NGC2264

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Interaction of YSOs with circumstellar matter

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Objectives with CoRoT

- To probe the inner disk regions and circumstellar environments of CTTSs and Herbig Ae/Be stars, by obtaining heavily sampled light curves of systems observed at high inclination

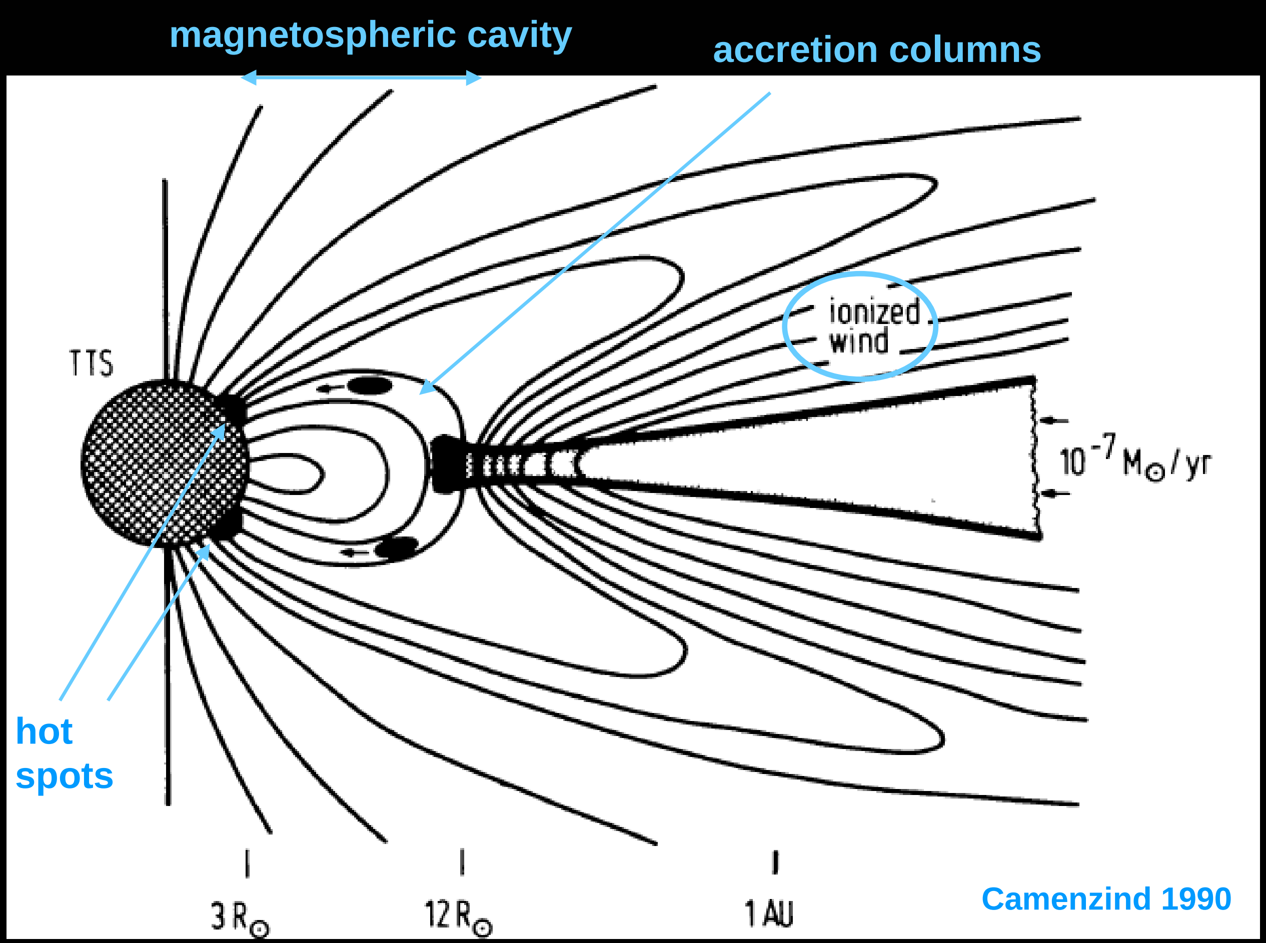
- To study the inner structure of circumstellar disks at different evolutionary stages in NGC 2264

Motivation

Magnetically dominated accretion occurs on a scale of a few stellar radii (≤ 0.1 AU) which, at the distance of the nearest star forming region cannot be resolved yet by current telescopes.

One of the most fruitful approaches to probe the structure and evolution of this compact region is to monitor the variations of the system over several rotation timescales.

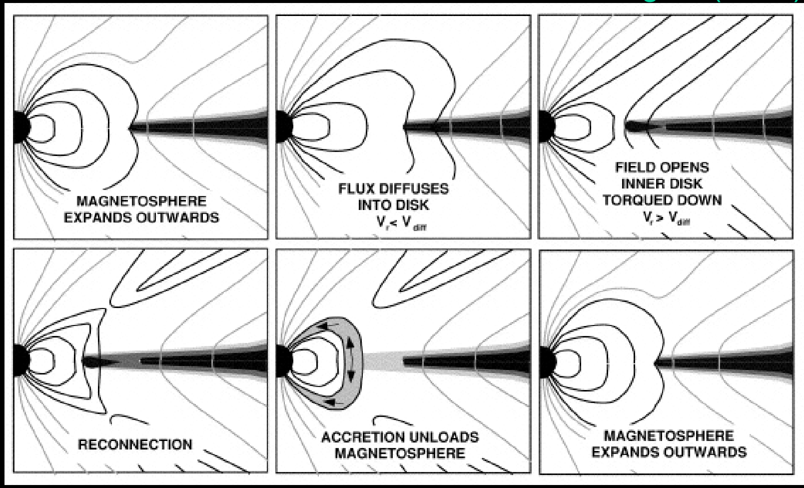
Magnetospheric accretion in CTTSs



Camenzind (1990), Paatz & Camenzind (1996), Konigl (1991),
Shu et al. (1994), Ostriker & Shu (1995), Shu et al. (1997)
Hartmann et al. (1994), Muzerolle et al. (1998, 2001), Kurosawa et al. (2006)

A dynamical interaction between the disk and the stellar magnetosphere

Goodson & Winglee (1999)



Model predictions :
Differential rotation along the field lines leads to their expansion, opening and reconnection

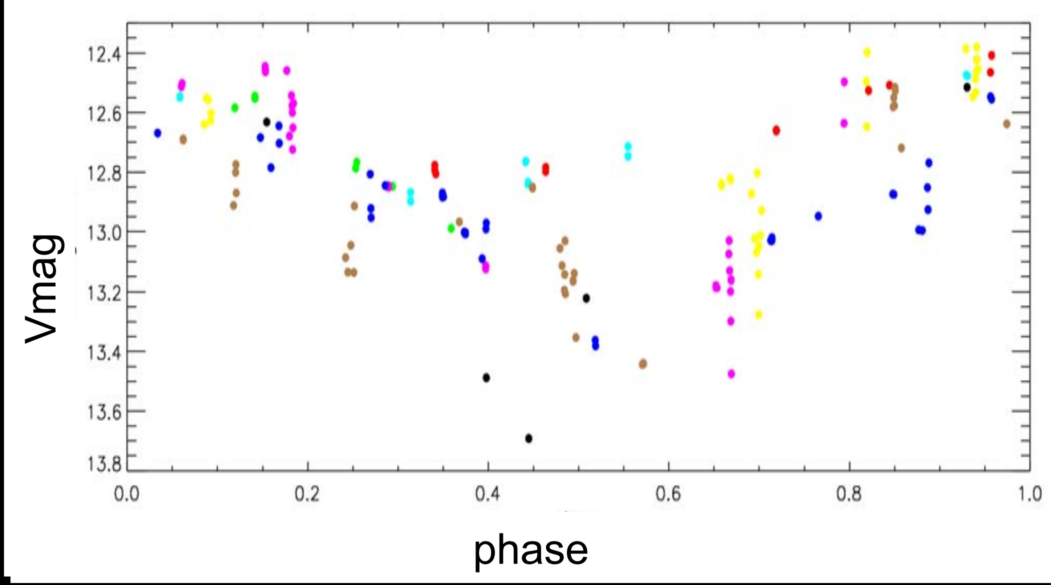
Restoration of the initial magnetospheric configuration

Timescale of a few rotation periods, determined by the diffusion of the magnetic flux through the inner regions of the disk

Goodson et al. (1997, 1999), Matt et al. (2002), Romanova et al. (2004), Von Rekowski & Brandenburg (2004)

There is the need to check if observations support the dynamical predictions of magnetospheric accretion models.

