar?

Extended magneto-spheres

Wind shocks

Jets & HHO

TO BE SHOWN IN THIS TALK

1. Circumstellar absorption around Solar System precursors clears up at age about 1Myr => UV obs. feasible

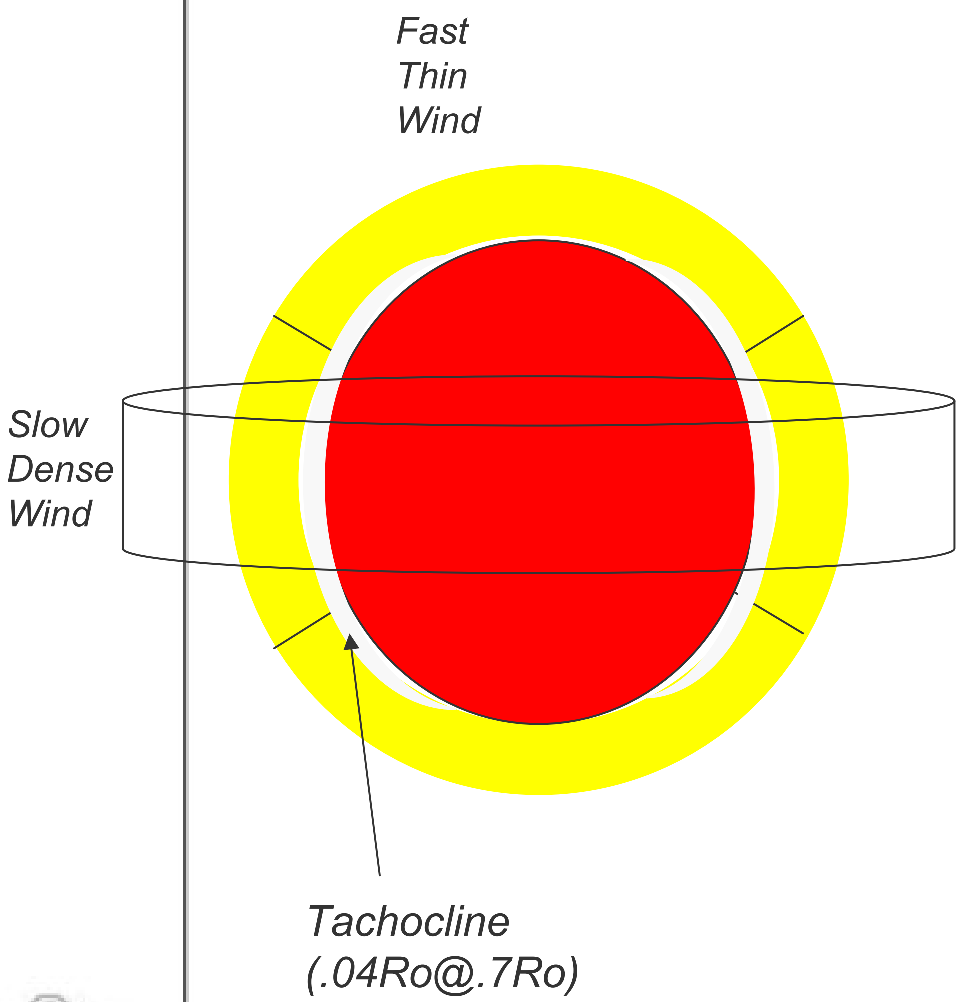
2. There is hot (10^4-10^5K) component with luminosity ~0.2Lo which strength declines as the star approaches the main sequence

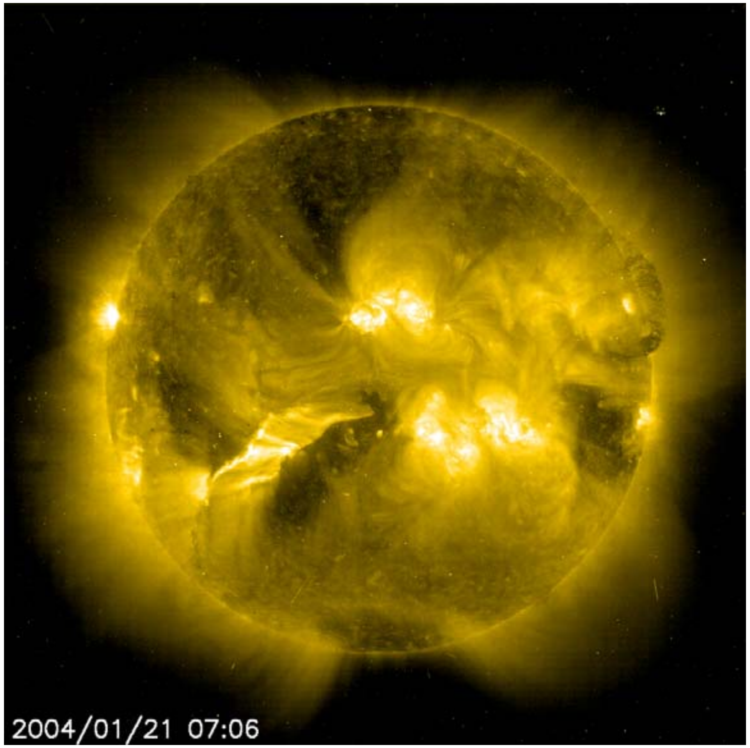
3. This hot component includes contributions from:
- Accretion shocks
- Winds (stellar)
- Rotating structures undergoing large shears
- Wind-shocks with disk material

4. Collisions with fast electrons is likely the source of H2 excitation in HH objects. Fast electrons are associated with plasmoid ejections.UV contains important clues on outflow source also at large scales

MENU

PRELIMINARIES – HOW DOES THE SUN WORK





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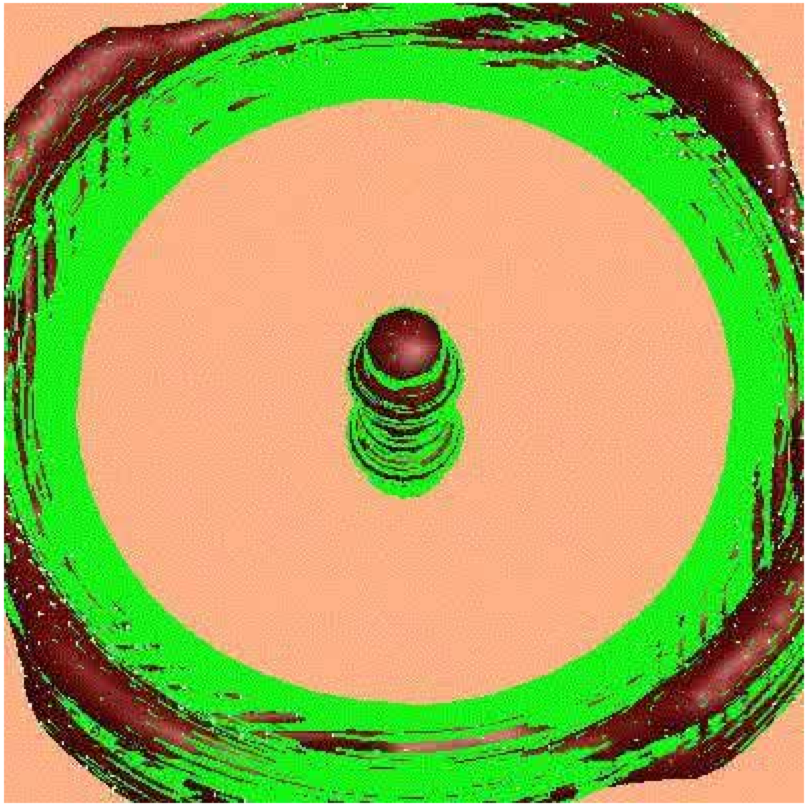
PRELIMINARIES – HOW THIS COMPARES WITH TTSs



von Rekowsky & Branderburg 2004

Simil. with SOLAR dynamo

Gravity drives the main matter flow

B-field is built in a turbulent dynamo and driven into the shear layer by gravity

Differential rotation amplifies the field and shear produces a strong toroidal component

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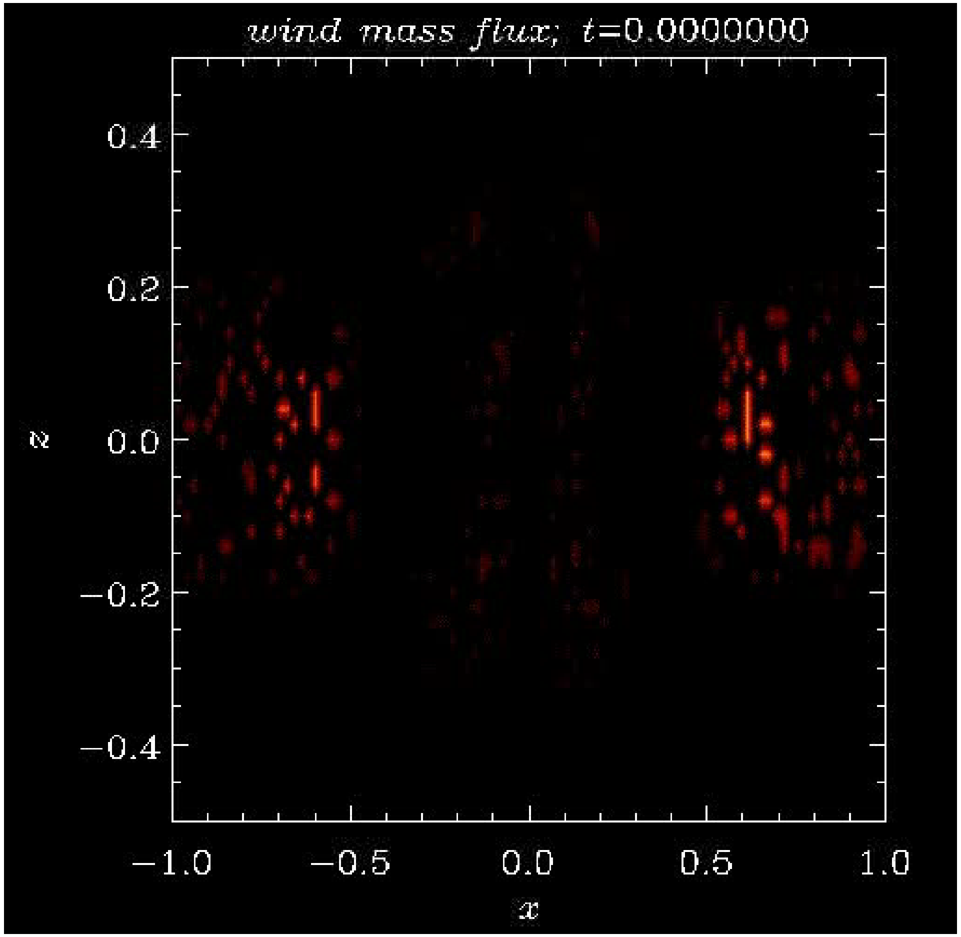

von Rekowsky & Branderburg 2004

DIFFERENCES:

