# Variability due to accretion episodes in Herbig Ae/Be Stars

**Jane GREGORIO-HETEM**

**University of São Paulo**

**Brazil**

# HAeBe's Team

- Sergio Vieira (UFMG)
- Marcelo Guimarães (UFMG)
- Sílvia Alencar (UFMG)
- Wagner Corradi (UFMG)
- Annibal Hetem Jr. (FSA)
- Marília Sartori (LNA)
- Claudia Rodrigues (INPE)
- Bruno Castilho (LNA)
- Simone Daflon (ON)

# Institutions

**UFMG: Universidade Federal de Minas Gerais**

**LNA: Laboratório Nacional de Astrofísica**

MG

**USP: Universidade de São Paulo**

**FSA: Fundação Santo André**

SP

**INPE: Instituto Nacional de Pesquisas Espaciais**

**ON: Observatório Nacional**

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20S
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# Historical Revision

- **Group's research on HAeBes started after PDS**

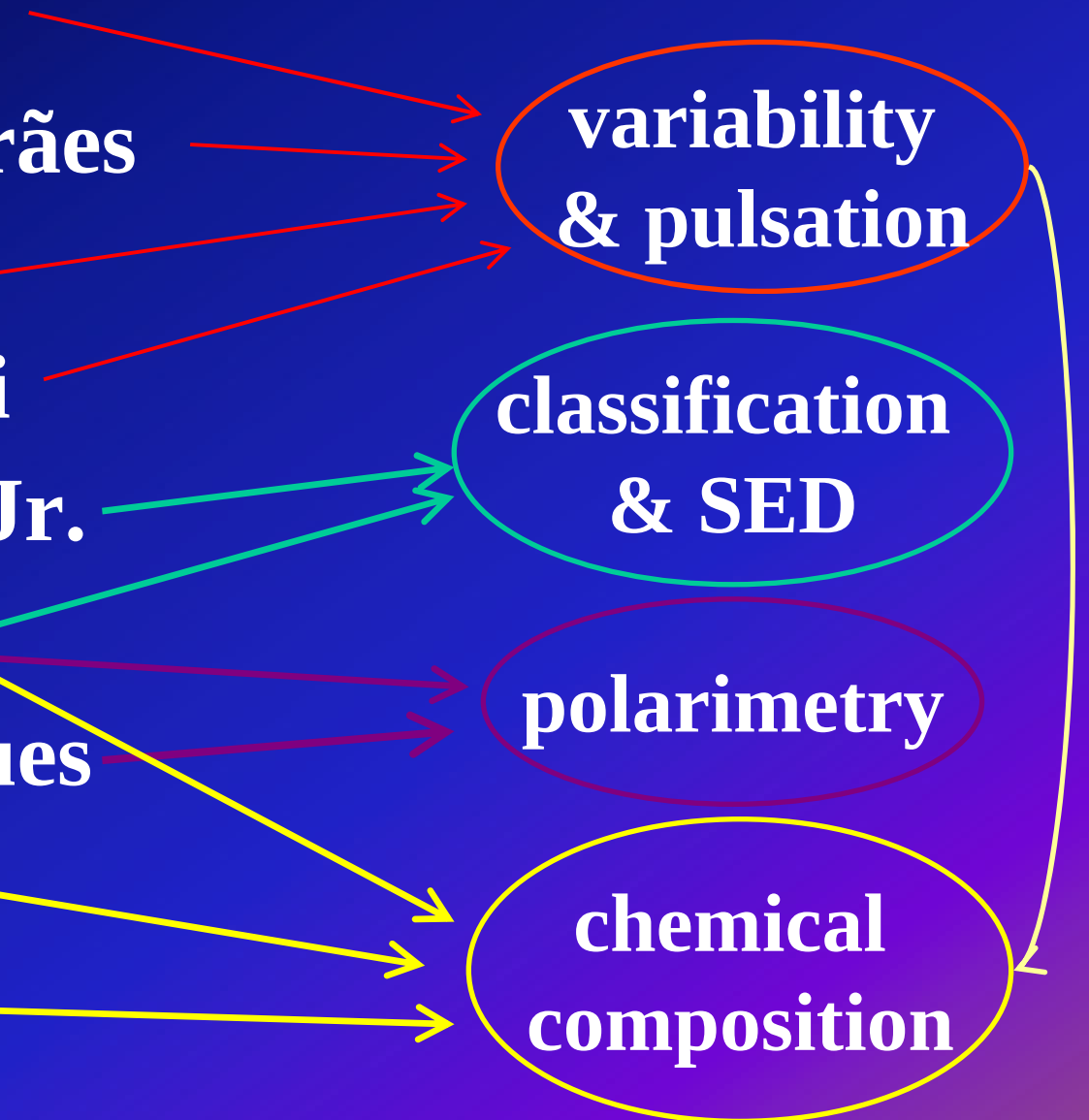
  ***Pico dos Dias Survey*, a search for young stars based on IRAS colors (Gregorio-Hetem et al. 1992; Torres et al. 1995; Torres 1999).**