AA Tau: synoptic studies with simultaneous spectroscopy and photometry (Bouvier et al. 1999, 2003, 2007)

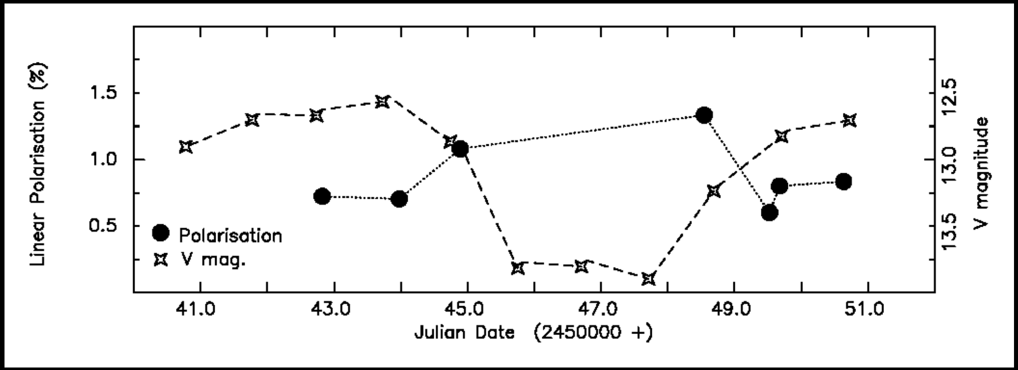


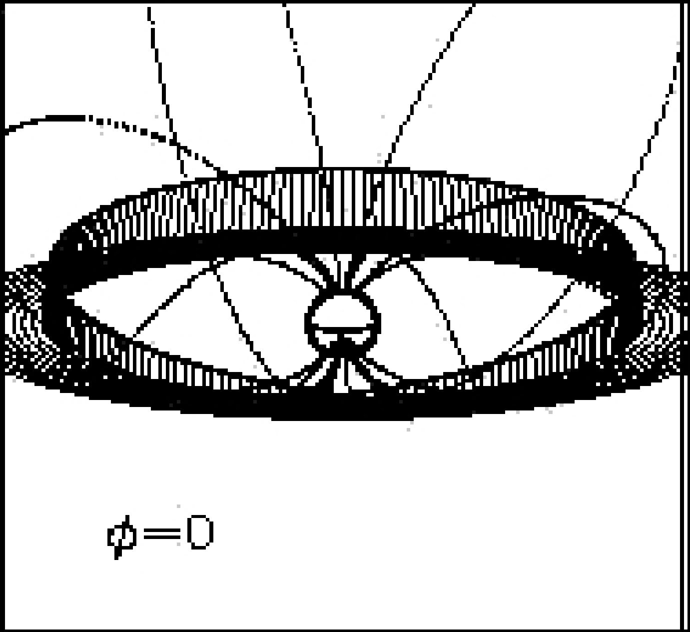
Light curve shows periodical (~ 8.2 days) eclipses of the photosphere that occur without much color variation.

The linear polarization increases as the system fades.

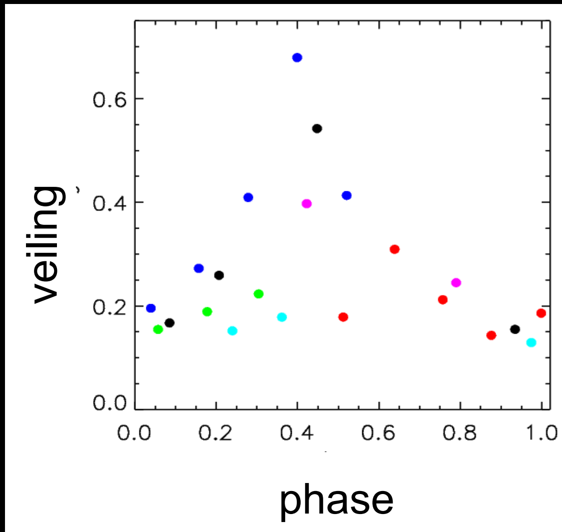
Periodical occultation of the photosphere by an optically thick, magnetically-warped inner disk region

Bouvier et al. (2007)

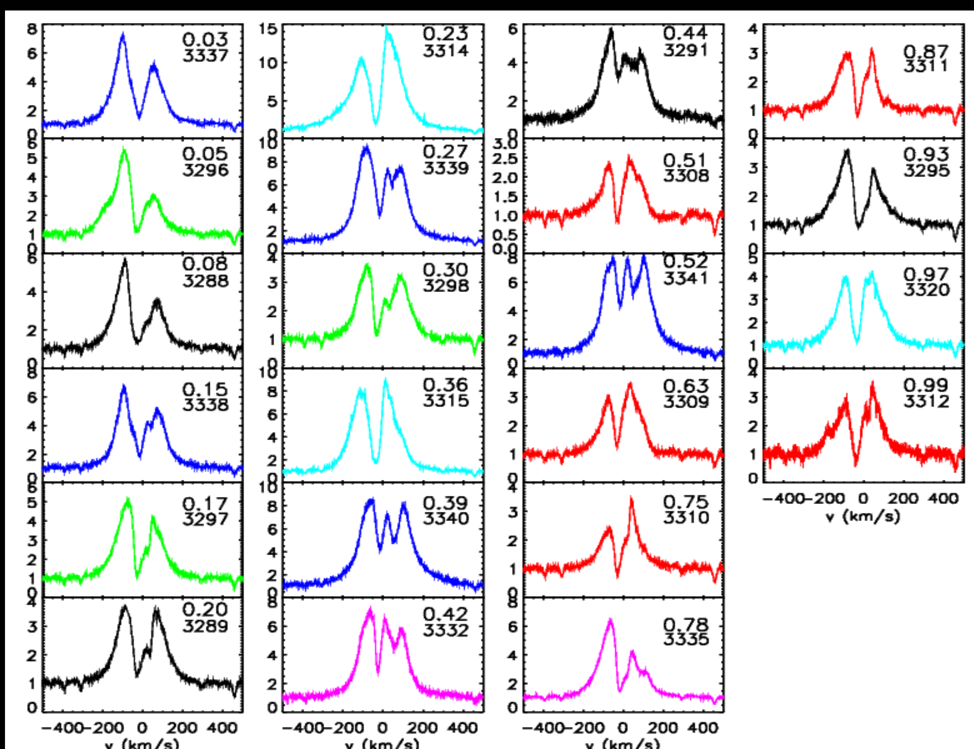




Ménard et al. (2003)



Shallow eclipses
→ low veiling



Hα profiles show the main accretion stream crossing our line of sight

Shallow eclipses → almost no redshifted absorption in the Balmer lines

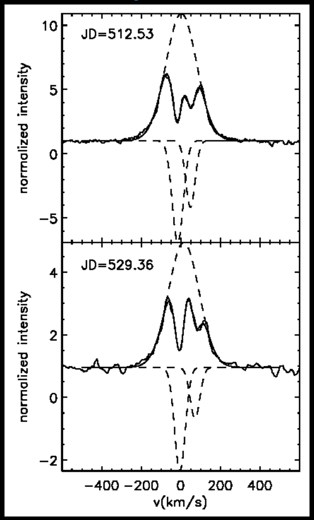
Bouvier et al. (2007)

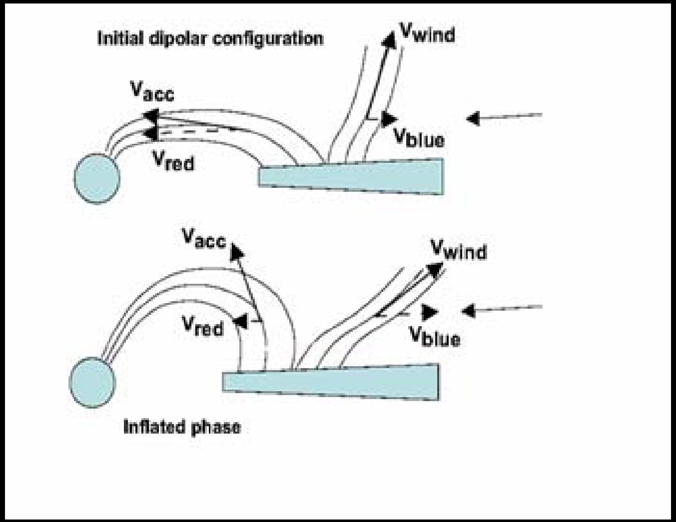
Accretion is at a very low level when most of the occulting circumstellar material is absent.

Clear correlation between the accretion level and the formation of the inner disk warp, both supposedly depending on the time variable magnetic configuration in the disk truncation region.

Magnetospheric inflation ?

