ON THE RELEVANCE AND FUTURE OF UV ASTRONOMY

- The relevance of the UV spectral range for astrophysics
- What is available now?
- Instrumental requirements for the future
- Actions:
  - Network for UV Astrophysics (NUVA)
  - Space missions on the table

1. The relevance of the UV spectral range for astrophysics

- The UV range supplies a richness of experimental data which is unmatched by any other domain for the study of ***hot plasma with temperatures in between 10^4K and 10^5K***.

  Diffuse baryonic component of the Universe – warm/hot gas (the largest filling factor by volume)

- In addition the ***electronic transitions of the most abundant molecules***, such as H_2, OH, or CO, are observed in this range which is also the most sensitive to the presence of large molecules such as the PAHs.

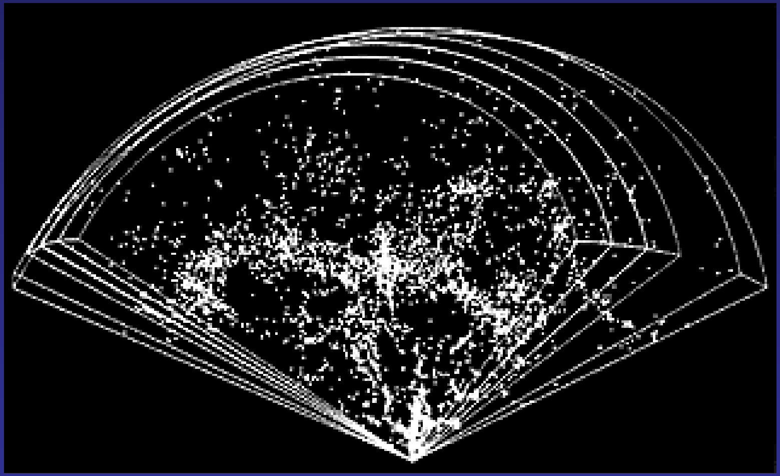
UV Astronomy

- Planets and the origin of life:
  - Planetary atmospheres, auroral variability, comets
  - Circumstellar environment at the epoch of planet building-up
  - Chemistry in the Early Solar System
- ISM and Formation and Evolution of Stars:
  - Hot stars atmospheres (and abundance determination) from white dwarfs to hypergiants
  - Cool stars atmospheres and magnetic dissipation phenomena
  - Formation of stars (from the epoch of planet building-up) and accretion physics
  - Circumstellar material and shells in warm environments, jets, shocks and HH objects
  - Chemical abundances in supernovae remnants and in the early phases of supernovae explosions
  - The warm and hot components of the ISM
- AGN and Compact Objects:
  - Accretion physics and disk instabilities
  - Reverberation mapping and gas distribution around AGNs
- (High-redshift) Universe, Galaxies and Galaxy Evolution:
  - Stellar metallicity ($0<z<2$)
  - Star formation rates
  - Intergalactic medium: distribution, physical properties included metallicity
  - Galactic haloes
  - High velocity clouds, magnetic buoyancy in galactic disks and disk-halo interaction
- Fundamental Physics and Cosmology:
  - Variation of fundamental constants with the gravitational field and redshift
  - The properties of "quantum vacuum" around $z=1$ (acceleration of the Universe expansion)

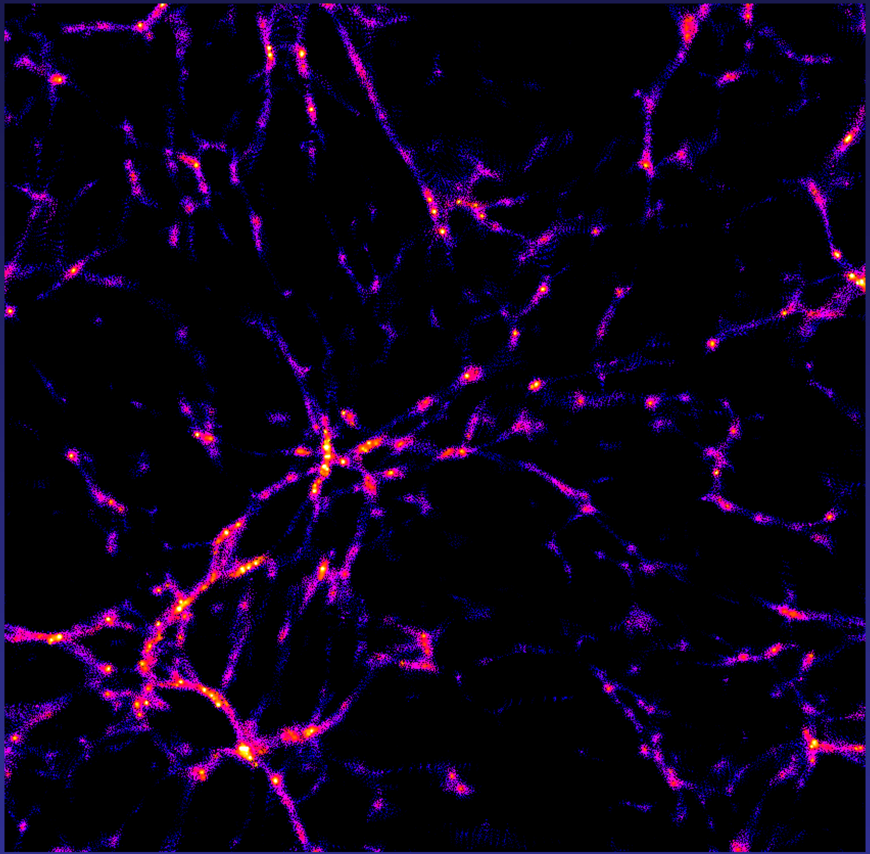
Key problems in astrophysics that cannot be solved without UV:

- The chemical evolution of the Universe during 80% of its lifetime
- The physics of accretion and outflow
- The chemistry in the inner part of proto-solar systems at the time of planet building-up
- The variation of the fine structure constant with z and the gravitational potential for $0<z<2$

THE COSMIC WEB



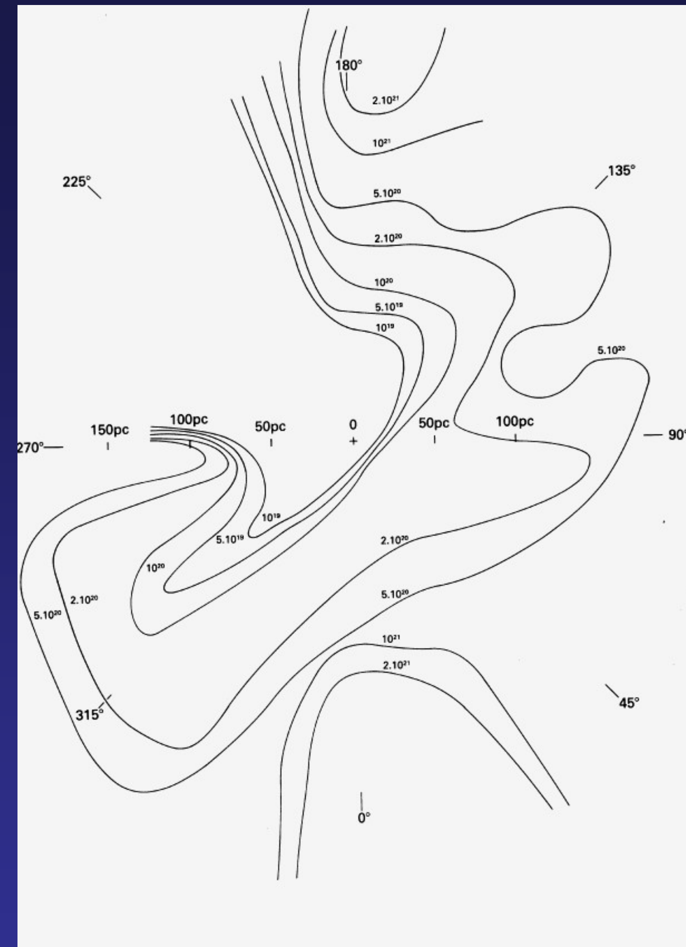
Geller & Huchra, 1989



VIRGO: Cosmological N-body simulations (with gas)