- **PDS revealed several new TT stars, as well as other very interesting objects: 108 of them were classified as Herbig Ae/Be (HAeBe) candidate stars.**

(*) The criteria used by the PDS group to classify HAeBe stars are described in Vieira et al. (2003).

# Main topics on Herbig Ae/Be research

- Sergio Vieira
- Marcelo Guimarães
- Sílvia Alencar
- Wagner Corradi
- Annibal Hetem Jr.
- Marília Sartori
- Claudia Rodrigues
- Bruno Castilho
- Simone Daflon



# Goals

**The main goal is to better understand the variation due to interaction with circumstellar matter.**

**This talk is dedicated to show some of the results of our study ⇨ the base of the projects we intend to develop with CoRoT.**

# CLASSIFICATION OF THE PICO DOS DIAS SURVEY
# Herbig Ae/Be stars

**Sartori, Gregorio-Hetem & Hetem (2003)**

**Analysis of the circumstellar matter distribution of 99 PDS stars (80 candidates and 19 well-known HAeBe stars).**

## 1a. Results from Sartori, Gregorio-Hetem & Hetem Jr. (2003)

**A disk model was adopted to fit the spectral energy distribution (SED).**

- **Circumstellar contribution (dust disk and/or envelope) compared with the total emitted flux:**

$$S_C = \frac{F_{circumstellar}}{F_{Total}}$$

## 1b. Results from Sartori, Gregorio-Hetem & Hetem Jr. (2003)

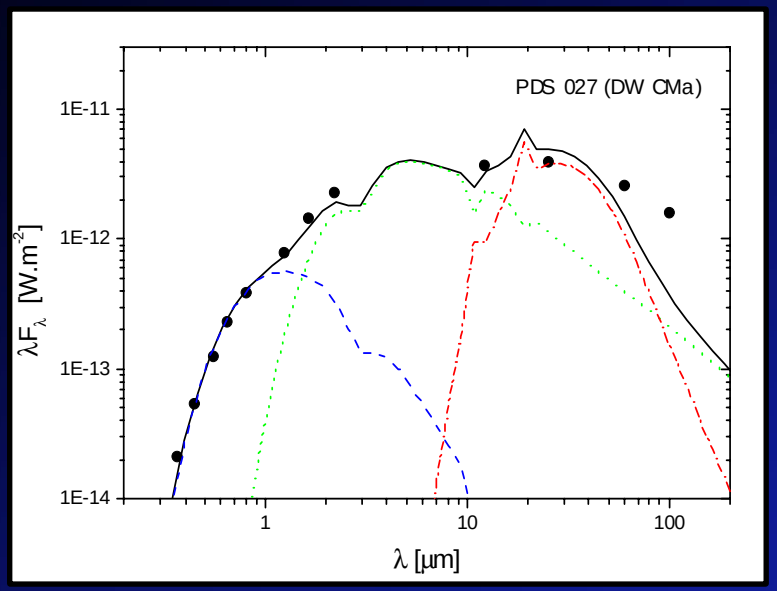
- **The sample was classified into three groups, according the shape of their SEDs. Their relation to *Sc* and other stellar properties were analyzed.**