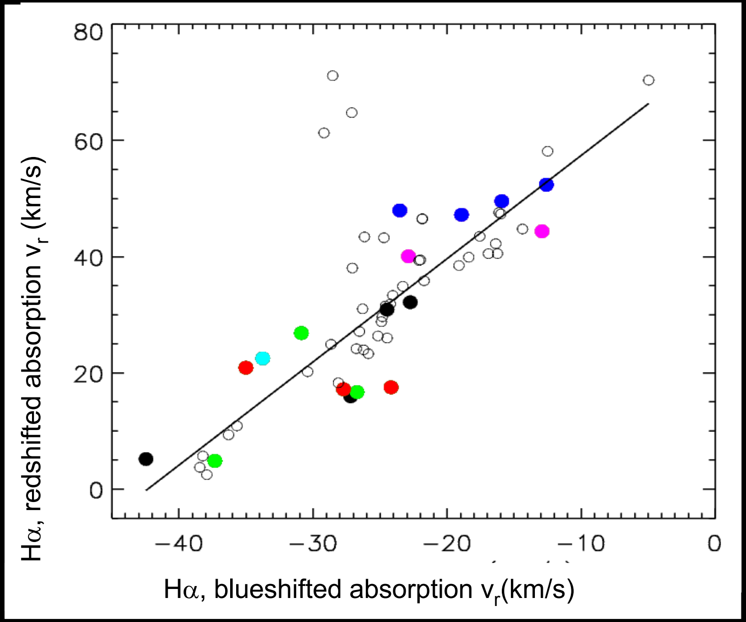
Hα profiles



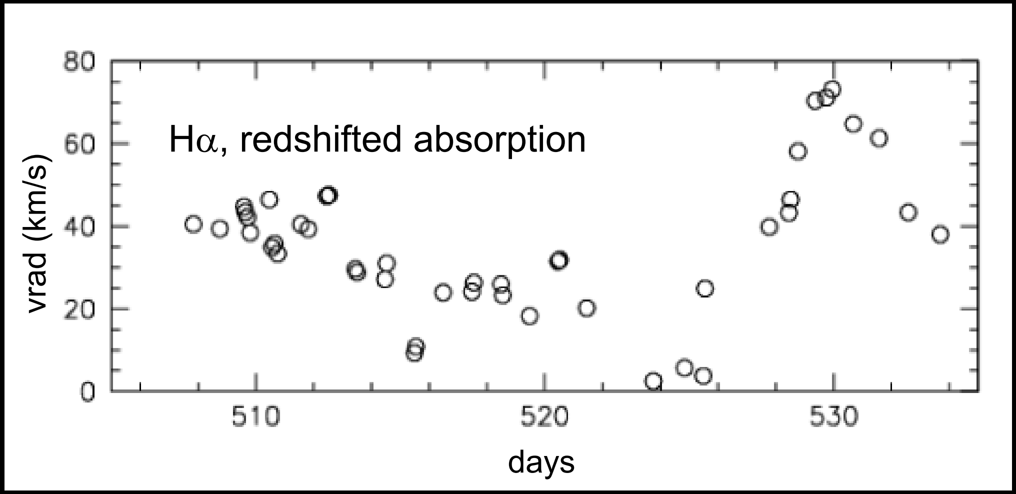


The projected radial velocity of the redshifted absorption component of Hα measures the field line inflation !!

Inflow-outflow relation



Bouvier et al. (2003, 2007)



These results tend to support the idea of magnetospheric accretion cycles on a timescale of several rotation periods in accreting T Tauri stars.

The periodicity of such episodes as predicted by dynamical models remains to be tested with longer time series.

But how unique is AA Tau ?

This is a question we can start to answer with the CoRoT data on NGC2264.

We need to identify cluster members and among those, CTTSs.

CTTSs: first CoRoT results

CTTSs were defined as
• stars that present Hα EW > 10 Å (Dahm & Simon 2005)
• stars that have U-V excess < -0.5 (Rebull et al. 2002, Falscheer 2006)
• stars that present Hα width at 10% intensity > 270 km/s (Fürész et al. 2006)

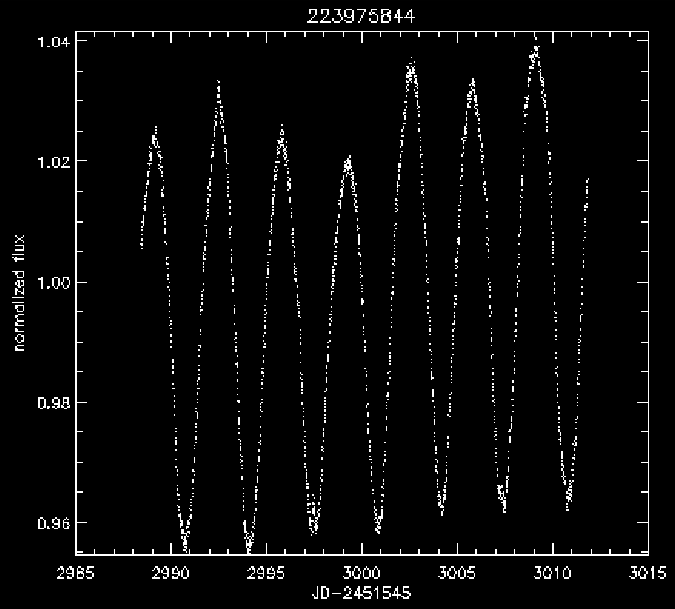
Up to now 88 CTTSs have been identified that belong to NCG2264 and were observed with CoRoT.

• 58 have monochromatic LCs
• 30 have chromatic ones.

Three basic types of light curves:
1- periodical due to spots
2- AA Tau type, periodical due to obscuration by circumstellar material
3- other

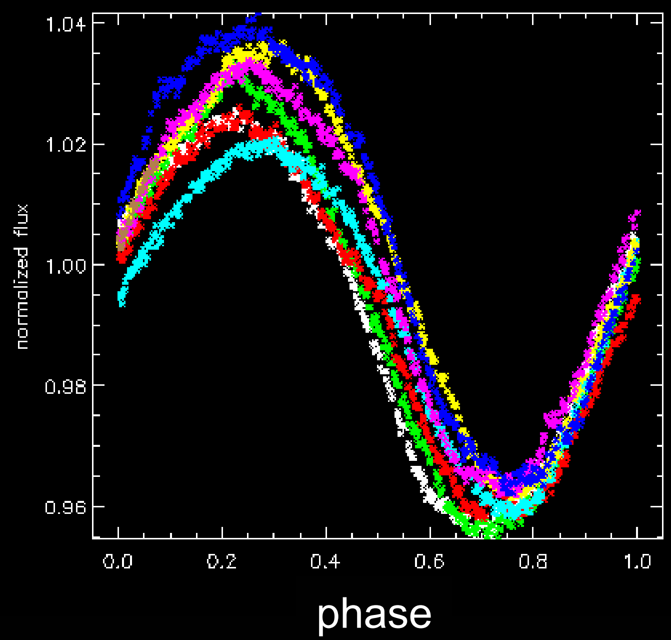
CoRoT colors can help distinguish spots from circumstellar material.

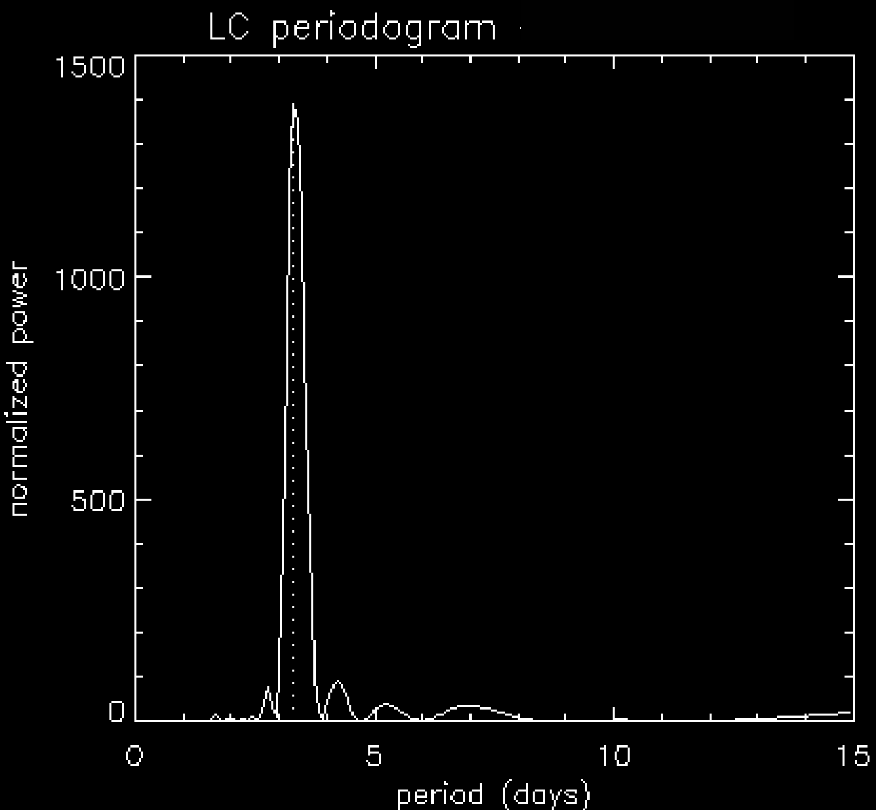
Periodical due to spots



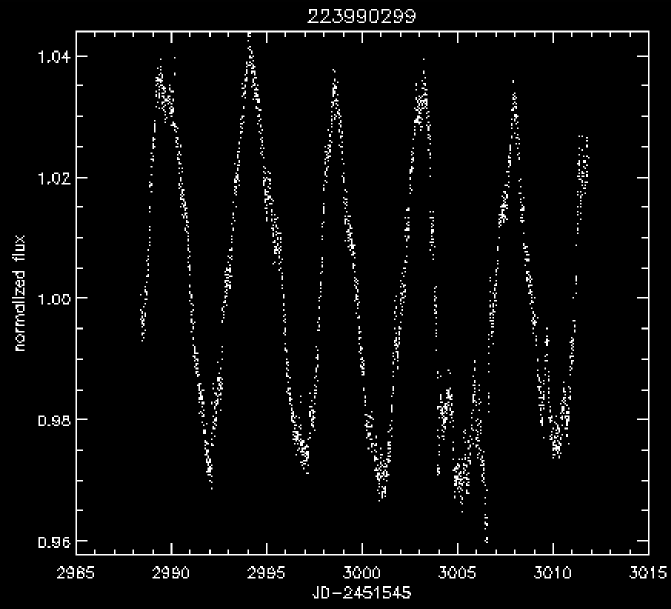
Variations mostly due to spots

COROT_ID=223975844, G1
WHα = 12.2 Å (Dahm & Simon 2005)
Hα width at 10% > 270 km/s (Fürész et al. 2006)
P = 3.42 ± 0.42 days (Lamm et al. 2005)