Specific targets:

- Mapping the gas distribution
- Determination of sizes, topology
  and ionization fraction
- Helium re-ionization
- Primordial D/H value (and cross-checks with C/H, N/H, O/H)
- Undepleted elements (Zn,S,P,N)

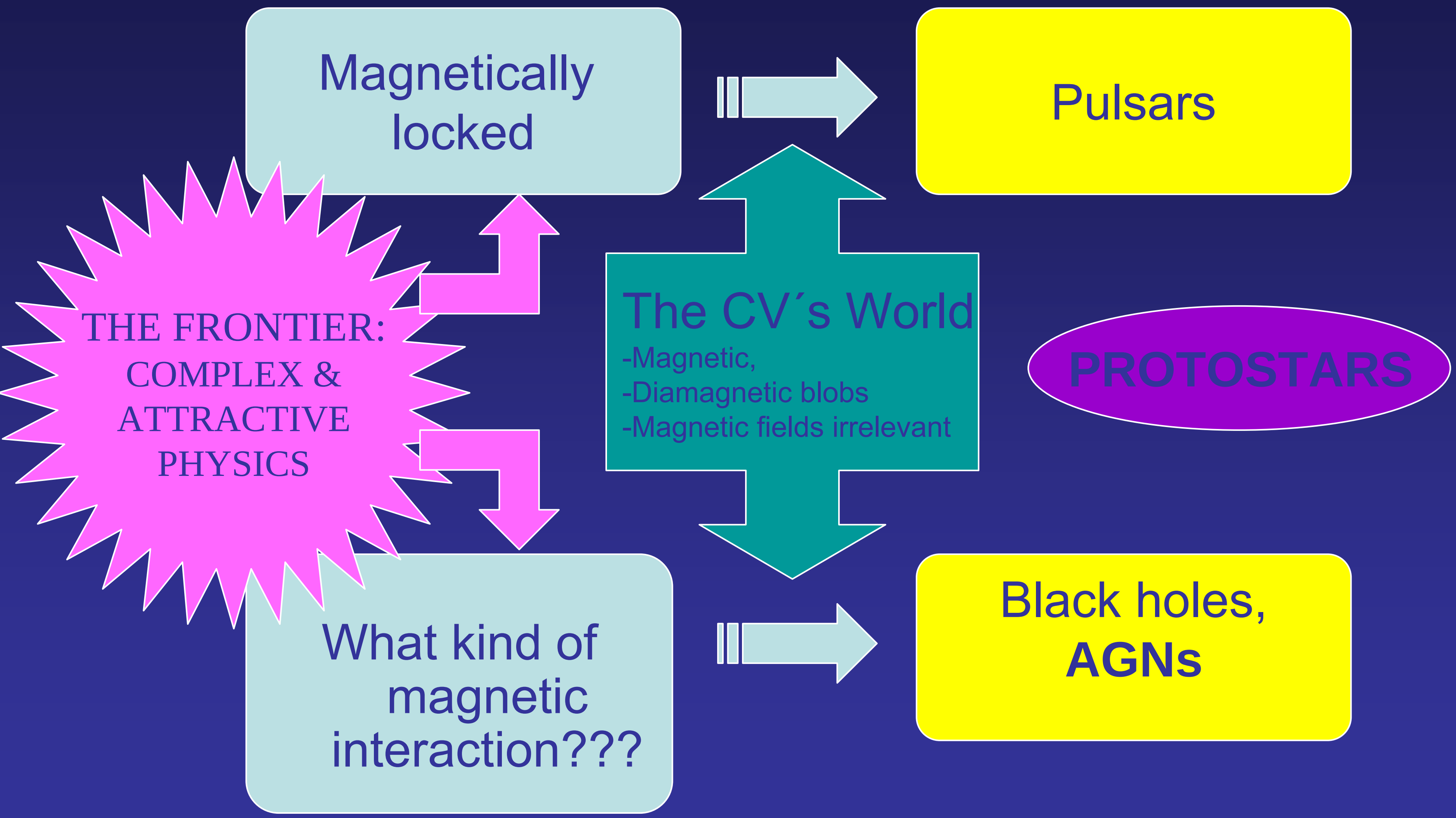


Paresce, 1984

Why now?

The GALEX survey is expected to identify 10^5-10^6 QSOs in the magnitude range $18<m_B<20$

The physics of accretion-outflow

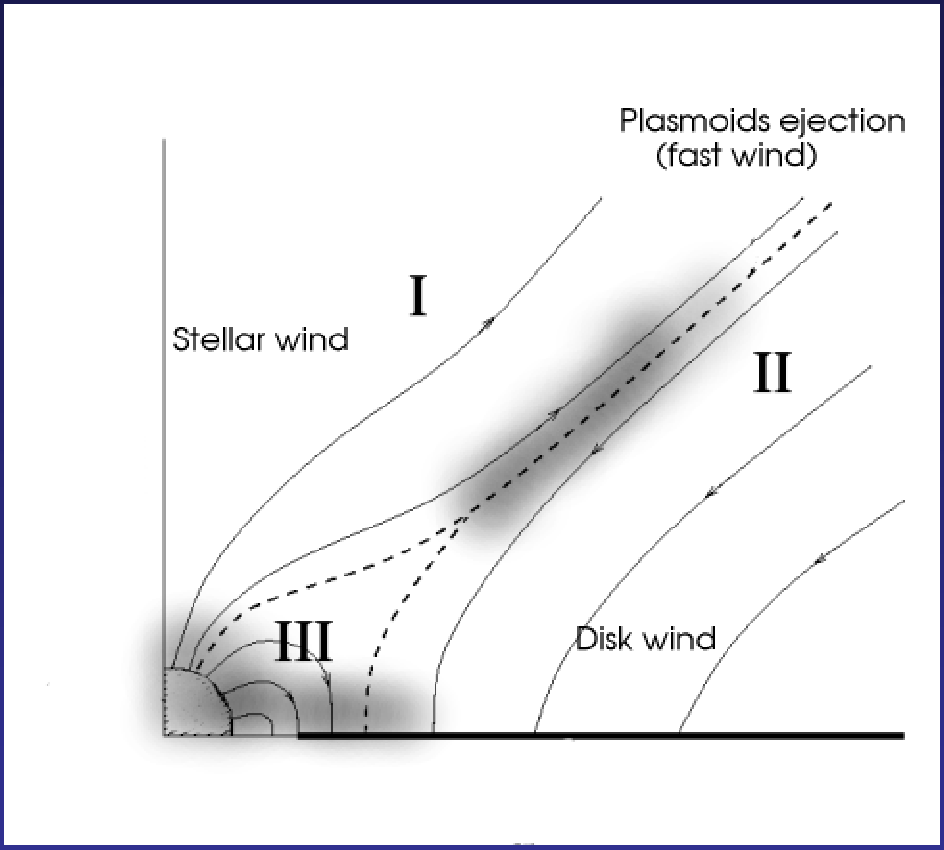


Basic Assumptions:

- Star & Disk good conductors
- Star & Disk have different rotation velocities

As a result:

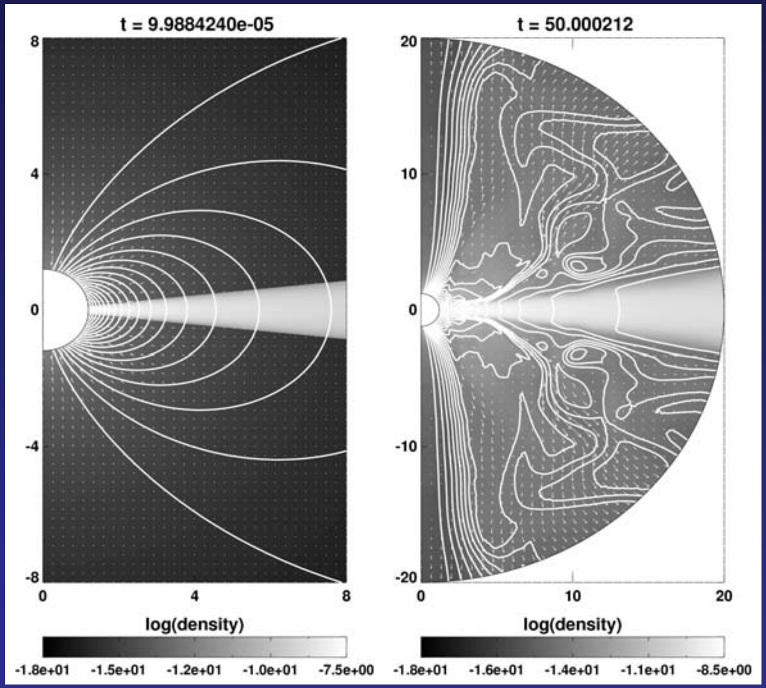
1. the field lines are twisted by the differential rotation
2. toroidal magnetic flux is generated out of the poloidal flux.
3. the toroidal field builds up and the associated field pressure tends to push the field lines outward
4. and inflate them
5. after the relative star-disk twist angle exceeds aroun1 rad the field lines start to expand faster (at an angle of 30^{o} with the disk)
6. the magnetic link between the star and the disk is eventually broken.



Adapted from Lovelace et al 1995 (Gómez de Castro, 2004)