- **Classification based on the spectral index* given by**

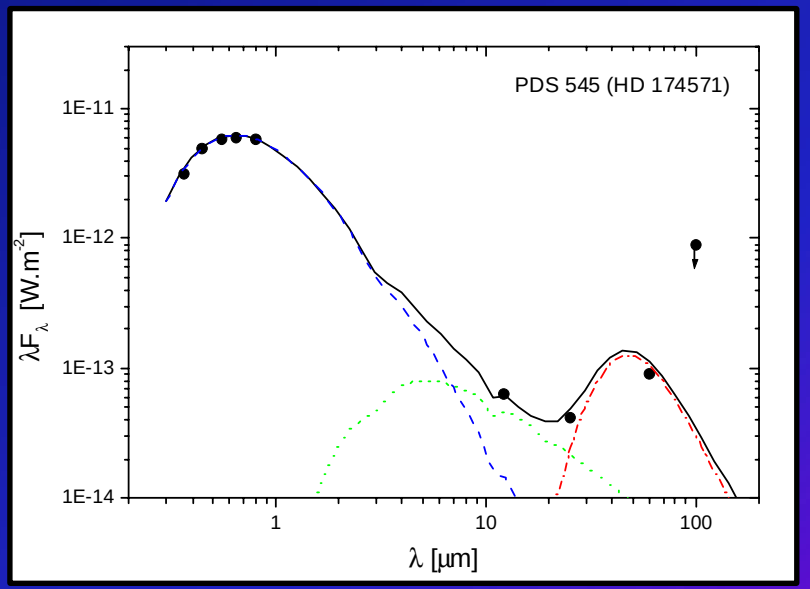
$$\beta_1 = 0.75 \log(F_{12}/F_V) - 1$$

(*) Torres 1999

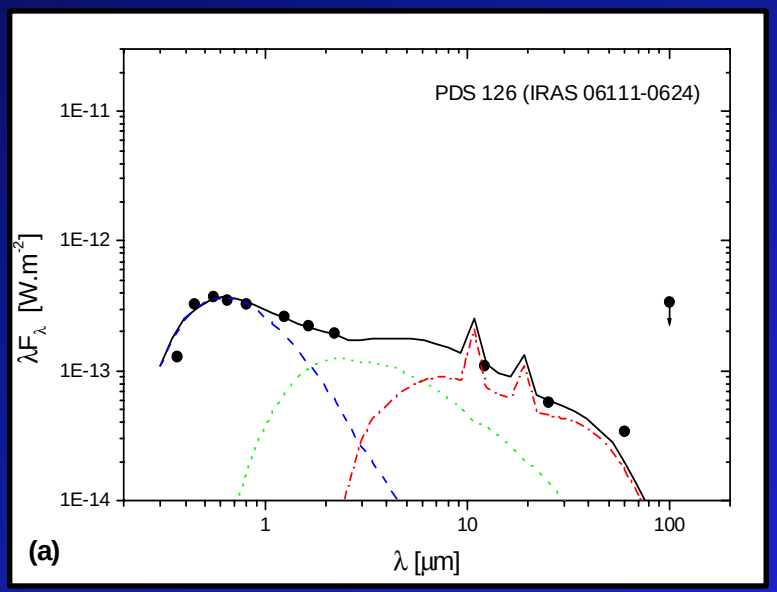
# 1c. Results from Sartori, Gregorio-Hetem & Hetem Jr. (2003)




$\beta_1 > 0$




$\beta_1 < -1$




$-1 < \beta_1 < 0$

## 1d. Results from Sartori, Gregorio-Hetem & Hetem Jr. (2003)

| Group | $\beta_1$ | $S_c$ | % of the sample | known HAeBe |
|---|---|---|---|---|
| **1** | $> 0$ | $> 70$ % | 44.4 % | 3 stars |
| **2** | -1 to 0 | 10 to 70 % | 49.5 % | 15 stars |
| 3 | $< -1$ | $\leq 10$ % | 6.1 % | 1 star |