Pressure gradient

Magnetic buoyancy
vs.
Magnetic pressure

Matter inflow controlled
by field dissipation rate?

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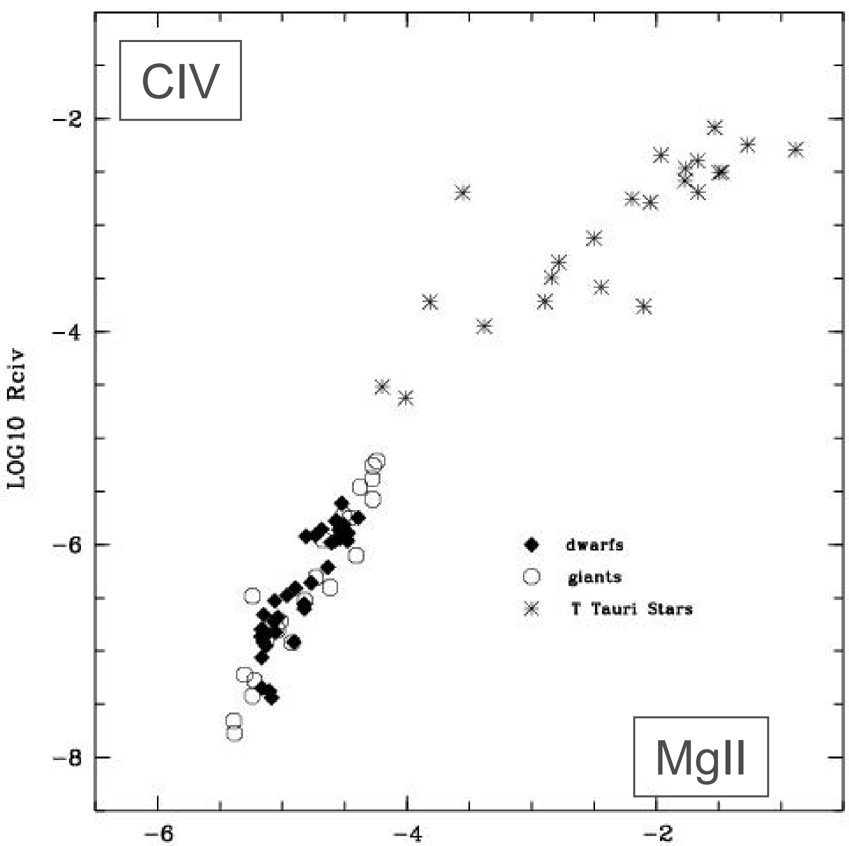
Solar progenitors are much hotter than Solar-like stars

T Tauri stars have UV and X- excesses with luminosities exceeding by 2-3 orders of magnitude those of main sequence stars

UV luminosities up to $0.2L_{sun}$

$$\left(\frac{L_{UV}}{L_{bol}}\right)_{TTS} \approx 50\left(\frac{L_{UV}}{L_{bol}}\right)_{Sun}$$



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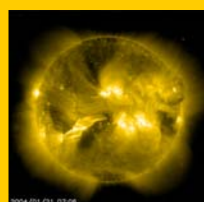
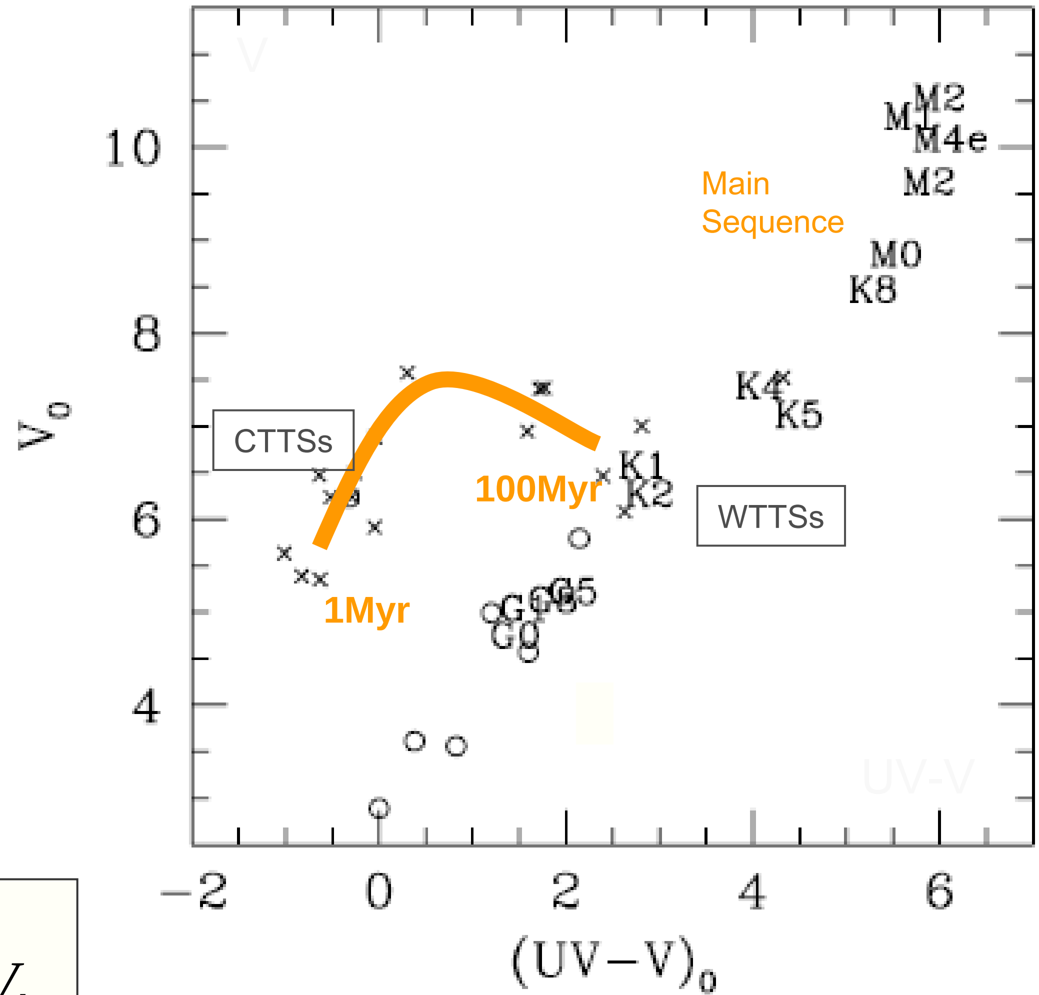
A factor of 50 enhancement on UV fluxes was converted into a factor $(20)^{1/2}$ in radius of the atmosphere – compatible with angular momentum conservation with the keplerian disk