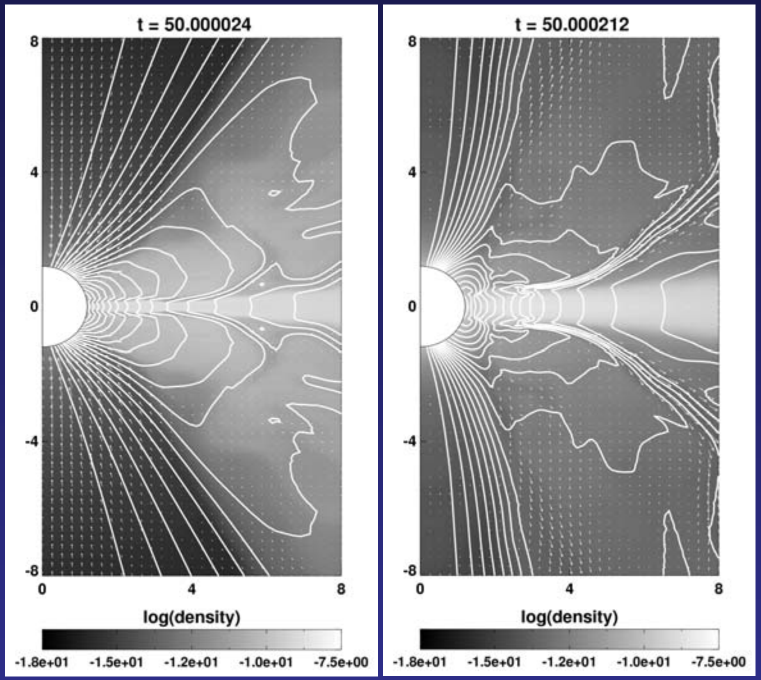
NUMERICAL SIMULATIONS

Initial and final configuration



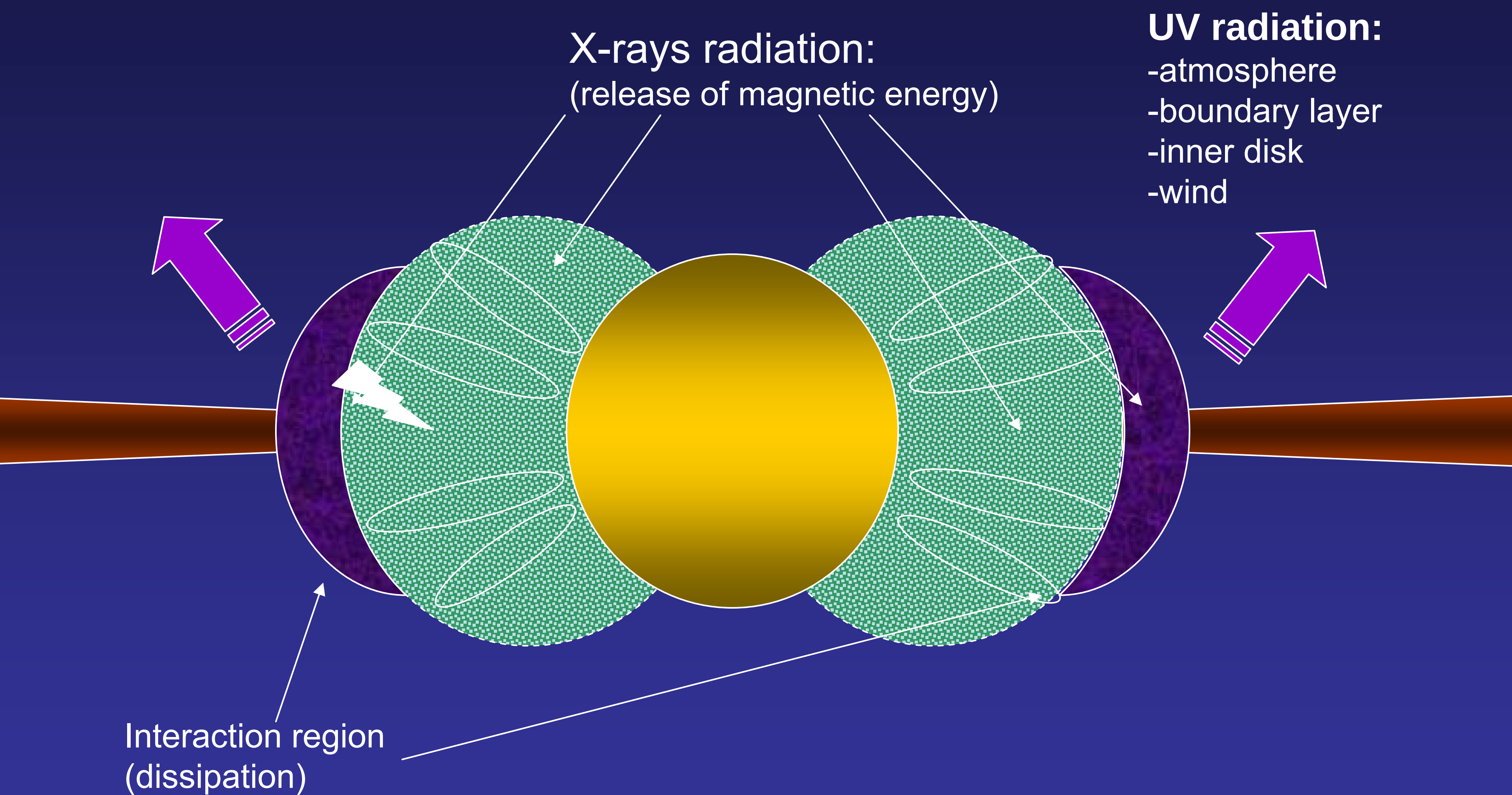
Kueker et al, 2004

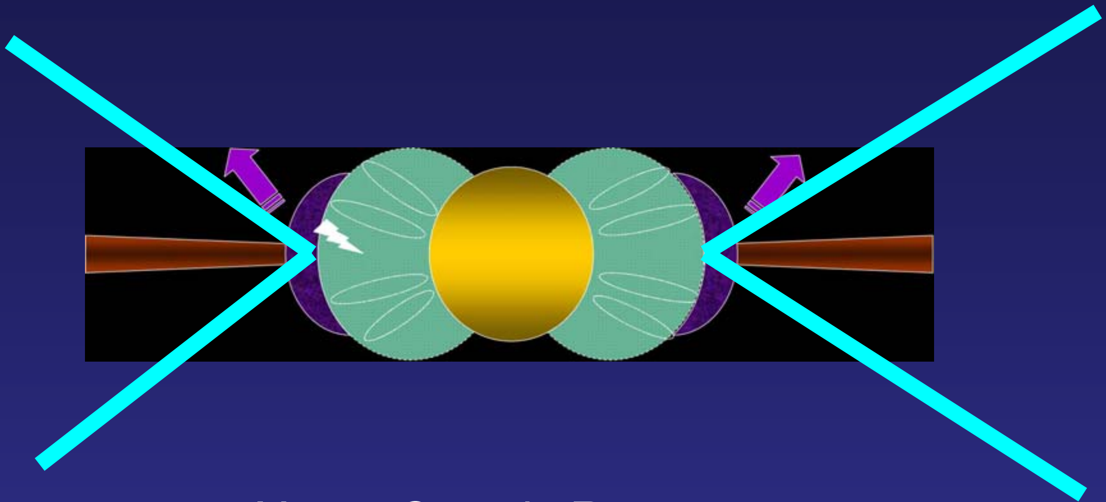
B=100 G B=1kG



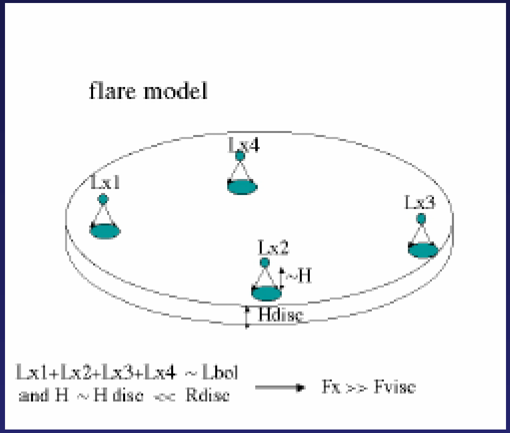
The results are robust: *the star-disk-outflow system is self-regulating when various initial disk densities, stellar dipolar field strengths and primordial field associated with the disk are tested*
(see Goodson et al 1997,1999, Matt et al 2002)

The original paradigm is changing from…

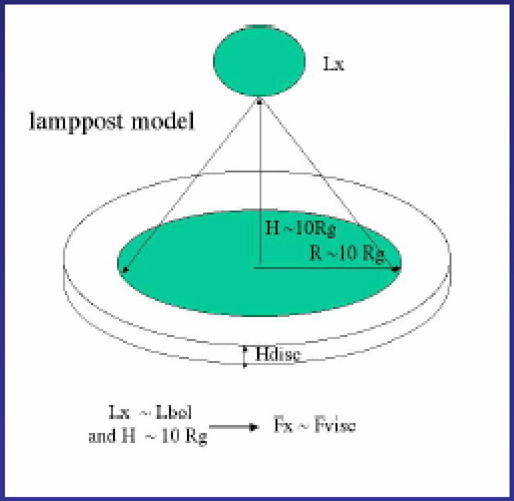


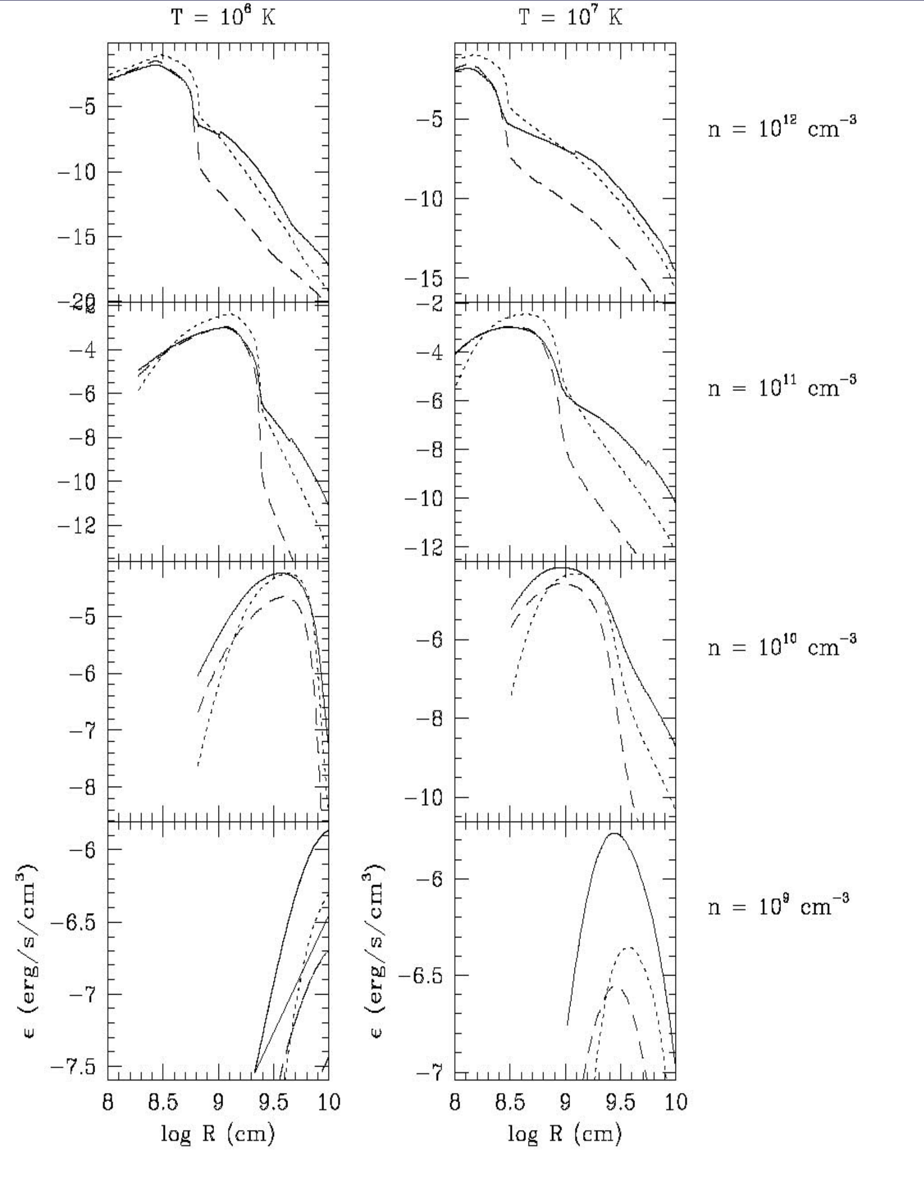


X-ray, Cosmic Ray
(and nearby UV reprocessing)



(Collin et al 2003)