# CIRCUMSTELLAR STRUCTURE OF HERBIG Ae/Be STARS

# Accretion episodes in PDS76 and PDS80

Guimarães, Corradi, Vieira, Alencar (2003, 2004)

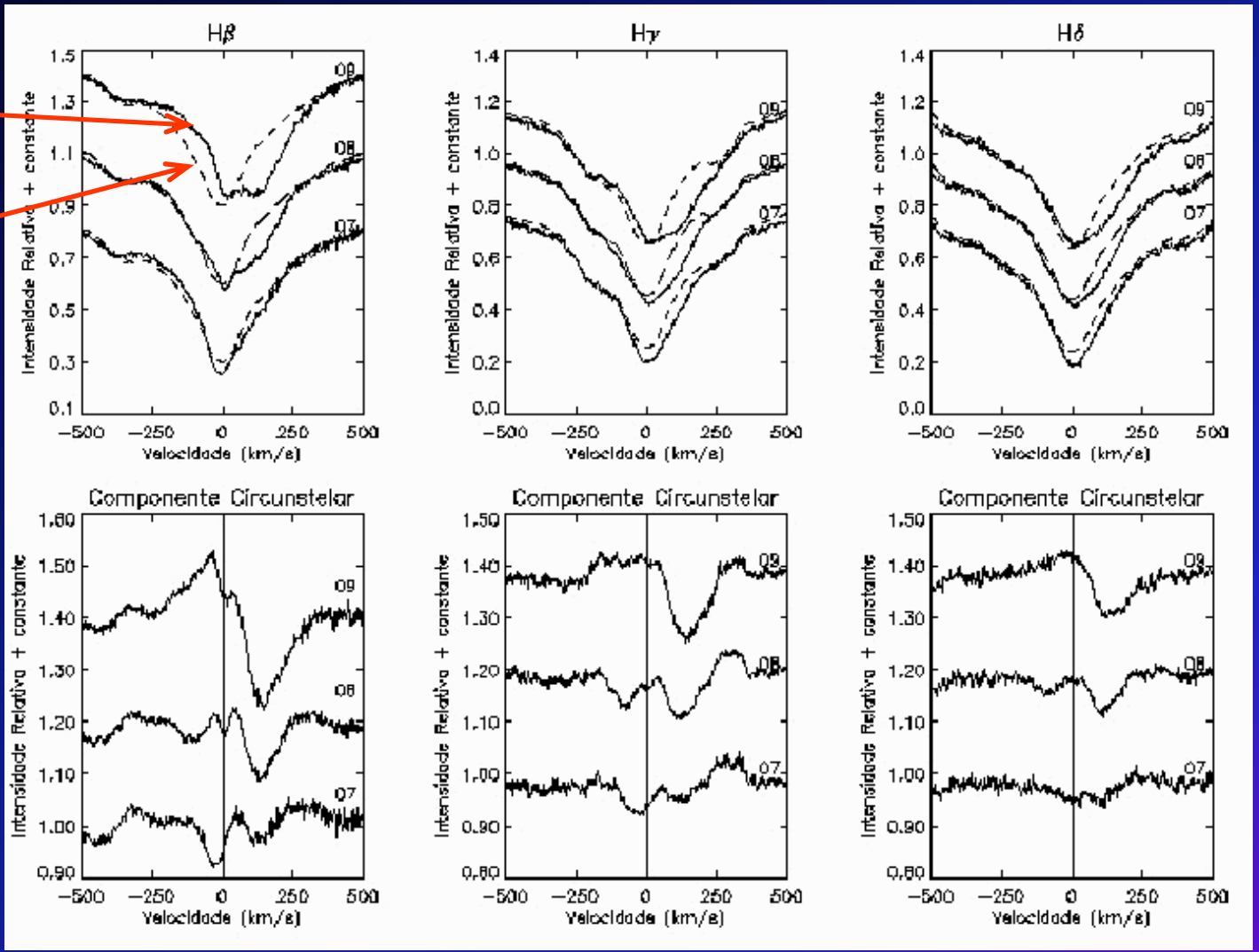
- Spectral synthesis* is used to fit observed stellar spectra ⇨ extract circumstellar components ⇨ give evidences about accretion and/or ejection of disk material.
- 20 HAeBe were observed during 3 nights ⇨ 1.5m ESO telescope & FEROS (May 7-9, 2002).