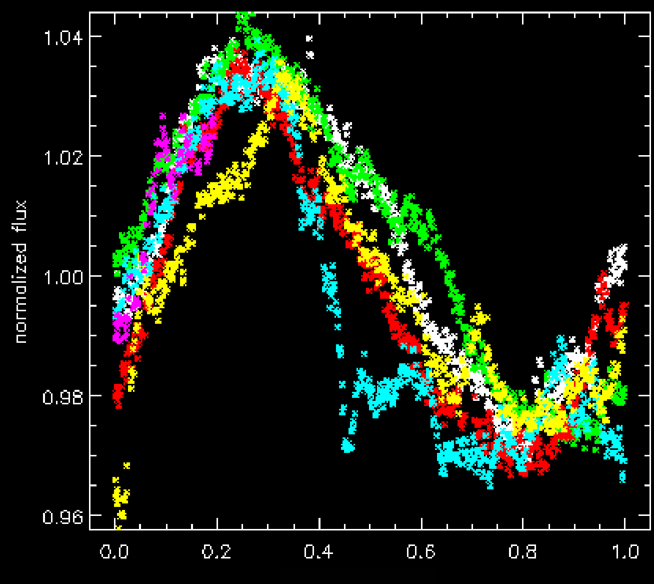


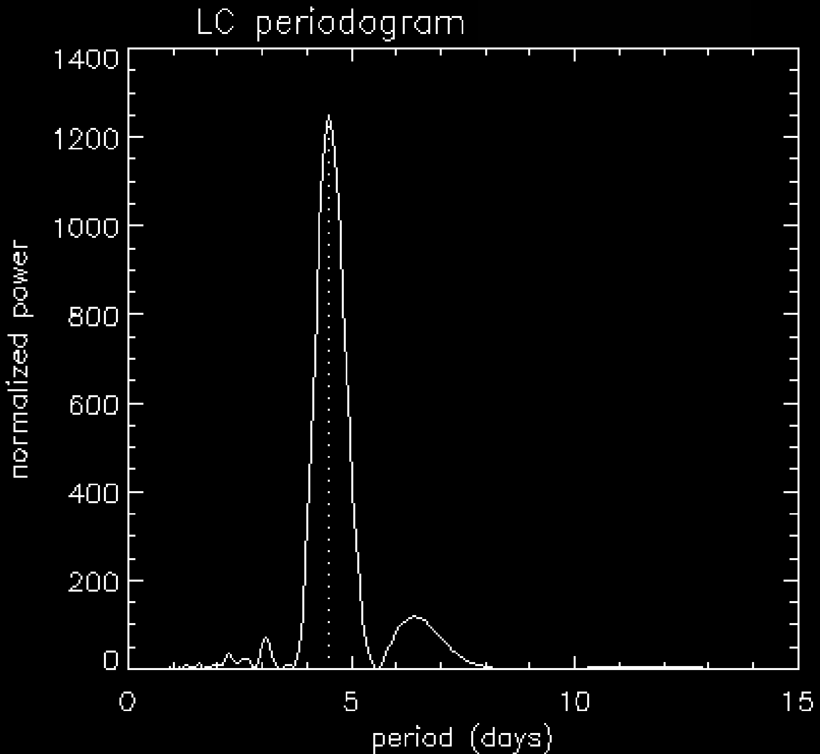
Periodical due to spots



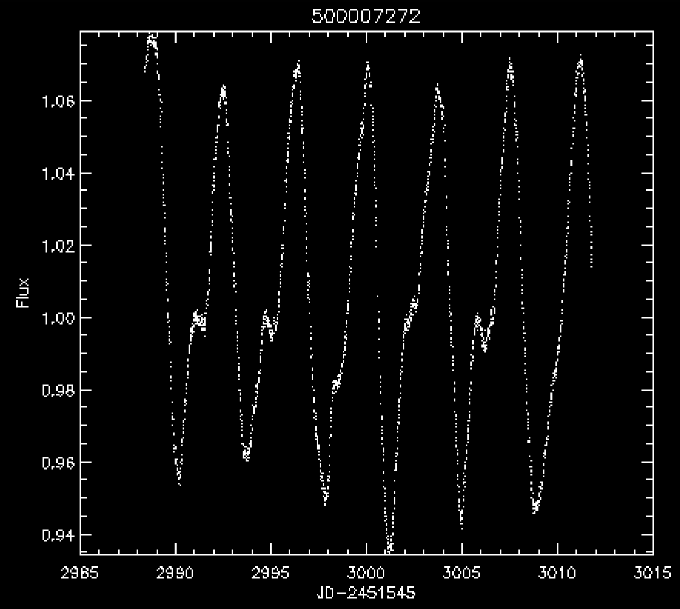
Variations mostly due to spots

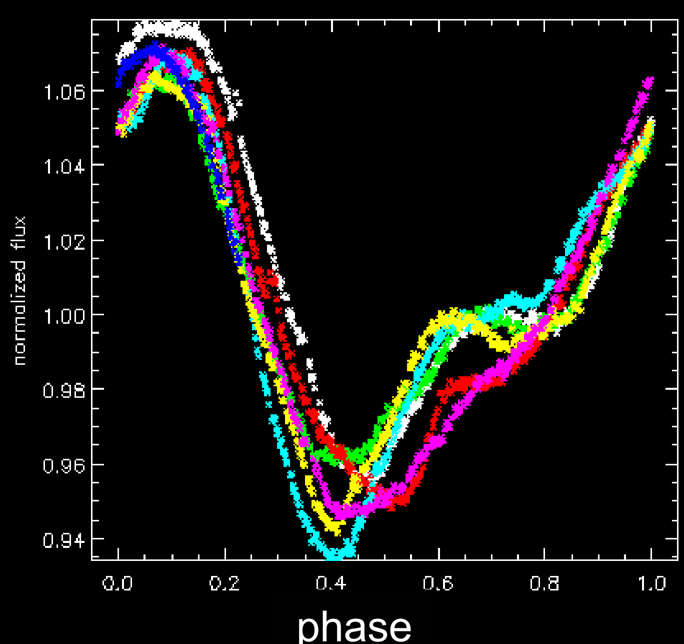
COROT_ID=223990299, K4
WHα = 35 Å (Dahm & Simon 2005)
Hα width at 10% > 270 km/s (Fürész et al. 2006)
U–V excess = –0.826 (Fallscheer 2006)
P = 4.45 ± 0.51 days (Lamm et al. 2005)