Gómez de Castro 1997

$$\frac{B_t B_p}{4\pi} 4\pi r^2 \Delta r = \dot{M}_a r V_{kep}$$

Basics of the external tachocline – the jet engine

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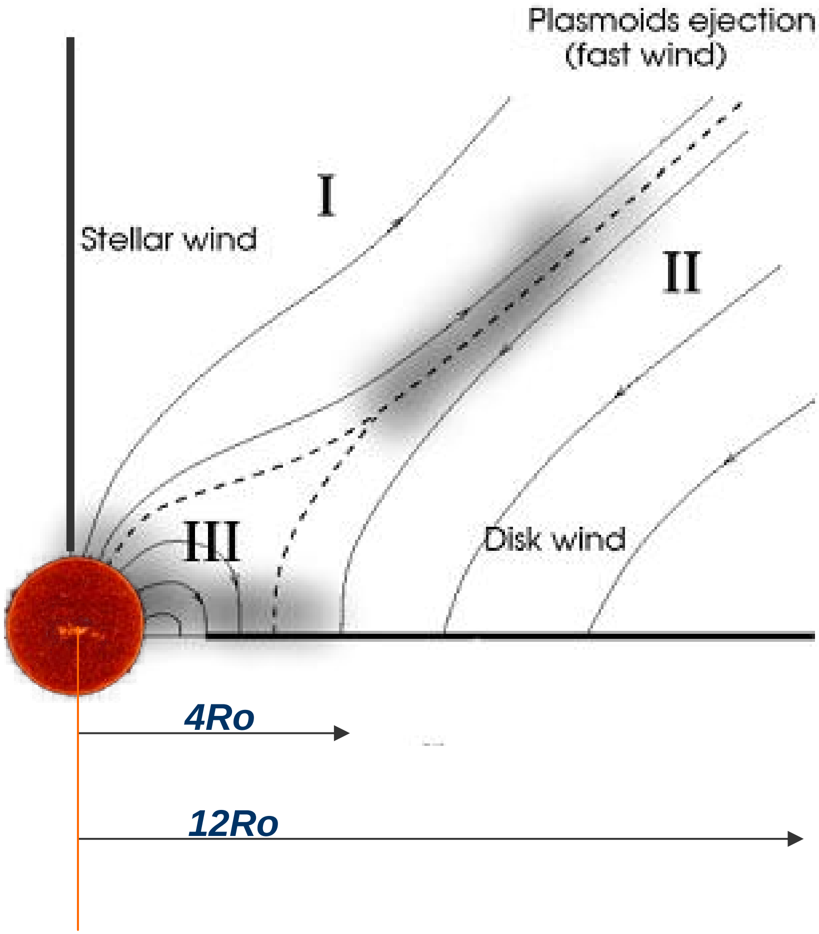
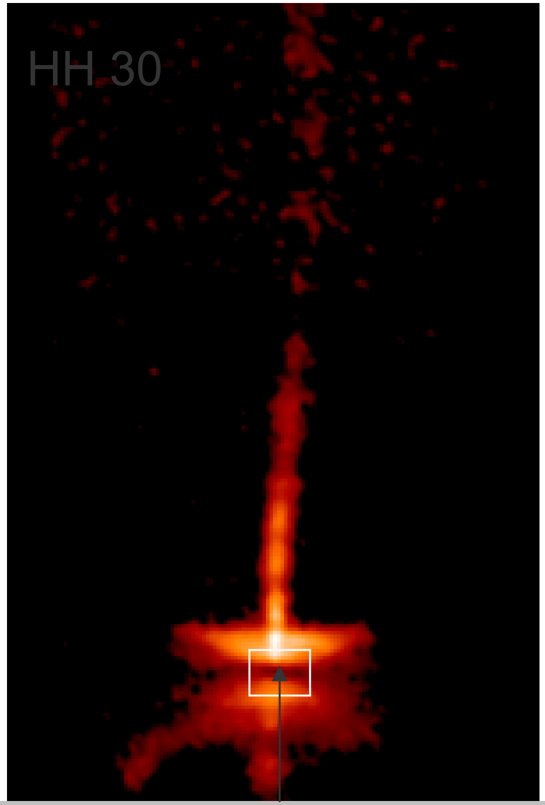


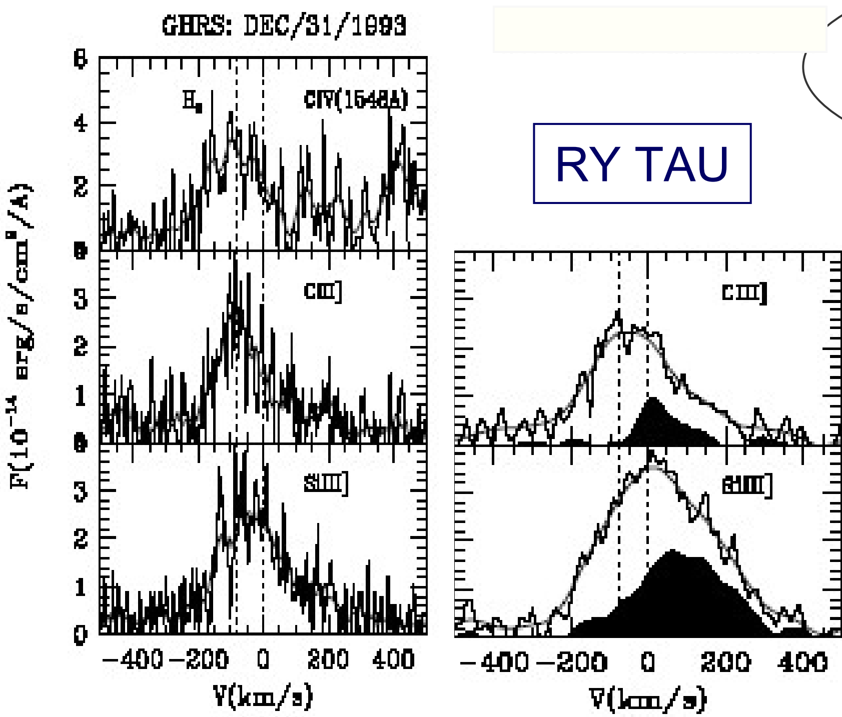
$a_{ŏ}$ =86Ro



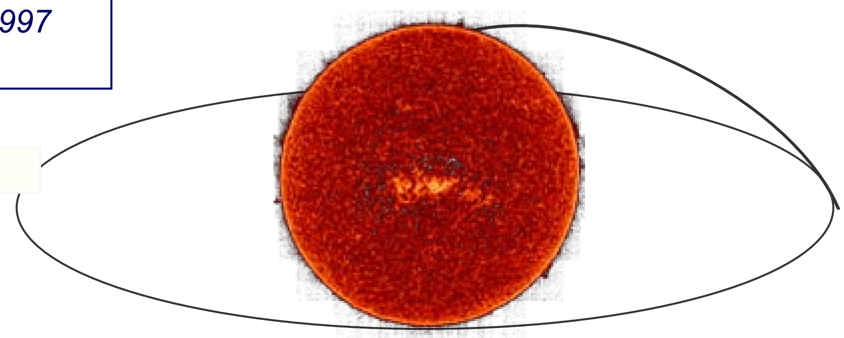
Jet engine (*mas-μas* scales)

UV radiation caused by accretion has to be released close to the surface – Scales:<R* - Basically emission in red wing

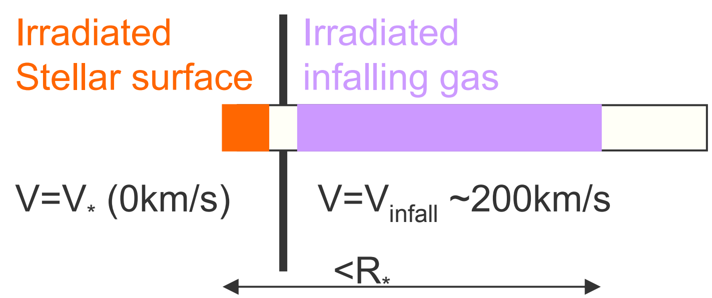
UV lines flux are rotationally modulated in BP Tau and DI Cep BUT modulation only affects to 50% of the flux
(Simon et al 1990; Gómez de Castro & Franqueira 1997 Gómez de Castro & Fernández 1996)



Gómez de Castro & Verdugo, 2007



Shock Front



Lamzin 1998
Gómez de Castro & Lamzin 1998

UV Forbidden lines show the presence of a hot (25000K), dense ($10^{10} cm^{-3}$) component associated with the outflow

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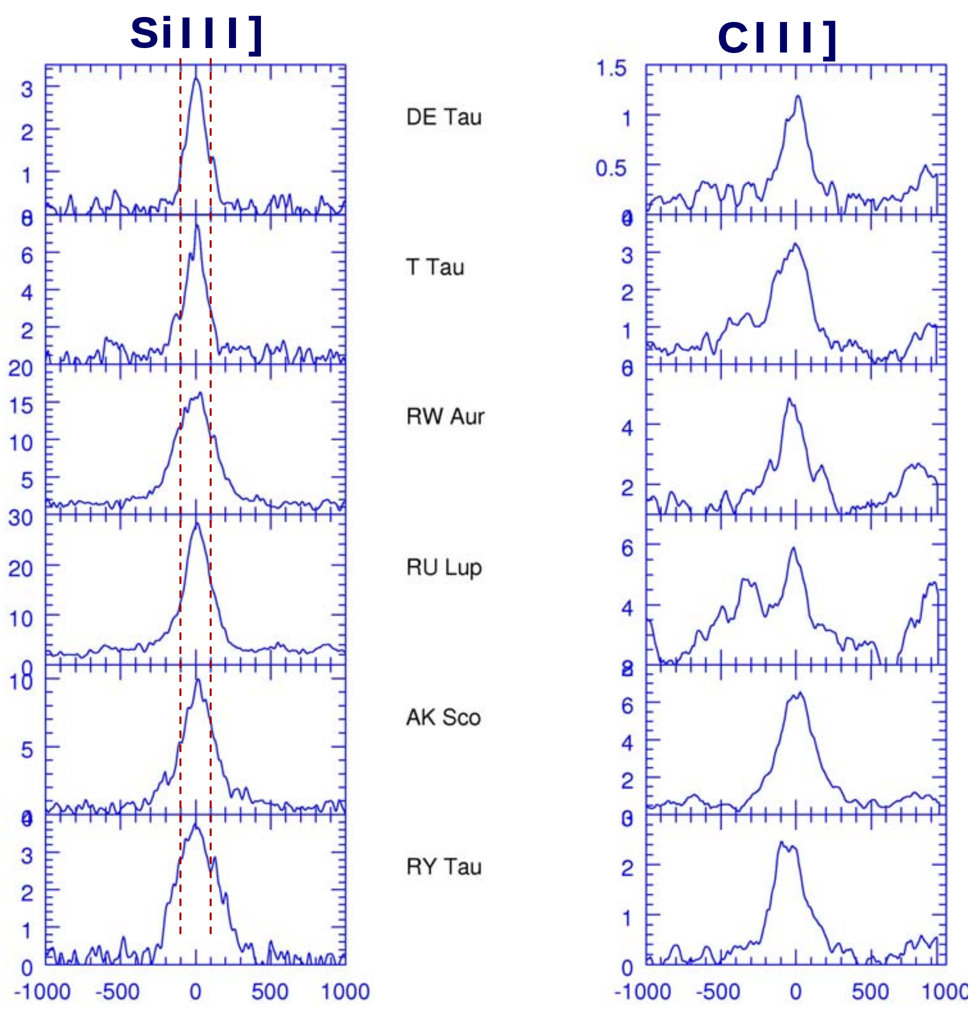


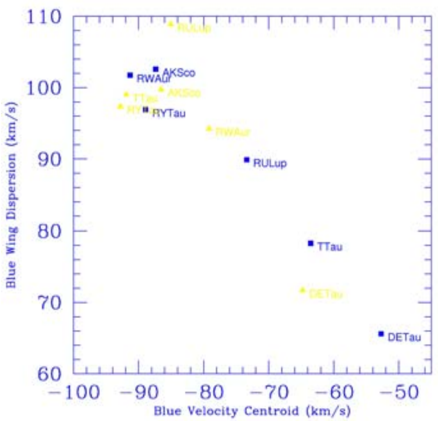
The jet has been resolved

- with HST/STIS

(Coffey et al 2006)

- with ACS/SBC

(Carpenter et al 2008)



Gómez de Castro & Verdugo, 2008

UV Forbidden lines cannot be produced in a photoionized cool disk wind BUT… what about a warm disk wind?