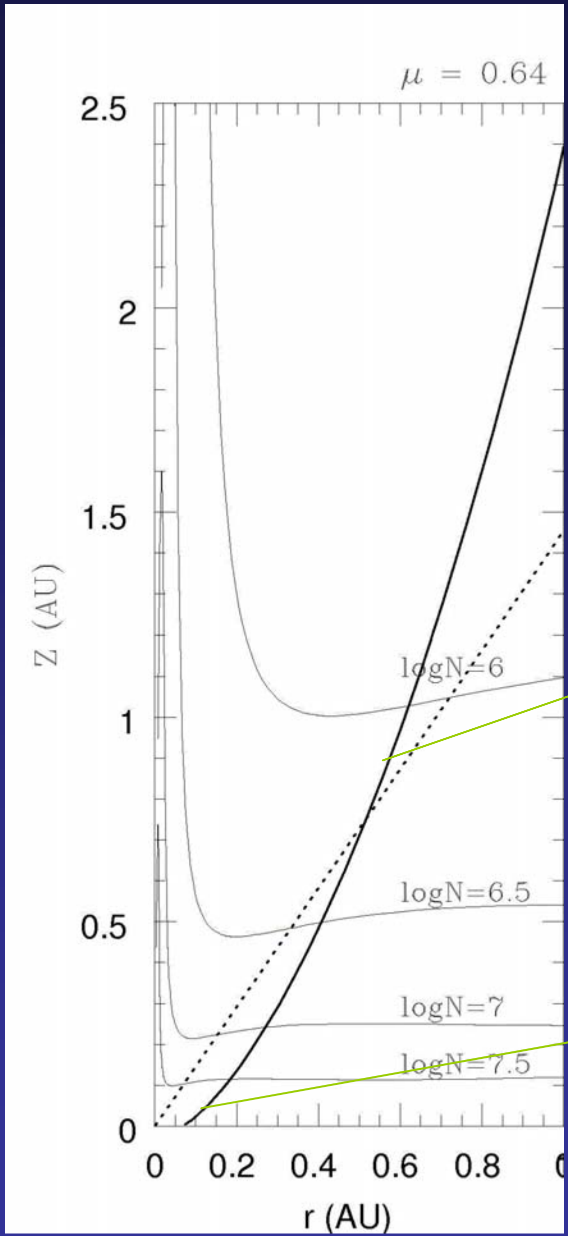




Gómez de Castro & Verdugo, 2003

The environment around the T Tauri stars is dense. If magnetic reconnection events are produced in the wind or in the star-disk interaction region they can be best studied by the UV recombination radiation produced after photoionization by the X-rays radiation released by the reconnecting loops.

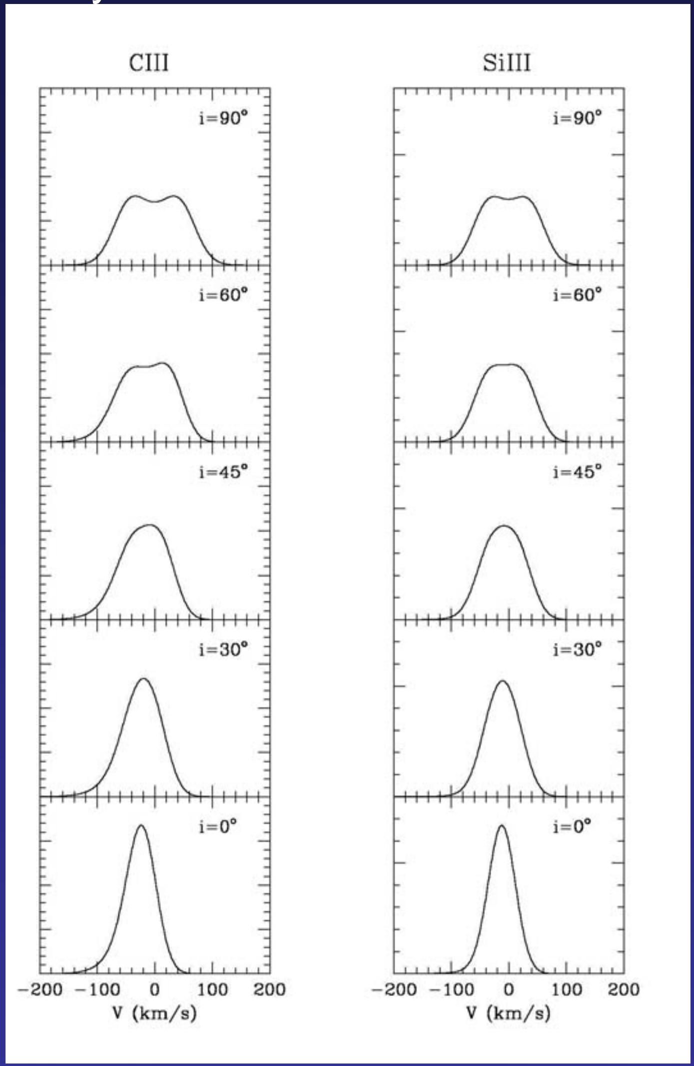
The thickness of the photoionized region is small as shown in the figure.



Expansion dominated

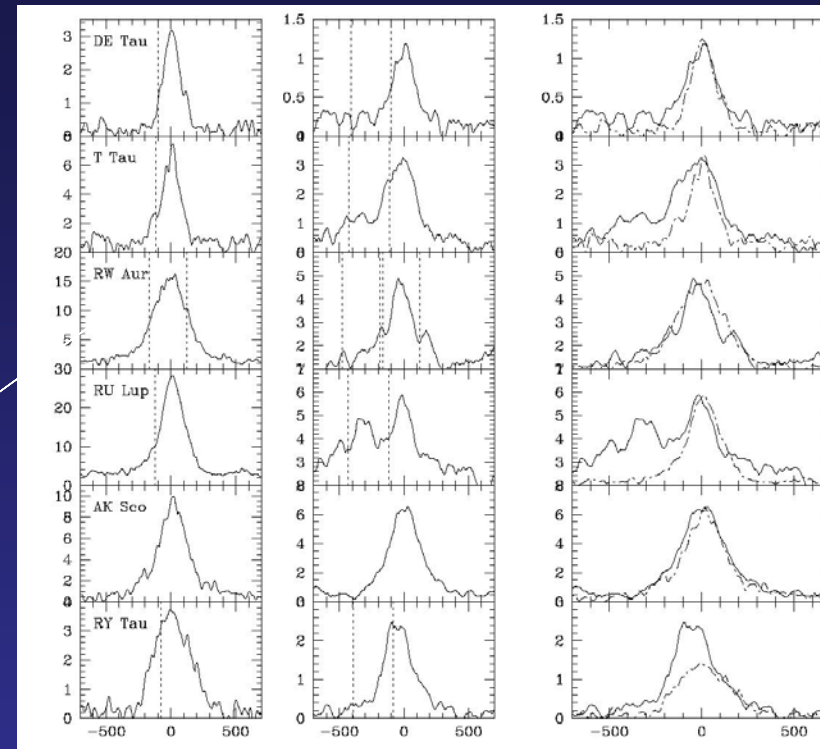
Rotation dominated

X-ray -> UV radiation



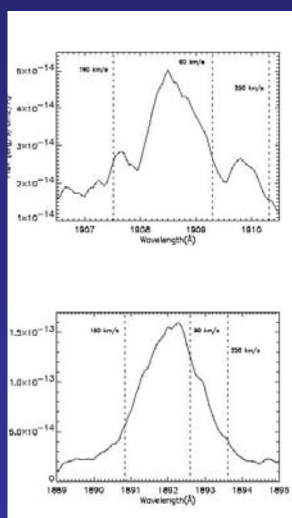
Gómez de Castro & Ferro-Fontán 2004

Semiforbidden UV lines are formed in the magnetic interaction regions or in the wind/jet?