Periodical due to spots



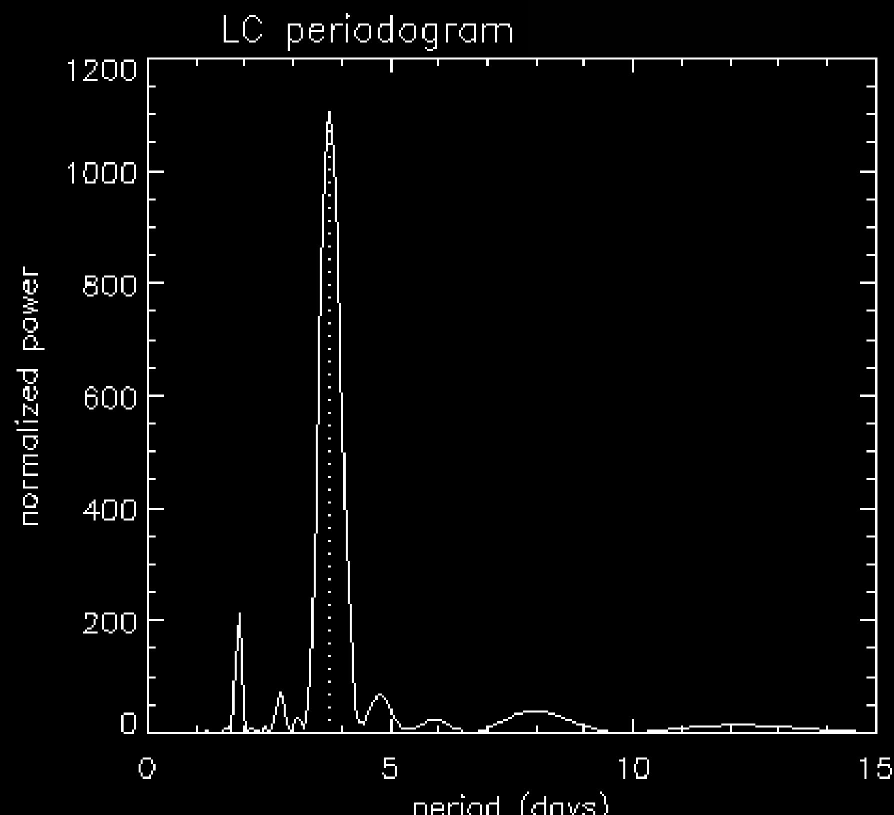


Variations mostly due to spots

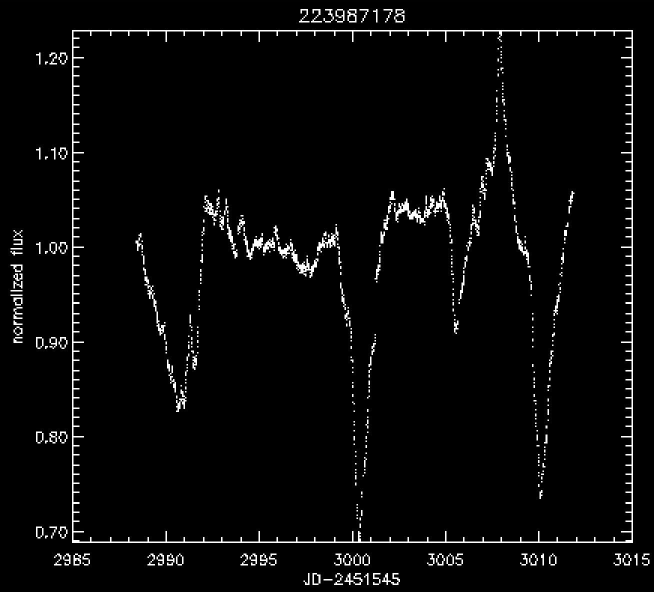
COROT_ID=500007272, K7

WHα = 58.3 Å (Dahm & Simon 2005)

No period determined in the literature

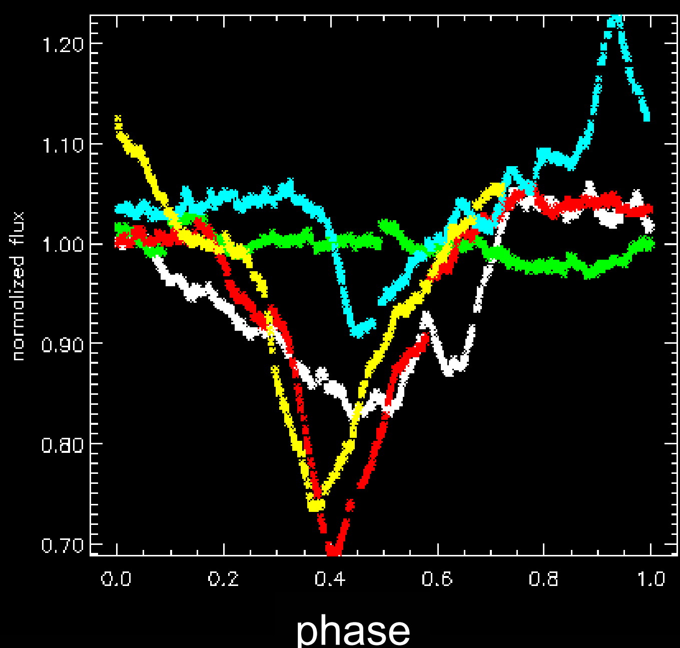


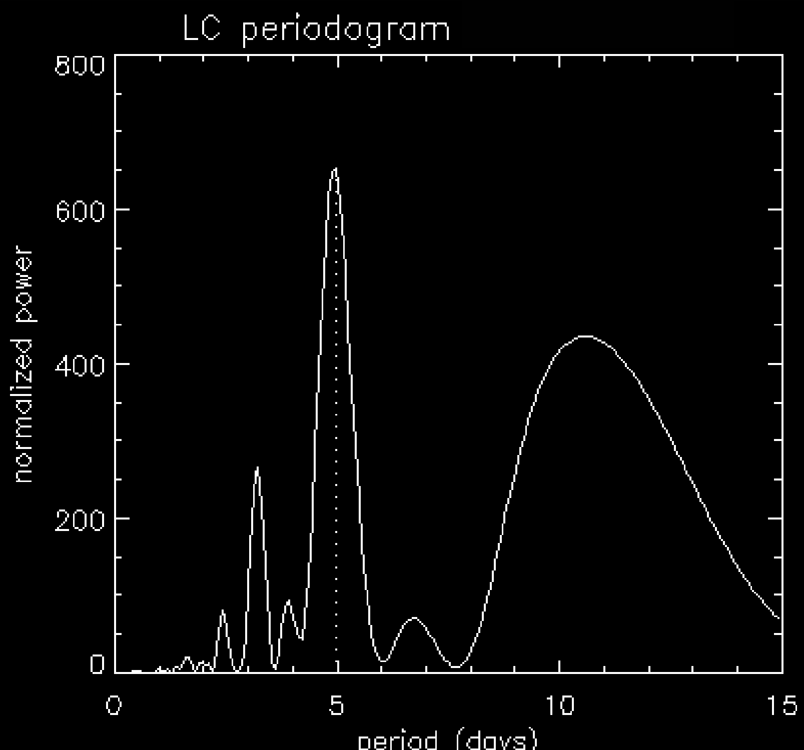
AA Tau type candidate



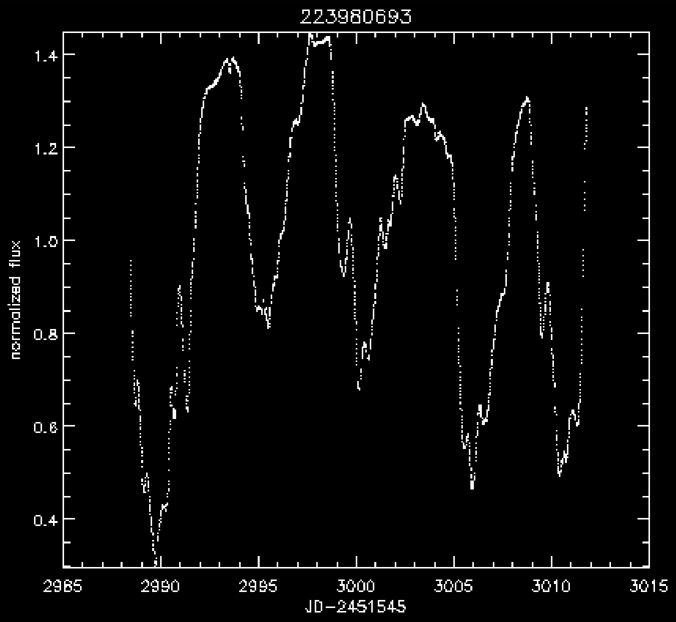
Variations mostly due to occultation by circumstellar material

COROT_ID=223987178, M0
WHα = 15.9 Å (Dahm & Simon 2005)
U–V excess = –1.233 (Fallscheer 2006)
No period determined in the literature