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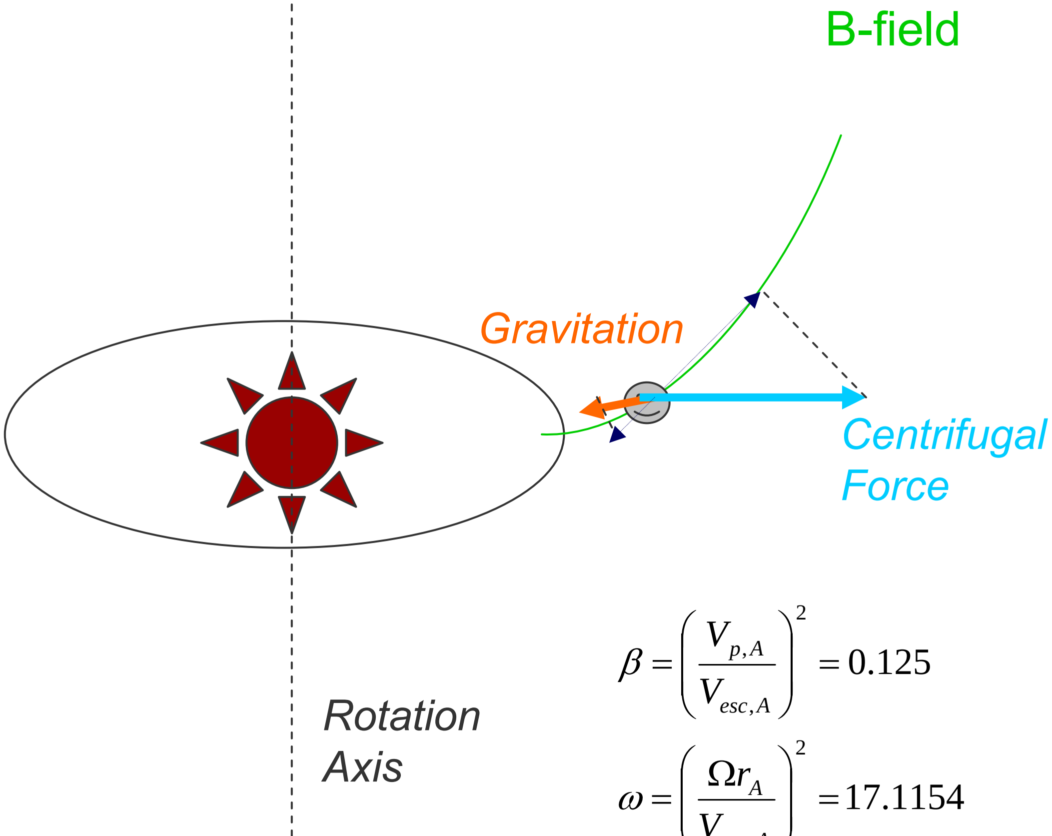


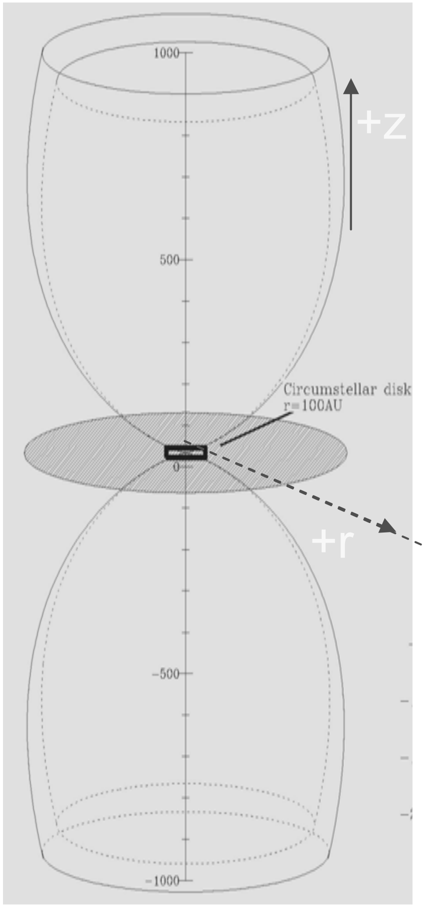
Vlahakis & Tsinganos, 2000

$$\beta = \left(\frac{V_{p,A}}{V_{esc,A}}\right)^2 = 0.125$$

$$\omega = \left(\frac{\Omega r_A}{V_{esc,A}}\right)^2 = 17.1154$$

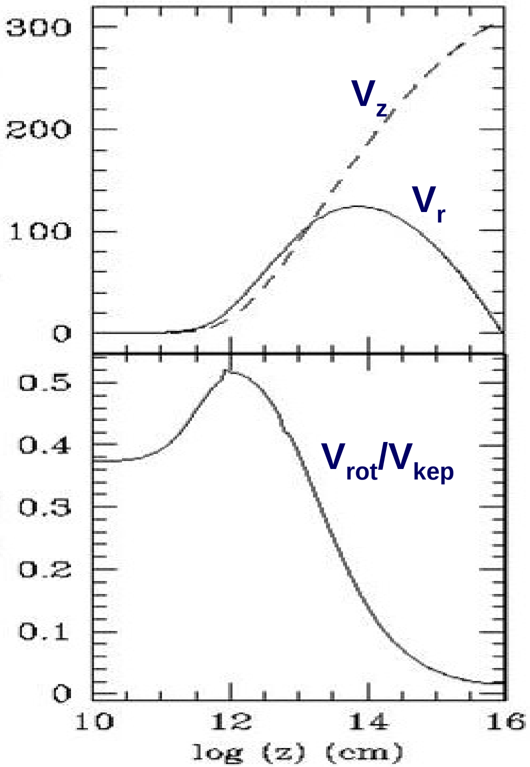
$$\theta = \left(\frac{C_{s,A}}{V_{esc,A}}\right)^2 = 0.196229$$

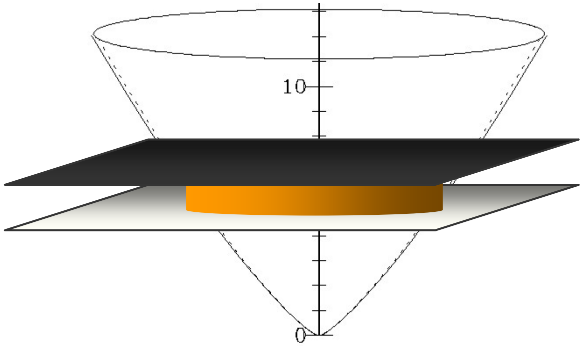
$$\gamma = 1.05$$



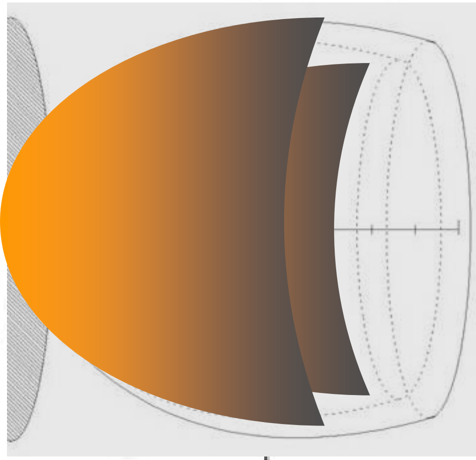
Ferro-Fontán & Gómez de Castrp 2003
Gómez de Castro & Ferro-Fontán, 2005