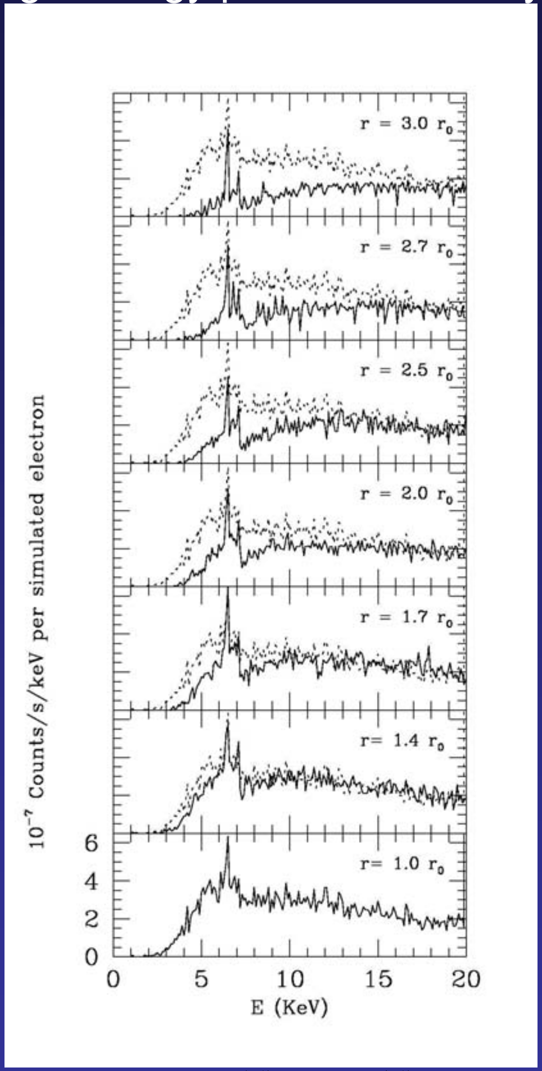


(Gómez de Castro & Verdugo, 2002)