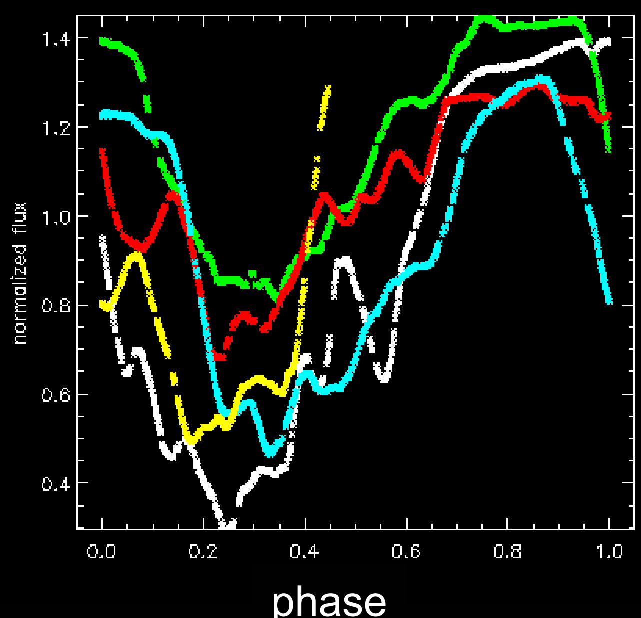


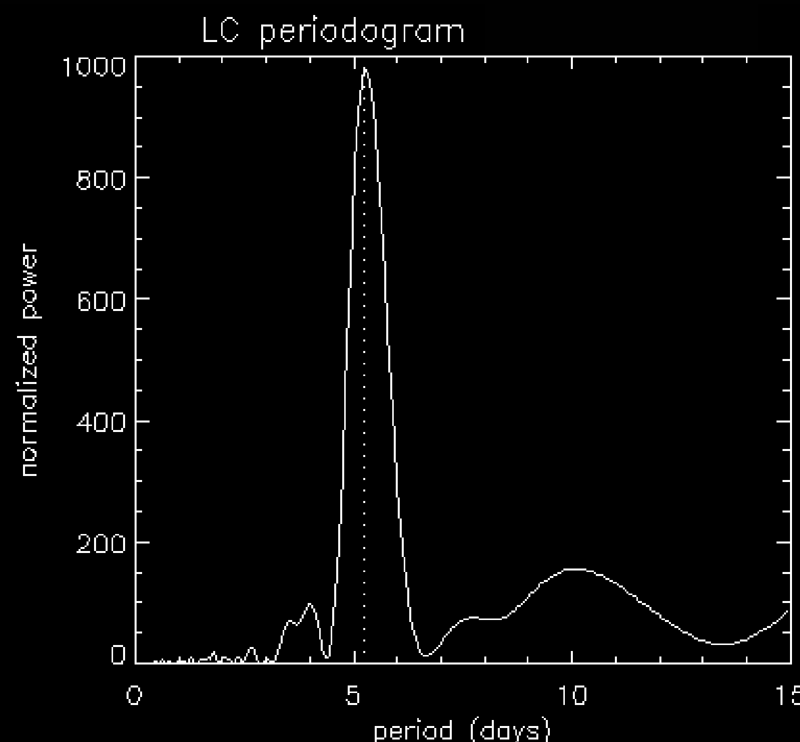
AA Tau type candidate



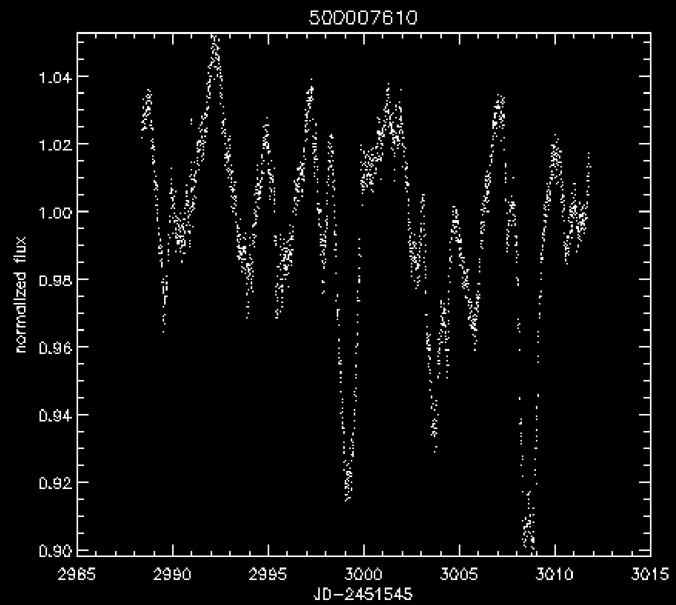
Variations mostly due to occultation by circumstellar material/spots

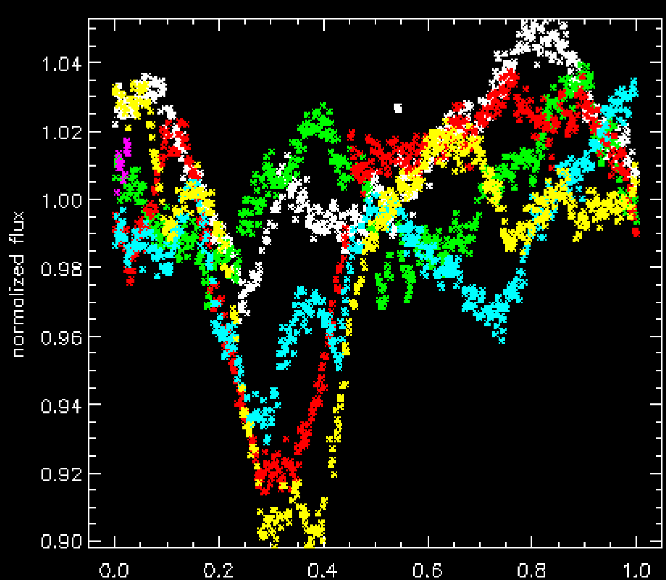
COROT_ID=223980693, K4V
WHα = 16.6 Å (Dahm & Simon 2005)
Hα width at 10% > 270 km/s (Fürész et al. 2006)
P = 5.22 ± 0.87 days (Lamm et al. 2005)





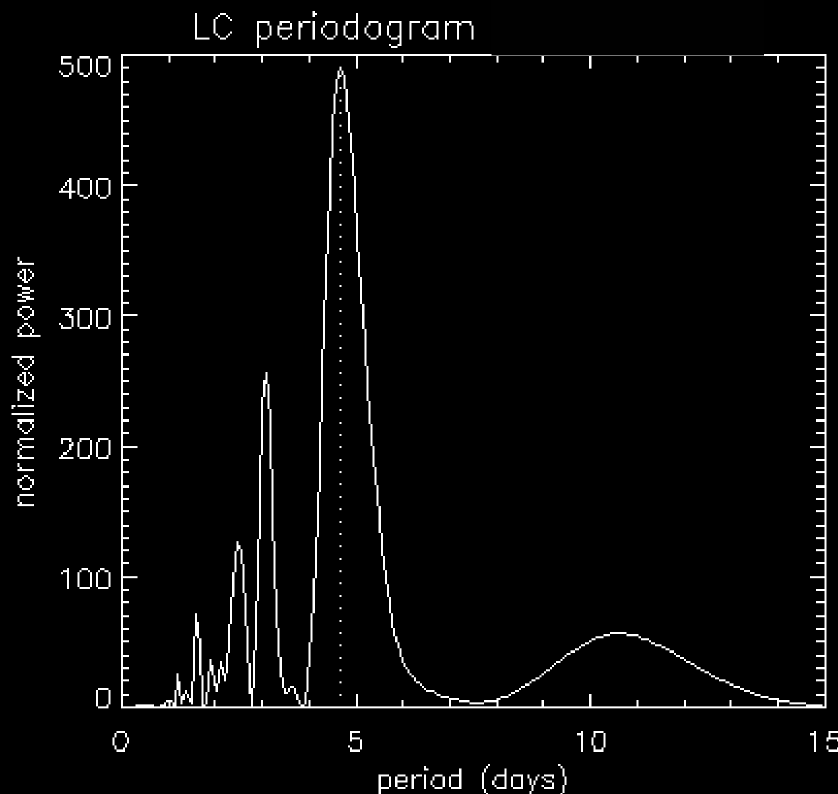
AA Tau type candidate



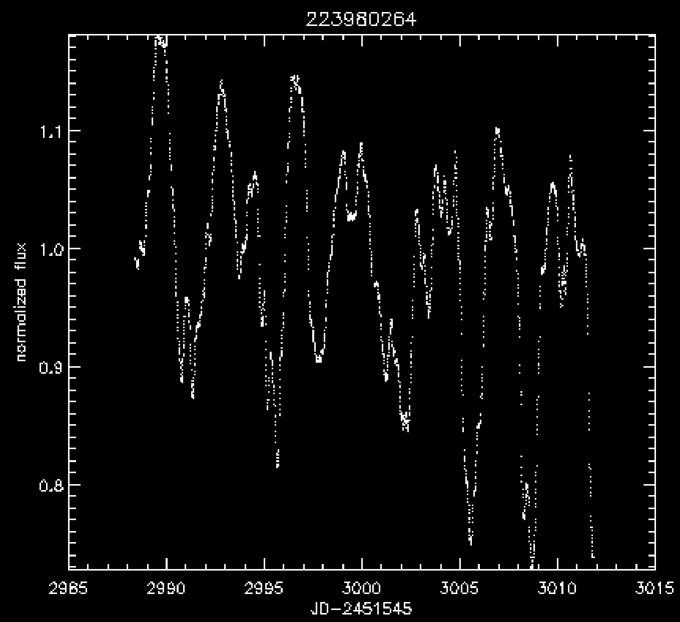


Variations mostly due to occultation by circumstellar material

COROT_ID=500007610, M3
WHα = 26.2 Å (Dahm & Simon 2005)
No period determined in the literature