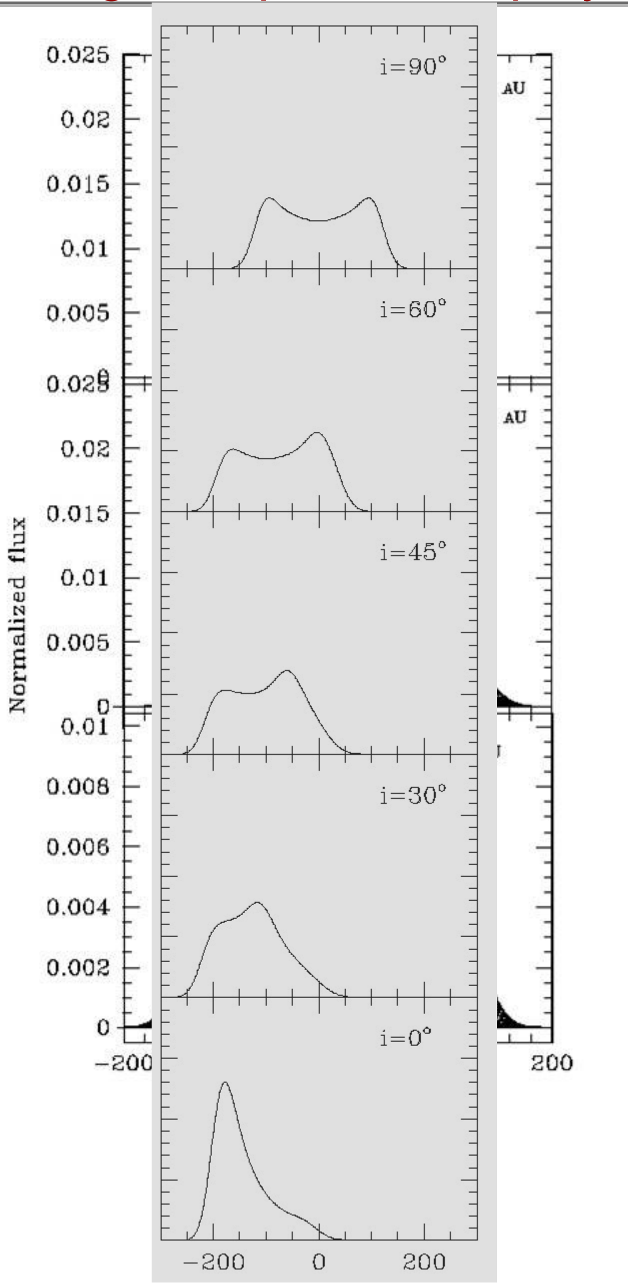
NO! lines are too narrow. These models are unable to get a rapid radial launching – It is necessary to get the magnetosphere into play





From z=0 to z=12 AU





Magnetospheric launching depends on the disk/star interaction and on the degree of magnetization from the disk

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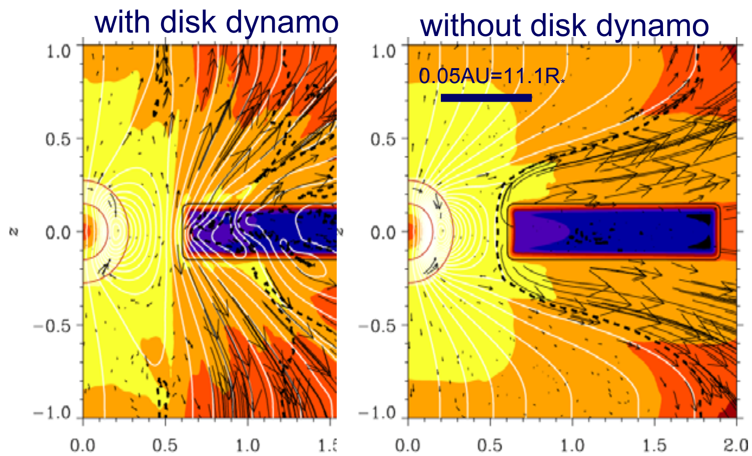
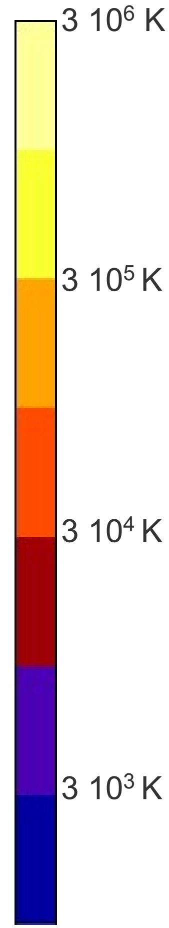
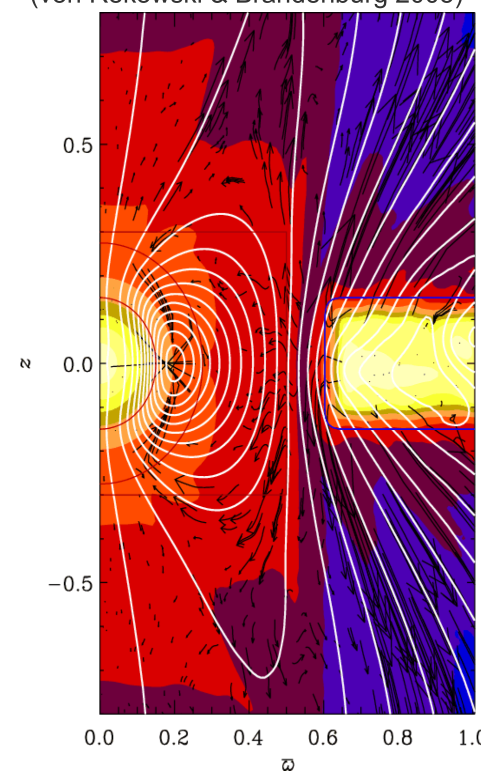
$B_* \approx 1$ kG





(von Rekowski & Brandenburg 2005)



The black dashed lines shows the Alfven surface.

Left/ the Alfven surface is outside the main acceleration region of the wind and magneto-centrifugal launching is significant.

Right/ the Alfven surface is inside the acceleration region, e.g., wind is pressure driven.

The accretion flow, at maximum, for ($B_* \approx 1$ kG) with the disk dynamo.

Colors code increasing density and arrows mass-flux.

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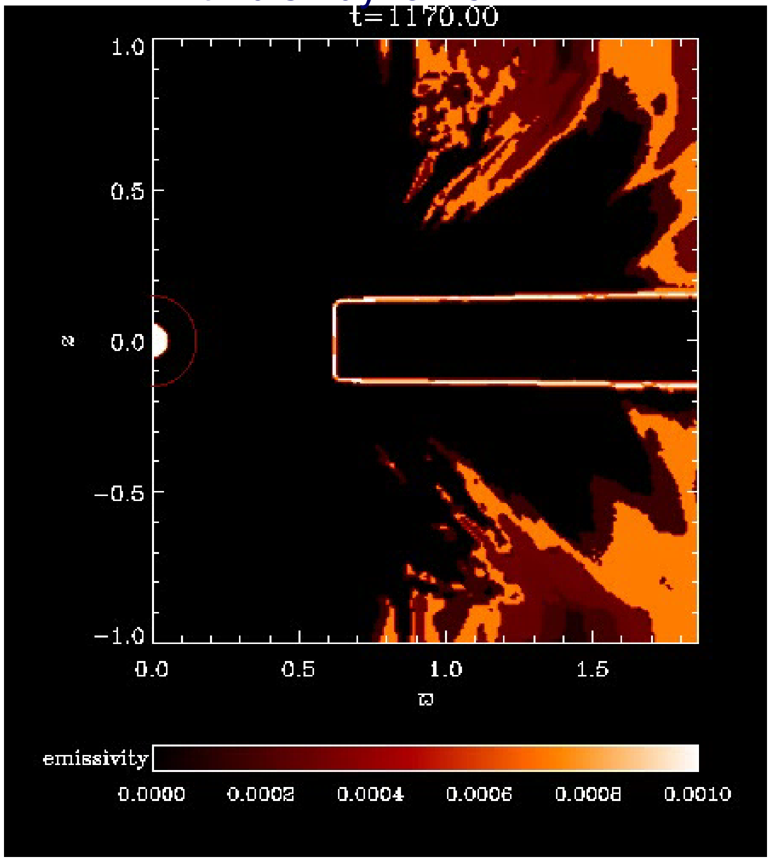
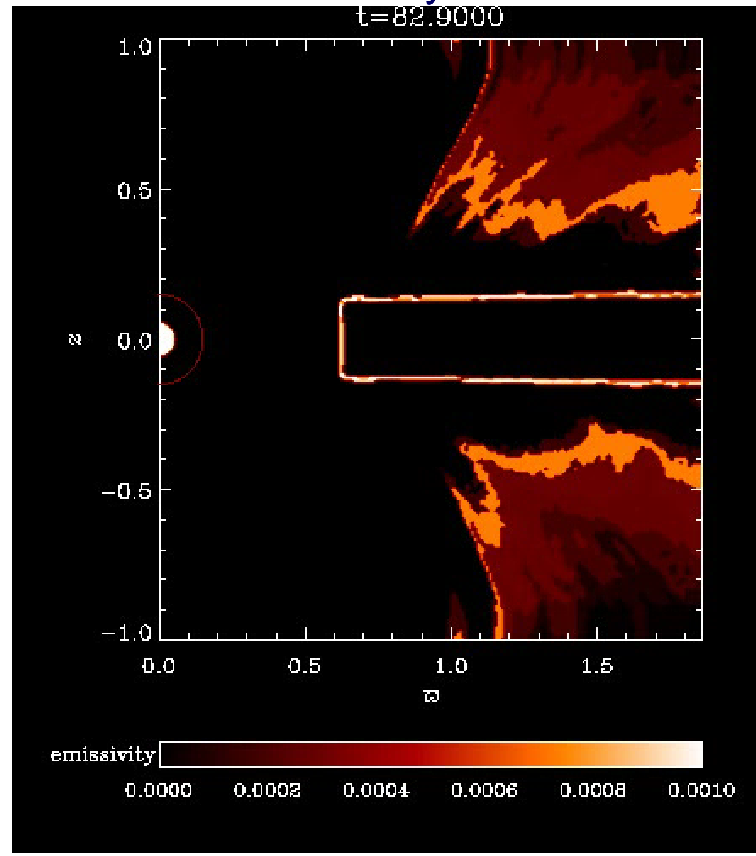
This shows on the spatial distribution of the UV forbidden lines emission region

with disk dynamo



without disk dynamo



Gómez de Castro & von Rekowski, 2008

and in the profiles that become broader and vary from quiescent to stationary phase