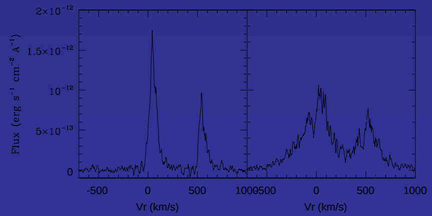
Rotating envelopes



High energy particles -> X-ray

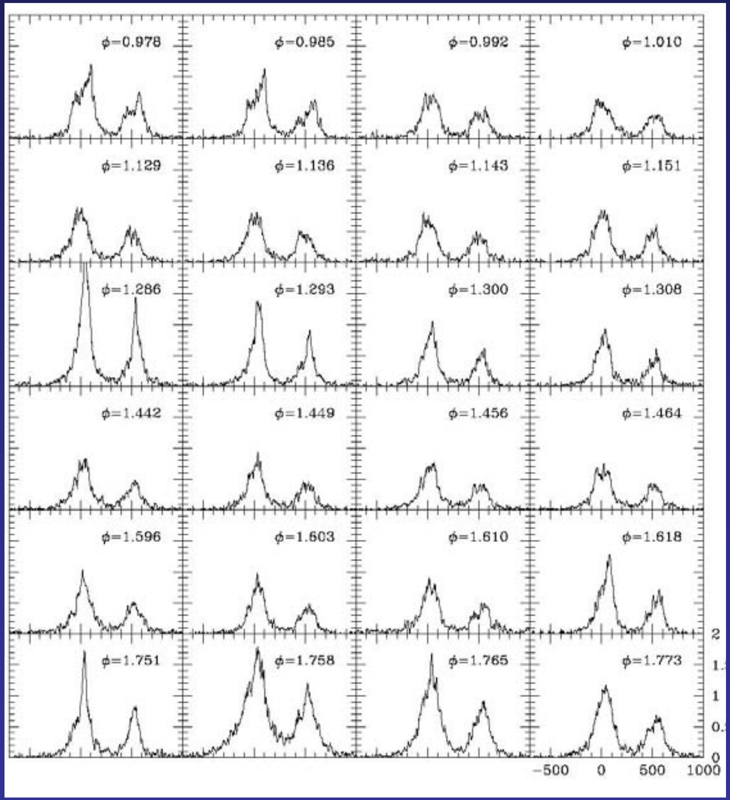


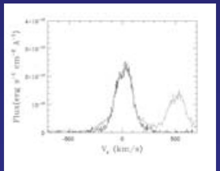
THE PARTICLES INDUCED X-RAY OUTPUT FROM RECONNECTION

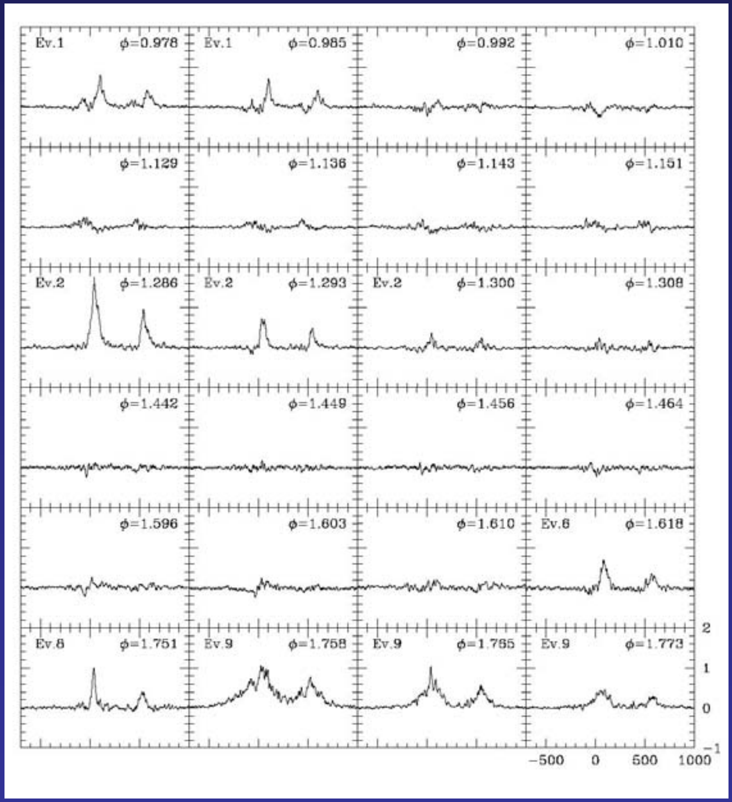


THE INTERPLANETARY MEDIUM:
The interplay between the wind and the disk

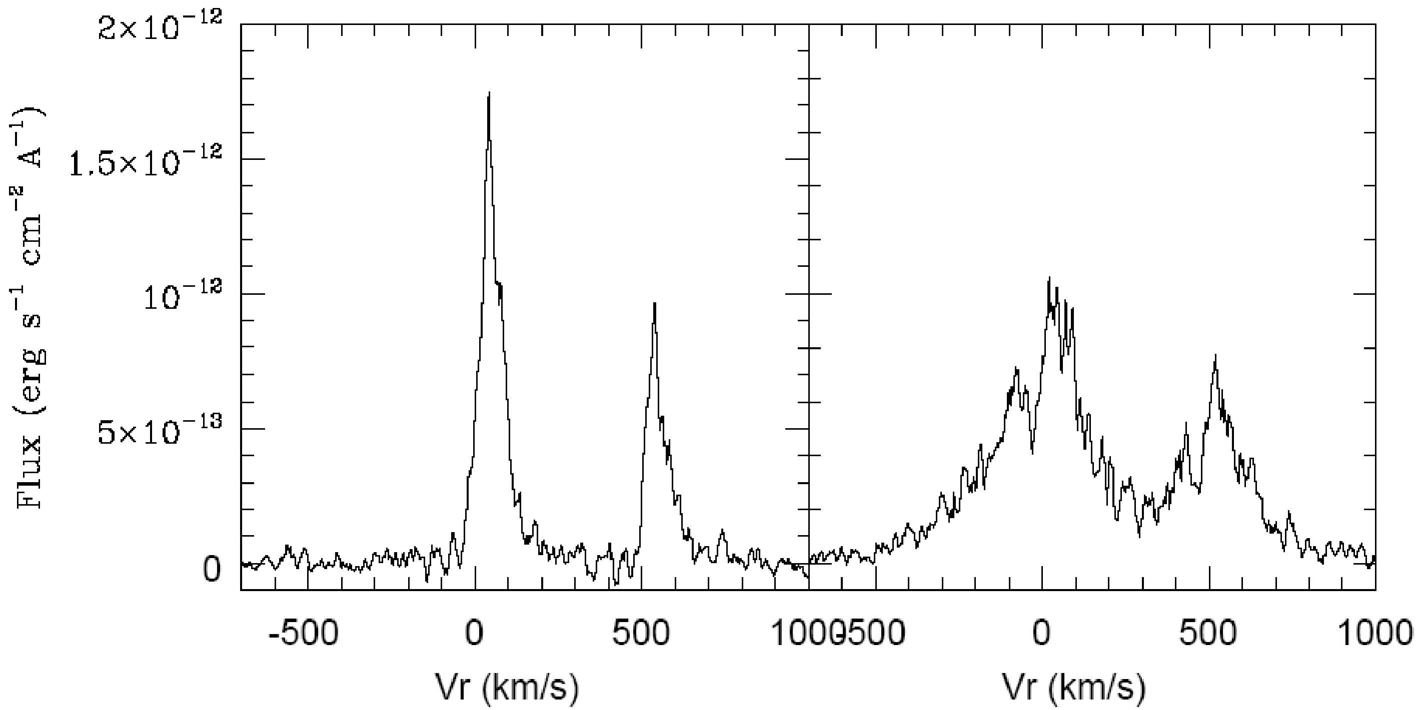
AB Dor Flares in CIV





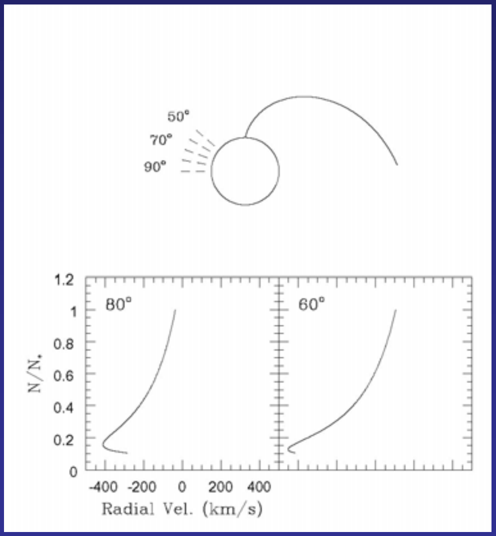


(Gómez de Castro 2002)

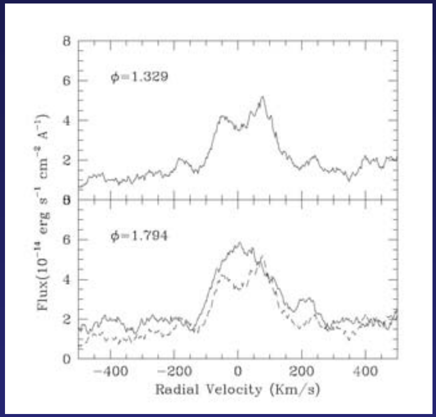


2×10^{-12}
1.5×10^{-12}
10^{-12}
5×10^{-13}
0
Flux (erg s^{-1} cm^{-2} A^{-1})
-500
0
500
1000
-500
0
500
1000
Vr (km/s)
Vr (km/s)

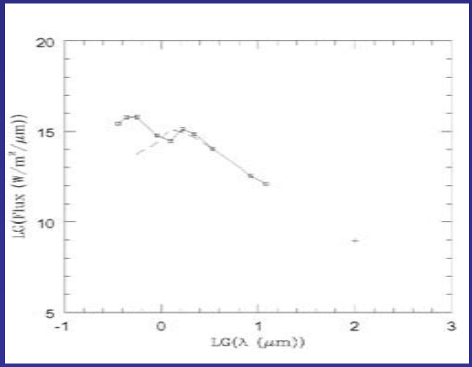
The *very broad wings* are most probably related with the interaction of plasma flows along curved field lines with a slow wind component...



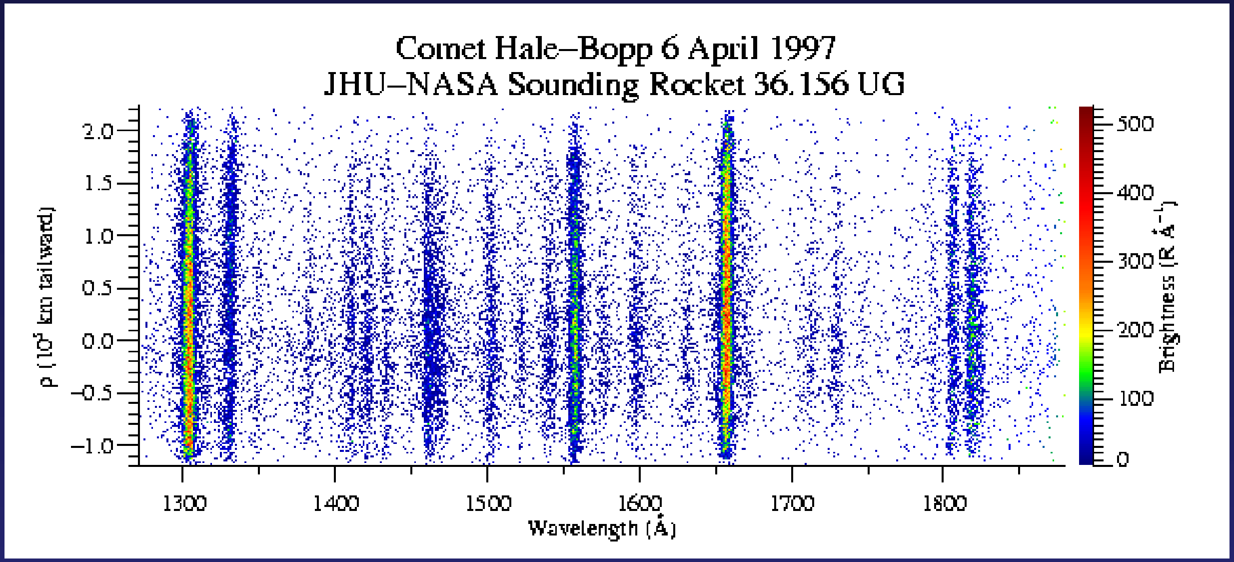
Indeed… there is a corotating envelope around AB Dor *(Brandt et al 2001; Gomez de Castro 2002)* ……….(alike in RW Aur)



AB Dor is a 30 Myr old binary, e.g. it is alike a weak line T Tauri star



Link with late-type stars Physics

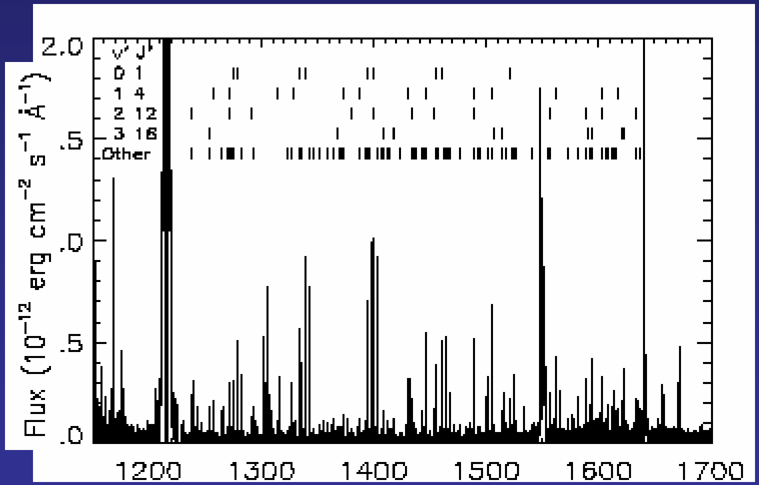


All this facts point out that that there is a strong and extended radiation field within the 1 inner AU s of protostellar disk