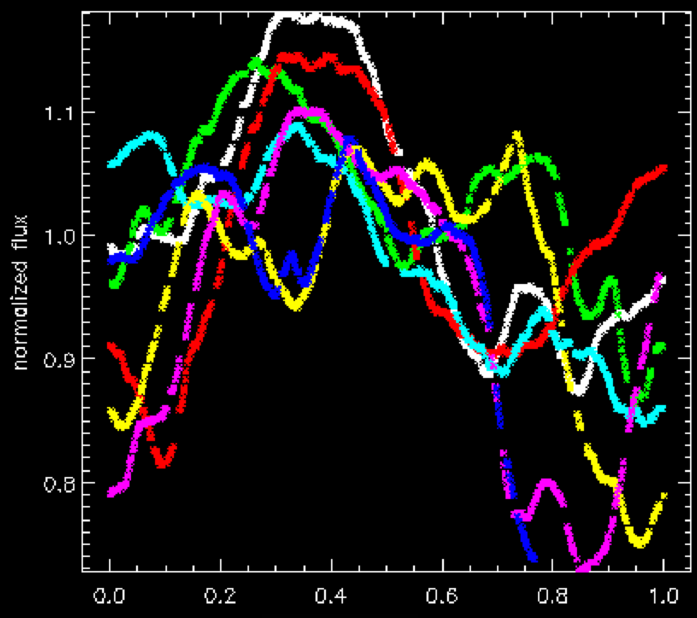


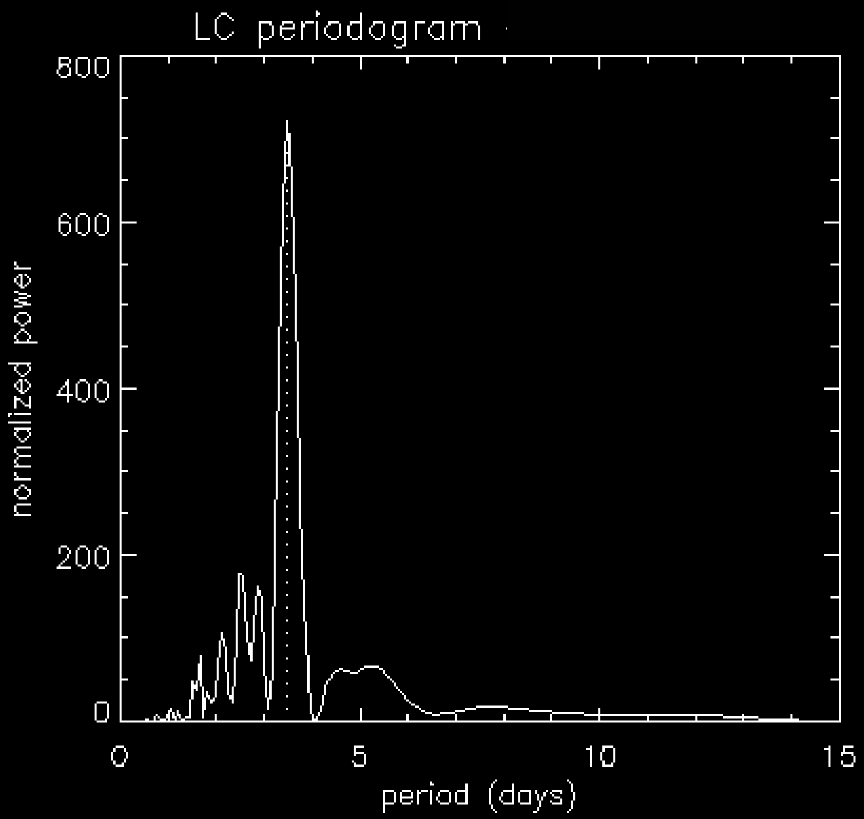
AA Tau type candidate



Variations mostly due to occultation by circumstellar material ?

COROT_ID=223980264,
K2-3 WHα = 14.3 Å (Dahm & Simon 2005)
No period determined in the literature





- The AA Tau type of light curve is quite common among CTTSs in NGC2264 (30 out of 88 candidates).

- The most variable stars in the cluster are CTTSs. The so far identified CTTSs already represent 60% of the stars with more than 20% of variability amplitude measured as $(flux_{max} - flux_{min}) \times 100$ and 83% of the stars with more than 40% of variability amplitude.

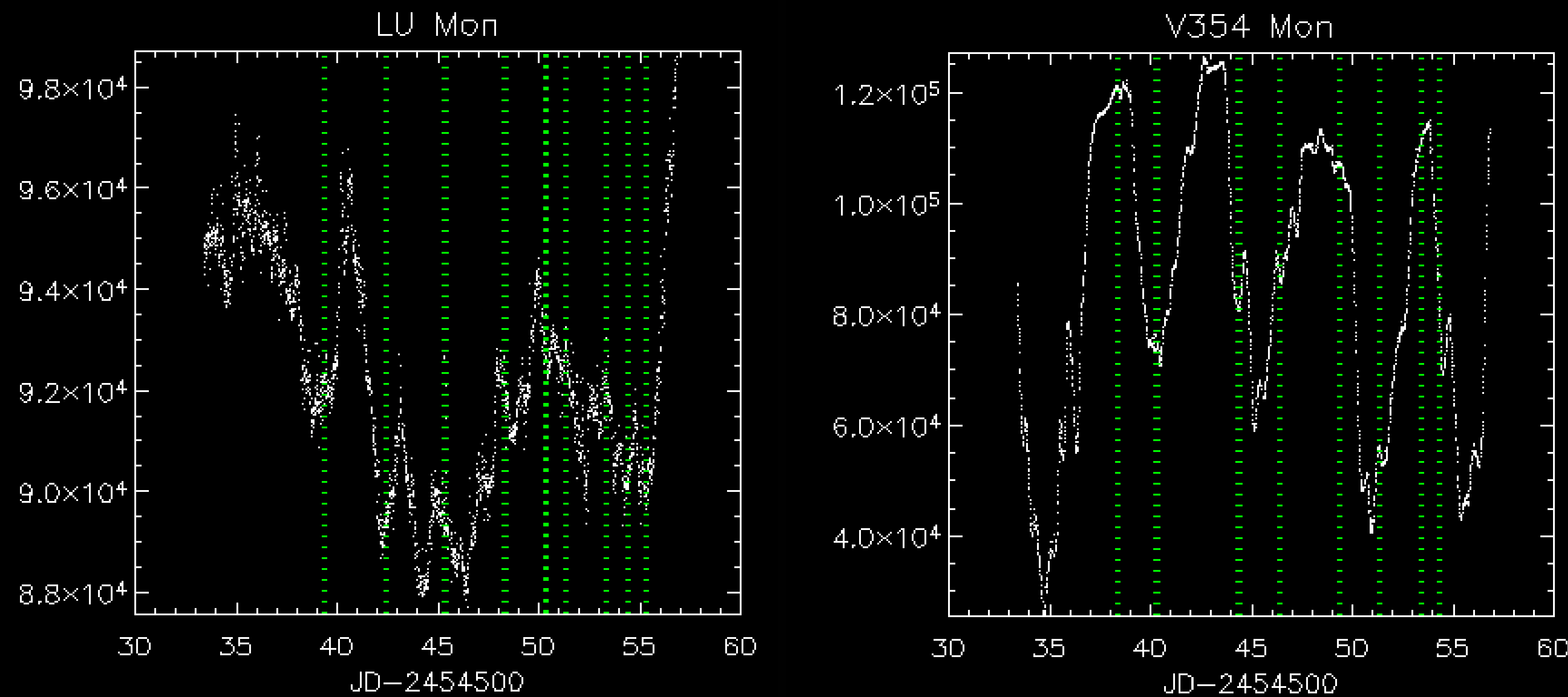
- The light curve morphology together with the strong variability can probably be used to identify CTTSs observed at high inclination with respect to the line of sight in other COROT fields.

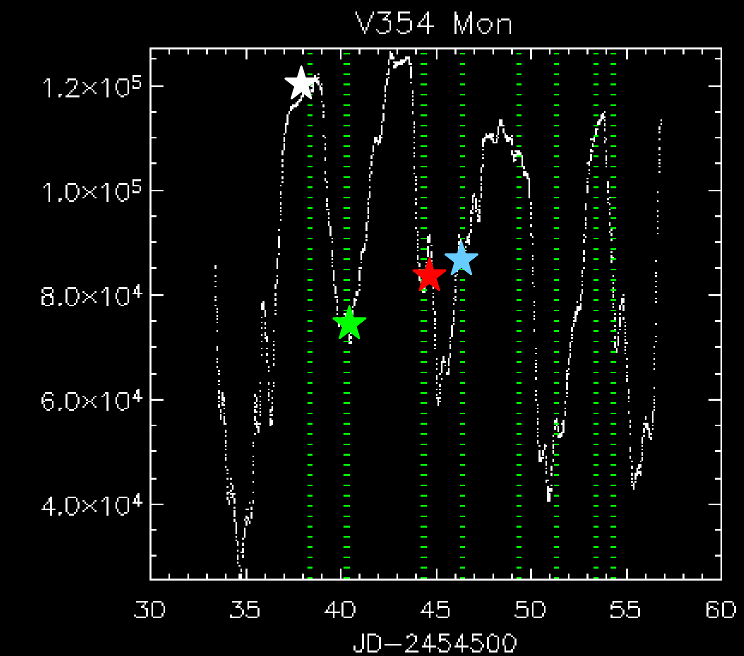
Spectroscopic observations of 2 CCTSs

Two CTTS were pre-selected and were observed with the SOPHIE échelle spectrograph from March 10 to March 30 of 2008 at the 1.93m telescope at OHP, simultaneously with the COROT observations.