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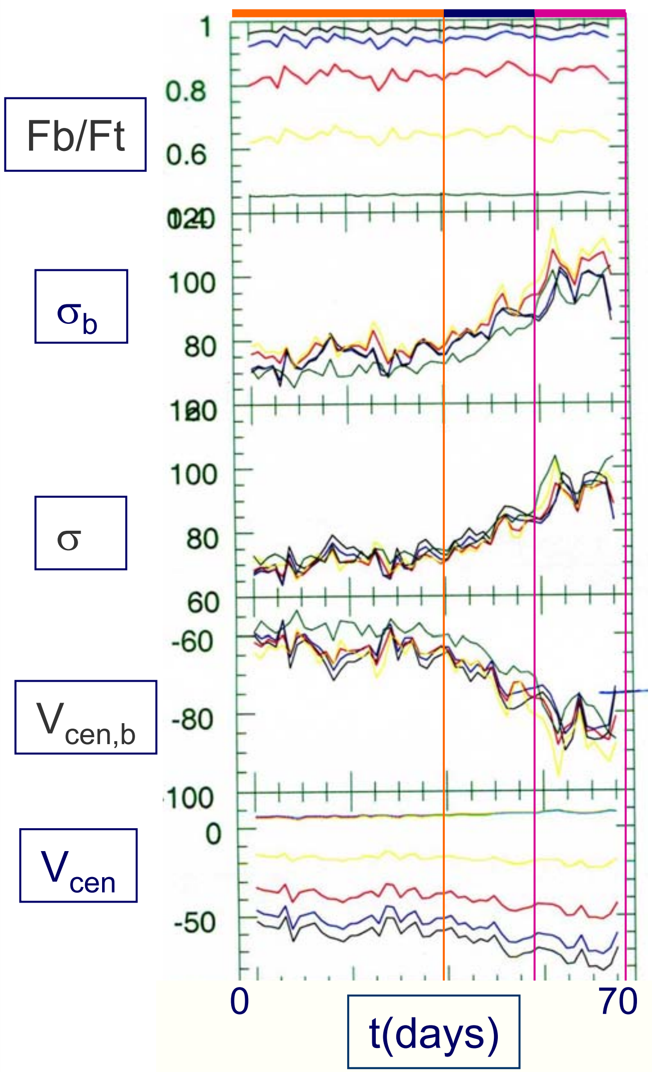

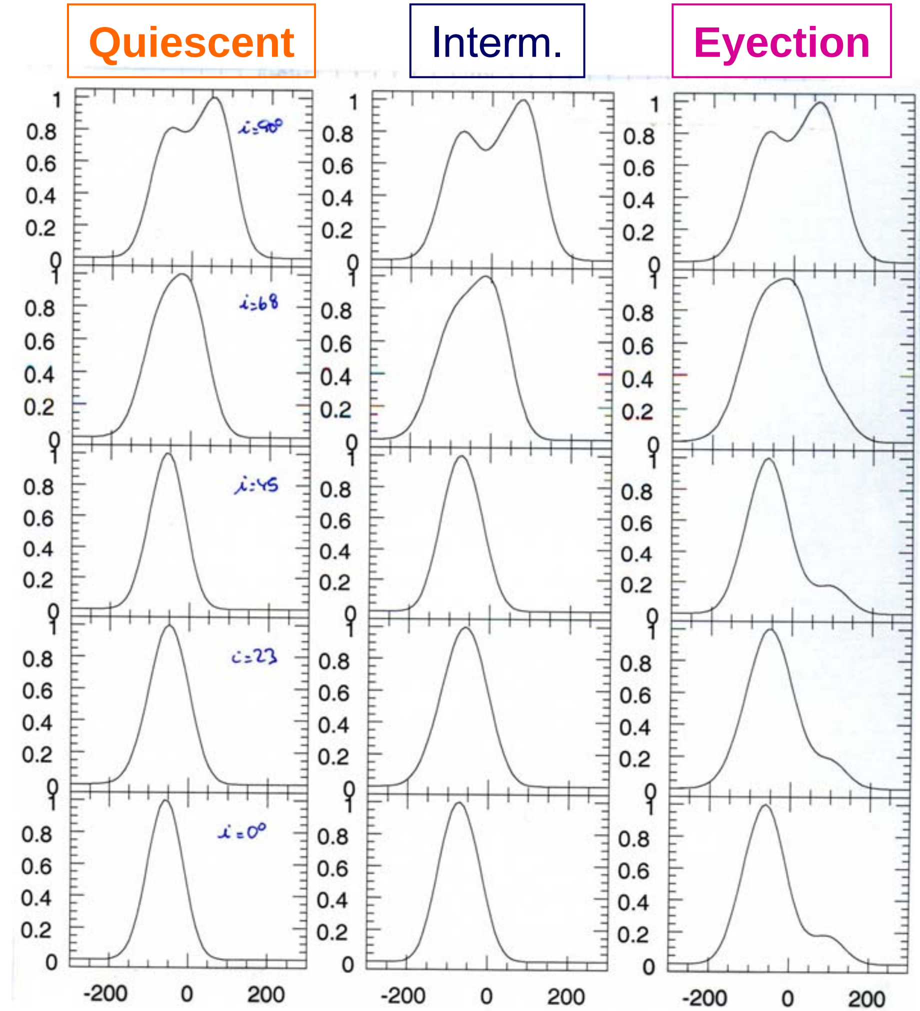

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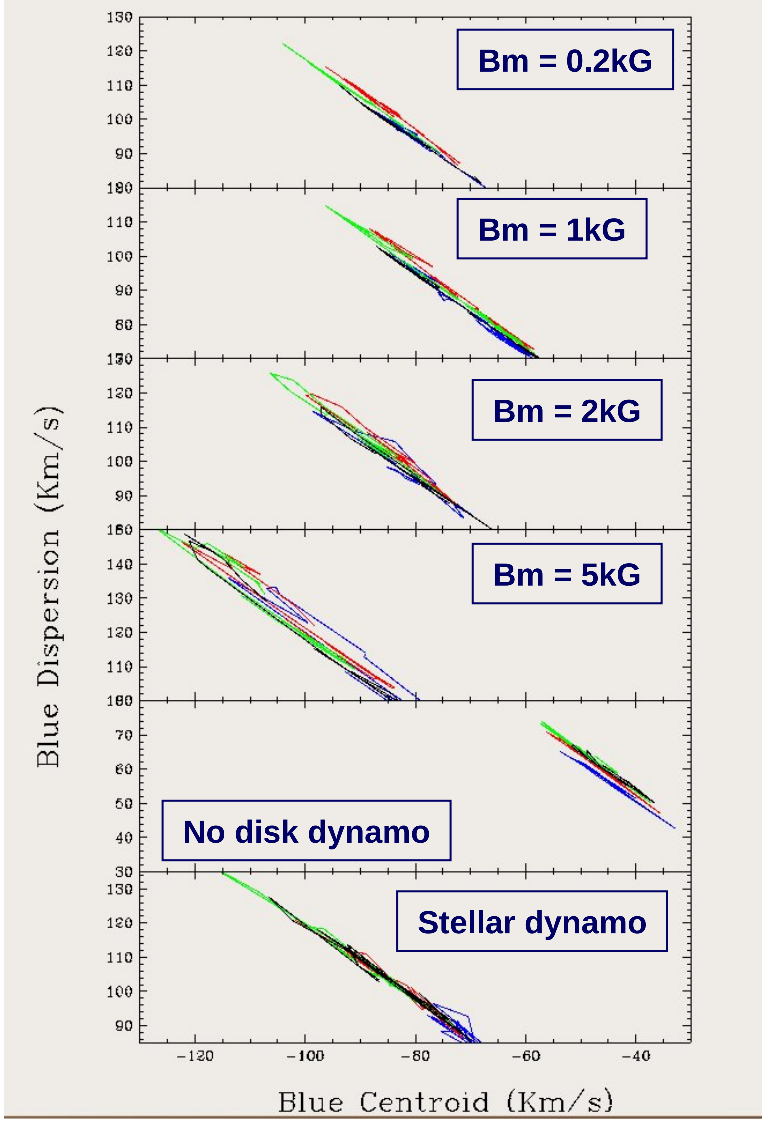
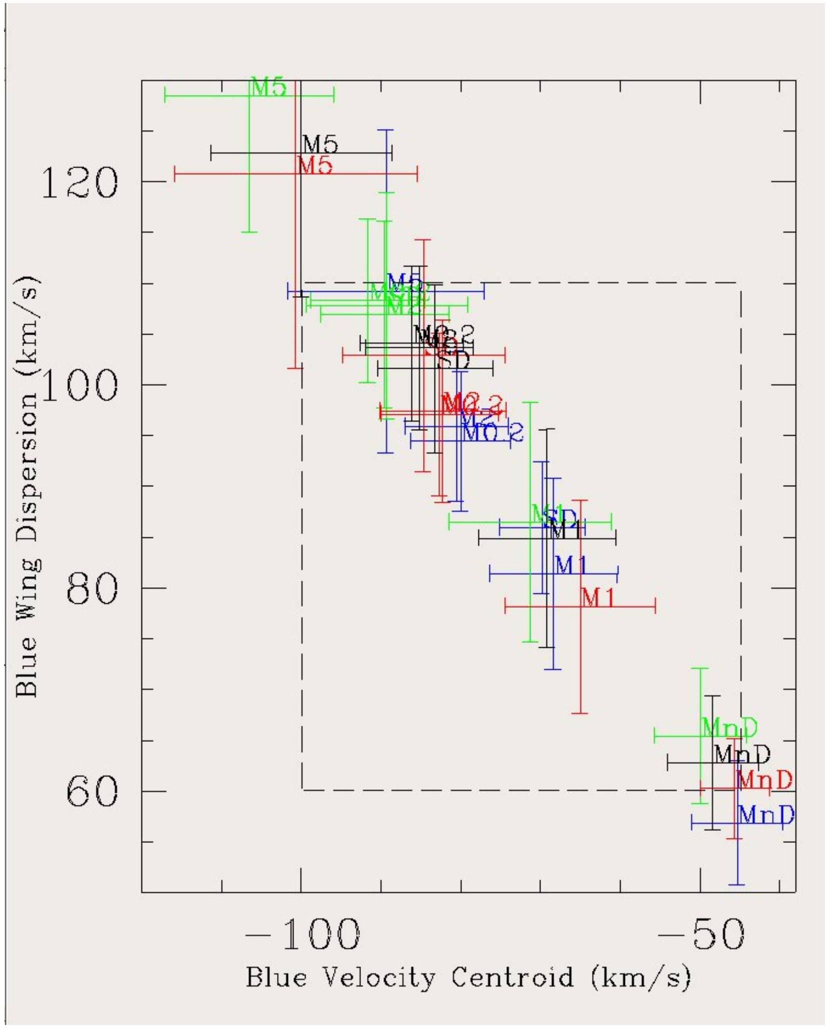
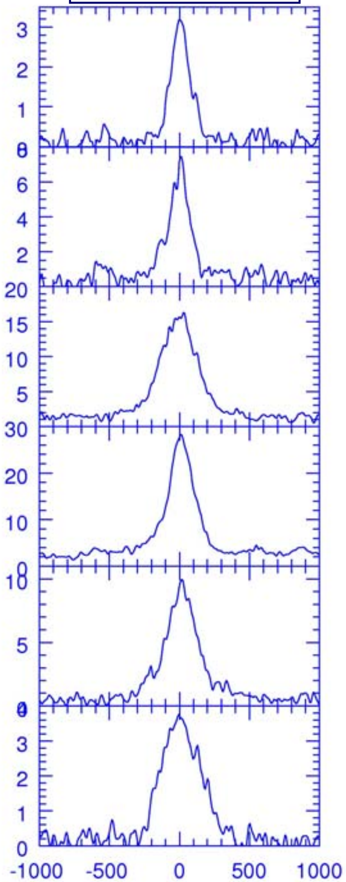