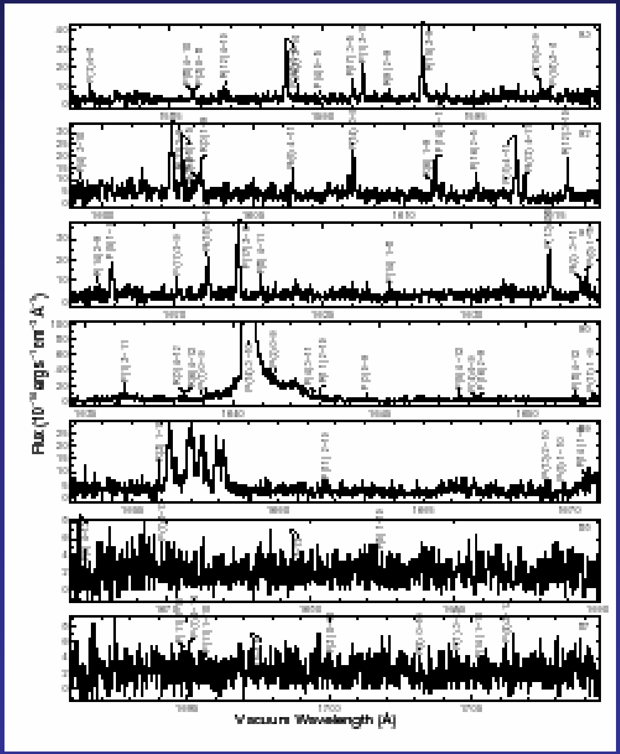
Photodisociation, Photoionization (and Photoevaporation) processes will affect the chemistry in the protoplanetary disk leading to a Cometary-alike Chemistry

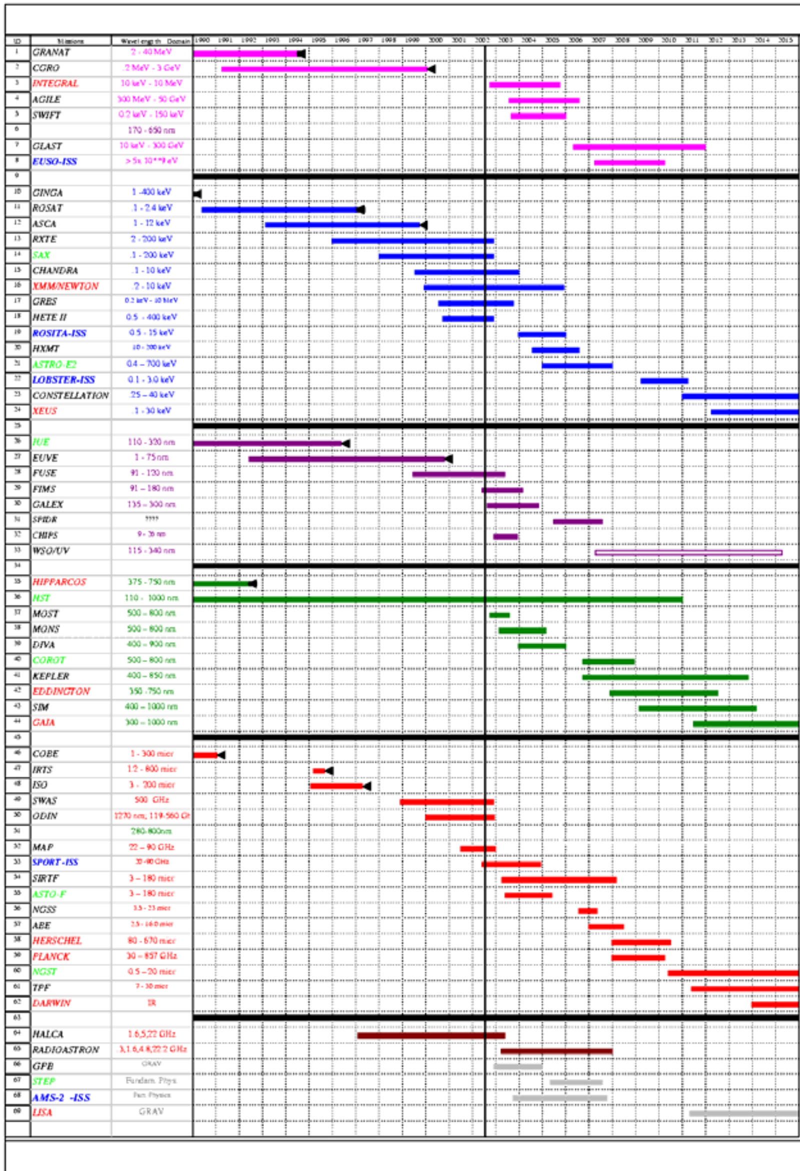
Fluorescence emission from: CO, H_2, OH, CS, S_2, CO_2^+, C_2 will be pumped by the UV radiative field.

Molecular lines (H_2,CO) in TW HYa



(Herczeg et al 2002)





SO WHAT IS AVAILABLE??

Facility (lifetime)	Type of Instrument	Spectral Range (nm)	Field of view (arcsec)	Spectral Resolution R	Spatial Resolution
HST (1990-...)	Imaging-ACS(HRC)	200-1100	26x29	Broad band filters (FWHM ~ 40nm)	0."027 pix^{-1}
	Imaging-ACS(SBC)	115-170	31x35		0."032 pix^{-1}
	Imaging-STIS	115-~350	25x25	Lyα, CIII], MgII Continuum filters	0."0246 pix^{-1}
	Spectroscopy-ACS	115-390	Grism	100	
	Spectroscopy-STIS	115-310	Long-Slit (52")	~15000 ~1000	0."03 pix^{-1}
		115-315	(echelle)	140000 ~50000	
FUSE (1999-...)	Spectroscopy	90.5-118.7		20000±2000	
GALEX (2003-2005)	Imaging	135-300	All-sky	Two broad bands: NUV(180-300) and FUV(135-180)	3"-5"
	Spectroscopy	135-300	(grism)	100	

Table 1: The main UV facilities working in 2003

But… the future of UV astronomy seems rather dark….

Instrumental Requirements for the future

Firstly,

A high resolution (R≈30,000) UV spectrograph with a sensitivity at least 10 times better than HST/STIS:

- COS
- WSO/UV (20 times better and full coverage of the 110-320nm range)

and then…(in the 2015 horizon!!!)

A 4m-6m space mission to provide enough effective area for high resolution efficient (echelle) spectroscopy. Imaging capabilities and mid resolution long-slit spectroscopy are necessary. Some overlap with the optical range is desirable (up to 5500Å) to guarantee a good overlap with the 10 m. ground-based telescopes cosmological studies

Actions:

- Creation of the Network for UltraViolet Astronomy (NUVA) to coordinate the efforts of the european community.
  - NUVA will map and review the instrumental performance of existing and near future capabilities in the UV on a global scale.
  - NUVA will assess for the future needs and develop a perspective for the future at European scale.

- International colaboration
- Answer to the ESA call