LU Mon : M1V, V=15.05, p=11.78 days, WHα=113.2 Å

V354 Mon : K4V, V=14.45, p=5.22 days, WHα=16.6 Å

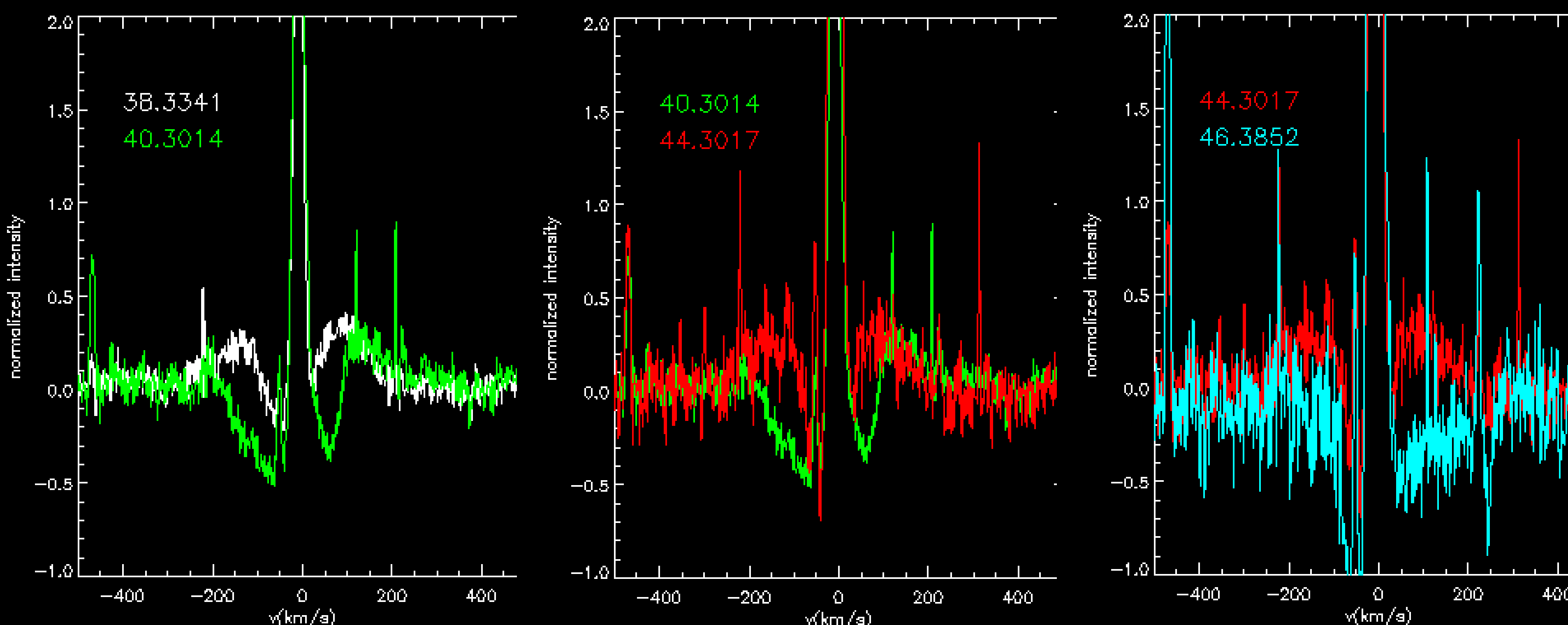


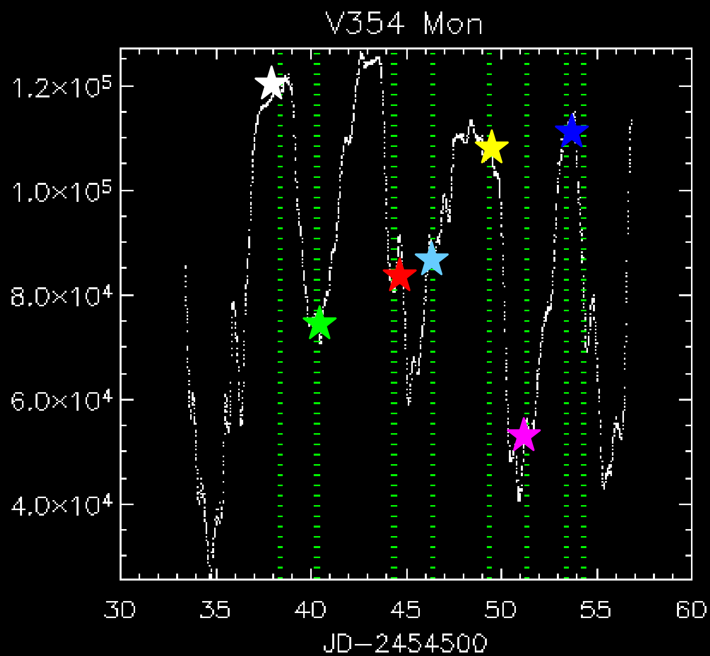


Circumstellar Hα profiles.

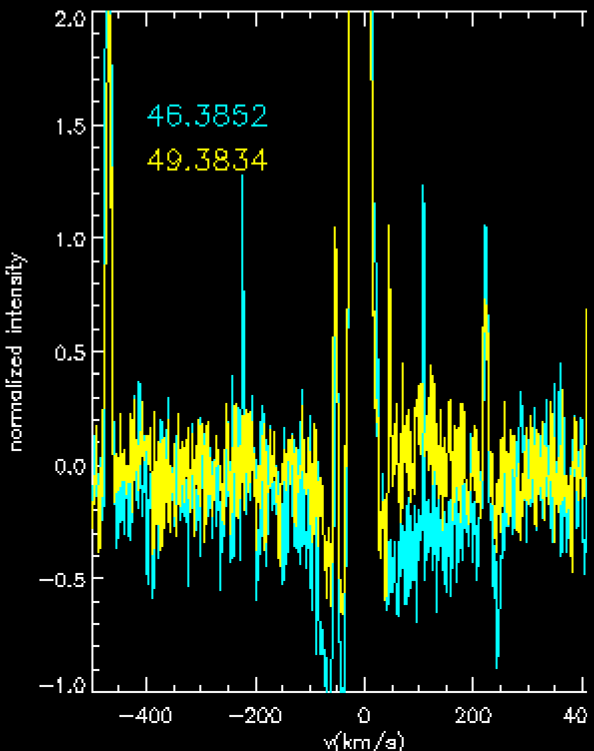
Nebular contamination hard to exclude properly.

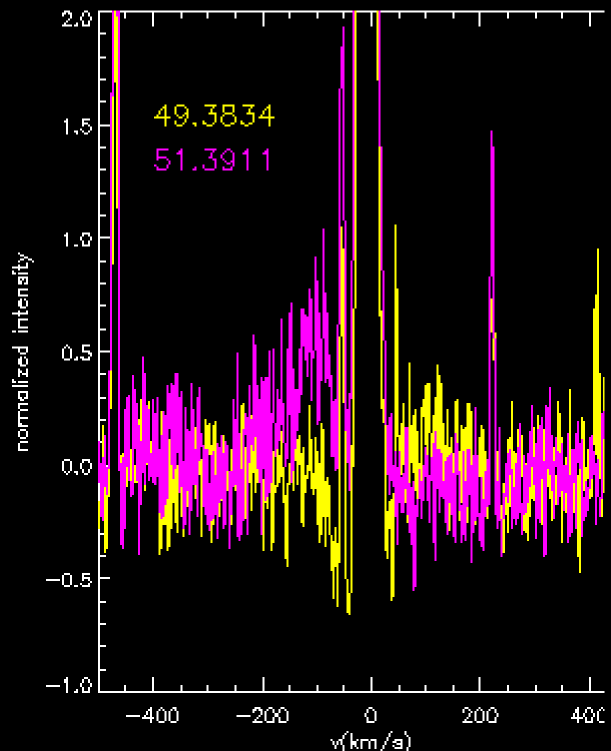
The Hα profile varies signficantly in each cycle, showing accretion/outflow variations.

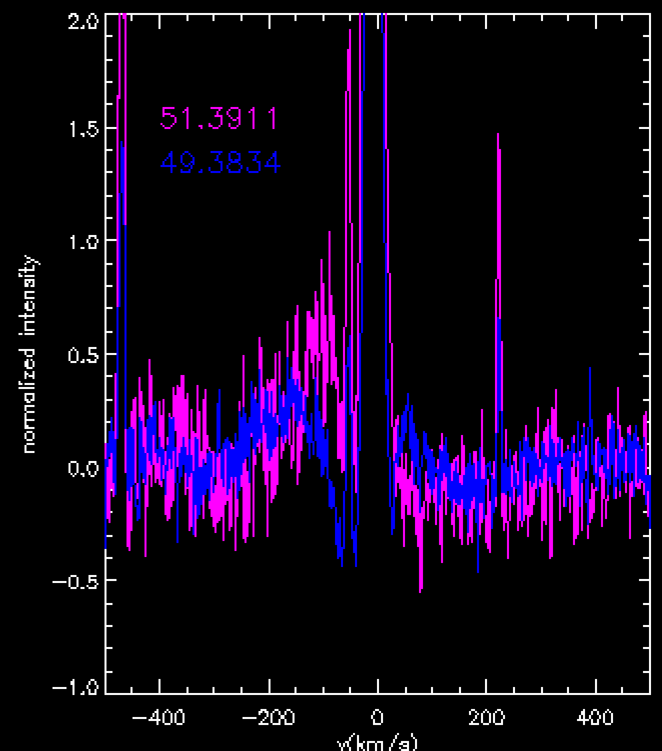




Work in progress....







Workplan for the CTTSs of NGC2264 observed with CoRoT

- Statistical work: light curve analysis and classification (morphology, periodicity), selection of interesting systems (like possible edge-on ones), analysis of accretion dynamics wherever possible

- Work on LU Mon and V354 Mon (simultaneous photometry and spectroscopy)

- Disk structure and evolution (together with Spitzer data), and the influence of companions to accretion and disk structure.