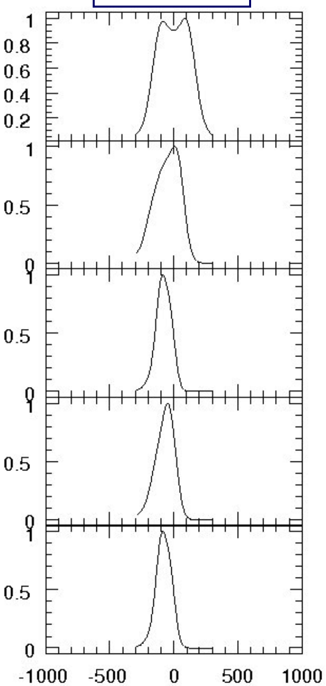


EVEN IN THIS CASE SOME OF THE PROFILES ARE TOO BROAD TO BE PRODUCED BY THE WIND…

HST Obs.



Model



If inclination effects are taken into account these models are able to fit the extended blue wings but not the whole profile broadening

A non-sheared (corotating) magnetosphere will have to extend to ~10R*

This does not fit the flux constraints

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Thus! Emission is produced in hot plasma rings (as the planetary or stellar belts) **around some TTSs**

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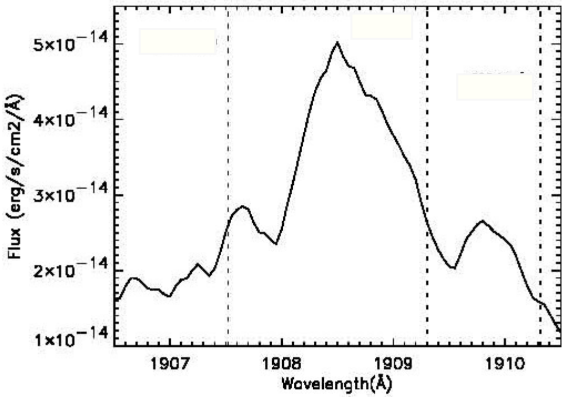
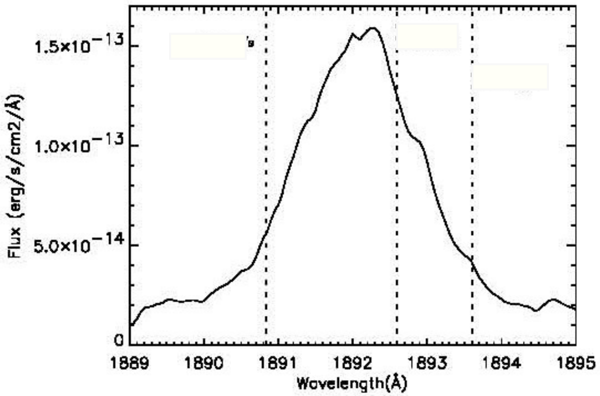
RW AUR





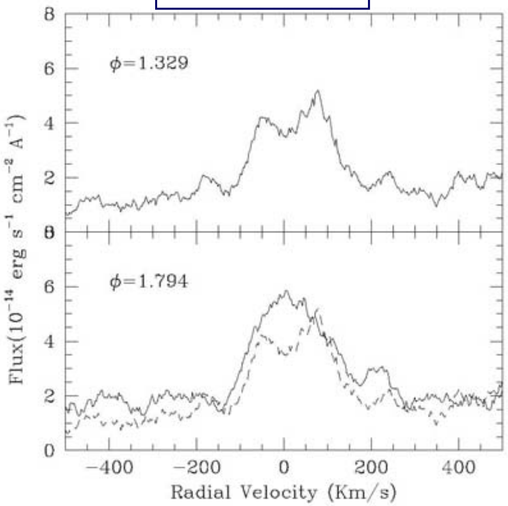
Gómez de Castro & Verdugo 2003

$n=1.4\ 10^{11}$ cm^{-3}

V=170 km/s ----->7.7 -8.8 R$_*$ (if corotating)
----->2.7 R$_*$ (if kepplerian)

(Corotation radius = 6.1 R$_*$)

AB Dor



Gómez de Castro 2002

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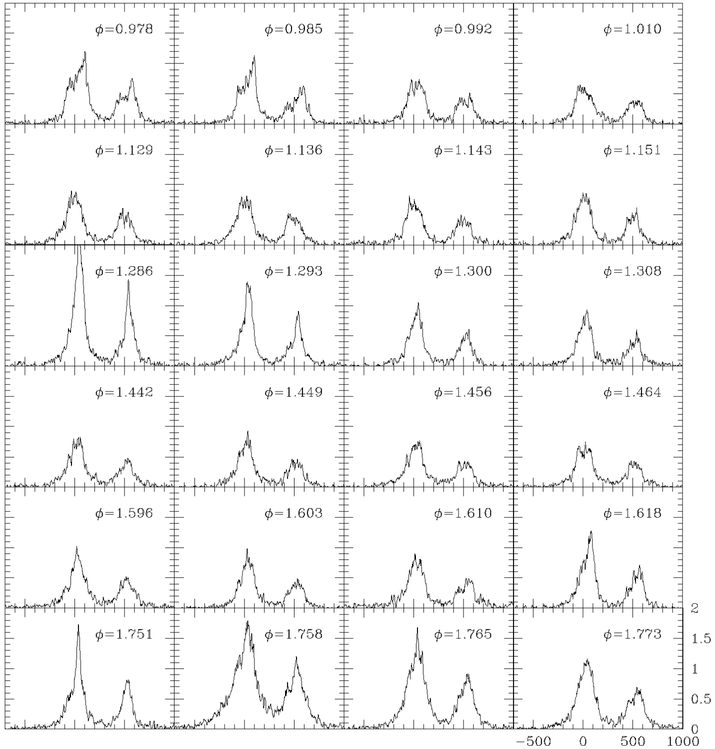
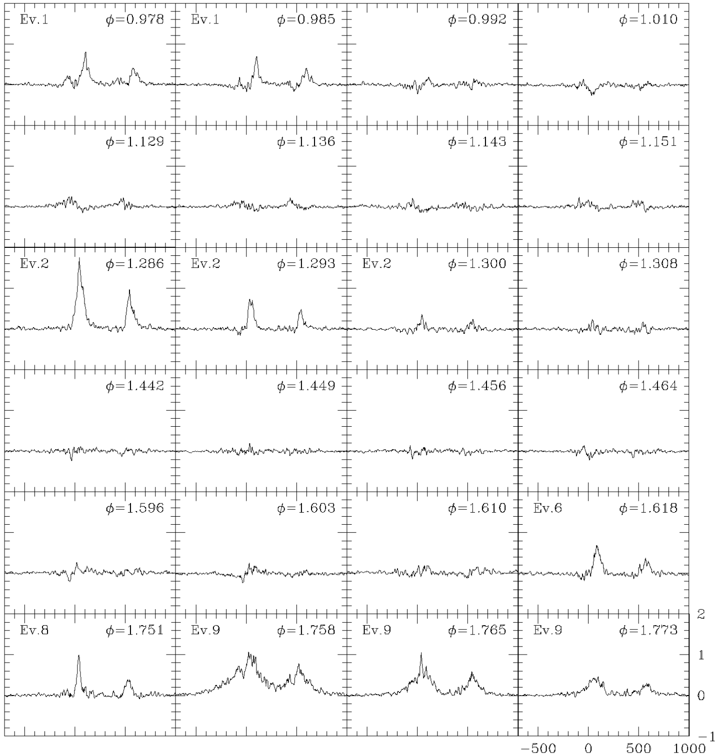
UV MONITORING OF **AB DOR** FLARING ACTIVITY HAS ALLOWED TO IDENTIFY, **FOR THE FIRST TIME, Pre-MS CIRs**

CIV [uv1] lines - observed



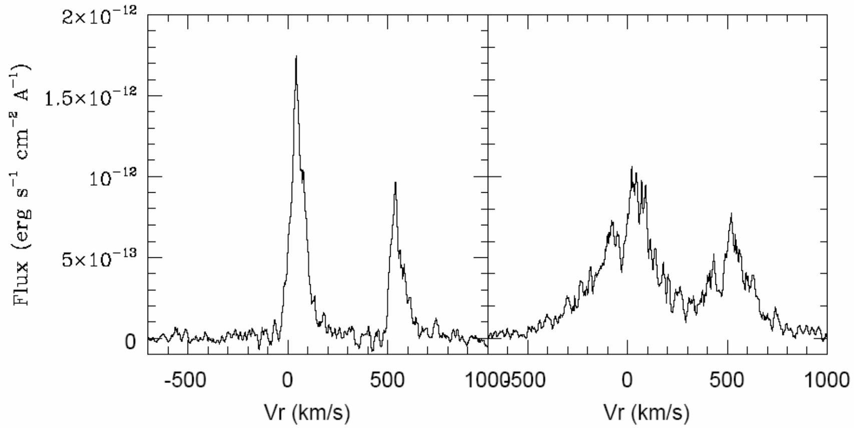
CIV [uv1] lines – flare contribution



Gómez de Castro 2002

AB Dor Properties:
Age 20-30 Myrs
Rotation Period: 0.51479 d
Surface field: >500 G

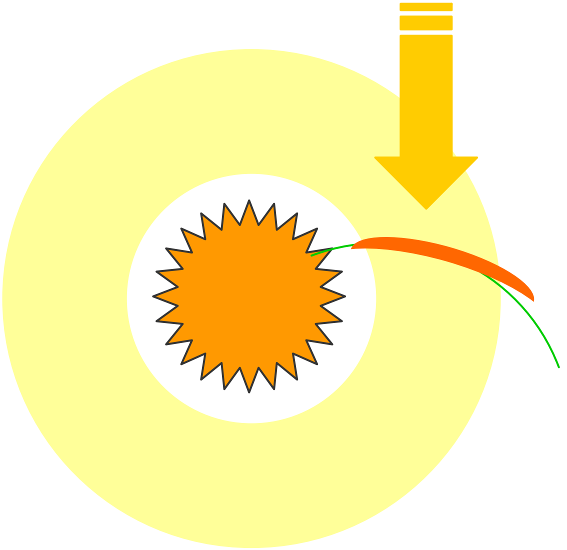
UV monitorings to study the interaction star-disk
(space weather at the time planetary atmospheres settle down)



The *very broad wings* profiles and the narrow central absorption indicates OBLIQUE SHOCKS

- Between the fast and slow stellar wind components? – CIRs?

- Between the stellar wind and the young planetary disk?



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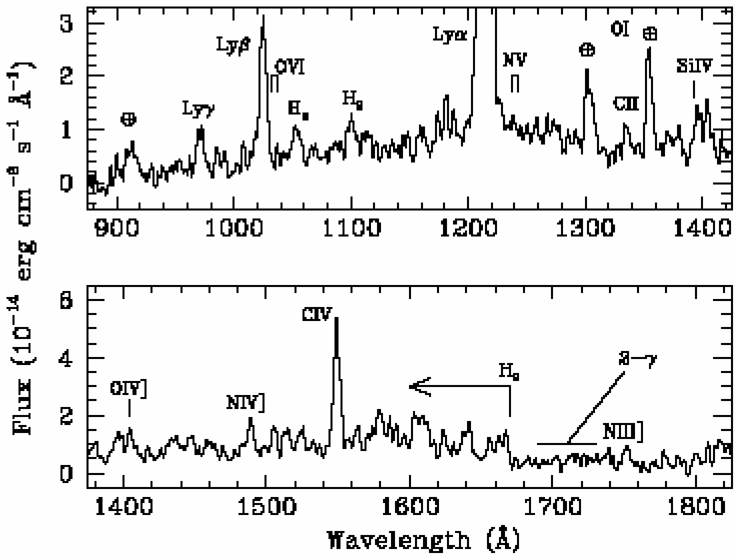
Large scale outflows show two components in the UV; are they caused by HD or MHD (plasmoid shocks)?



Two phase model:

- *warm component* (T=10^4K, n_e =10^3cm^{-3})
- *hot, dense component* (T=10^5K and n_e = 10^6cm^{-3}) and filling factor 0.1%-1%.

(from HH29 optical and UV observations by Liseau et al. 1996)

How the kinetic energy of the flow is damped into radiation?

Radiative cooling models cannot reproduce HH2 observations: strong CIV and H_2 emission with no OVI emission

(HUT: Raymond et al. 1997)

How H_2 emission is excited (in high excitation HH objects)?

Maybe collisional pumping of the H_2 levels by “hot” electrons Are this hot electrons associated with plasmoids

(Raymond et al. 1997)

MENU

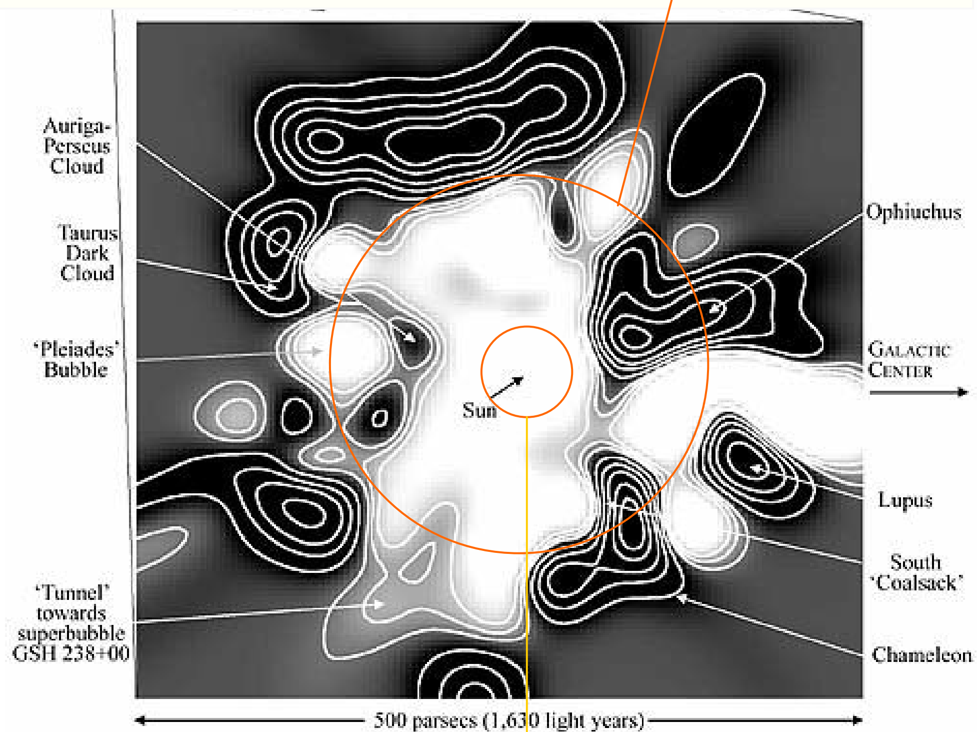
WHAT NEXT?

2013-2023

Russia
Spain
Germany
China
Ukraine

Distribution of star forming complexes around the Sun

HST/COS
WSO/HIRDES



STIS

AB Dor is at 14 pc

TW Hya is at 56 pc – the farthest we can reach with a reasonable SNR for a classical TTS

There are several laboratories within 140 pc: Taurus, Lupus, Ophiuchus

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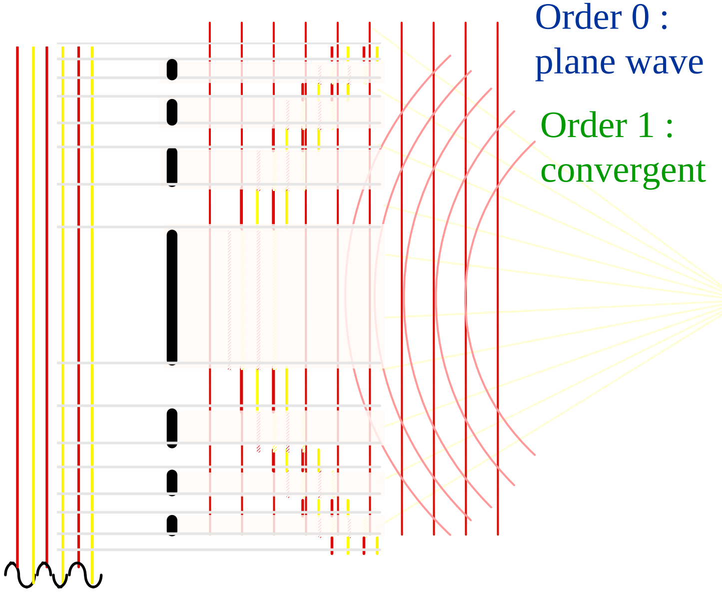
WHAT NEXT?

>2025:

TWO COMPONENTS FLYING FORMATION TELESCOPE
Focusing by difraction

Key technology: Ionic engines for a long living facility



40 pc 70 pc 140 pc