*SME: Spectroscopy Made Easy (Valenti & Piskunov 1996)

## 2a. Results from Guimarães, Vieira, Alencar & Corradi (2003, 2004)

observed

synthetic




(a) observed and synthetic spectra; (b) detected circumstellar components. Each night the absorption features of Hβ, Hγ and Hδ lines show redshift.

## 2b. Results from Guimarães, Vieira, Alencar & Corradi (2003, 2004)

- **two of the candidates: PDS76 (HD142666) and PDS80 (HD145718) ⇨ redshift of the absorption features in the circumstellar components.**
- **Kinematical analysis of the detected events ⇨ indicates accretion episodes.**

## 2c. Results from Guimarães, Vieira, Alencar & Corradi (2003, 2004)

# Time evolution of the circumstellar absorption depth (Natta et al. 2000):

- defined by

$$\tau = 1 - \frac{F_{obs}}{F_{syn}}$$

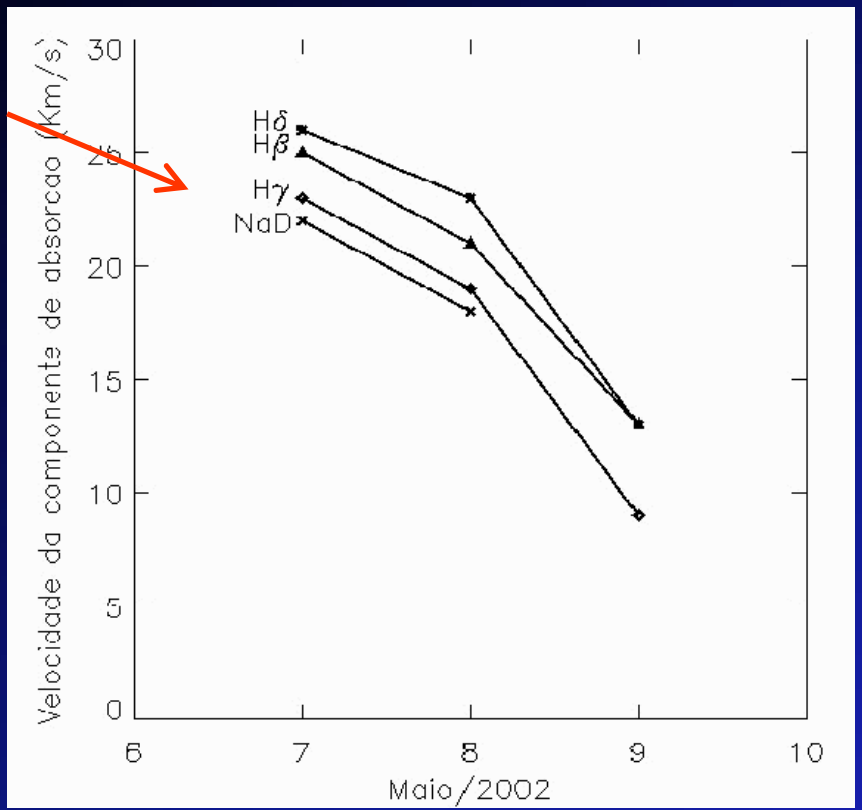
$F_{obs}$ ← observed flux

$F_{syn}$ ← synthetic flux

- $\tau \sim 1$ circumstellar line is saturated
- $\tau \sim 0$ no circumstellar contribution

## 2e. Results from Guimarães, Vieira, Alencar & Corradi (2003)

V

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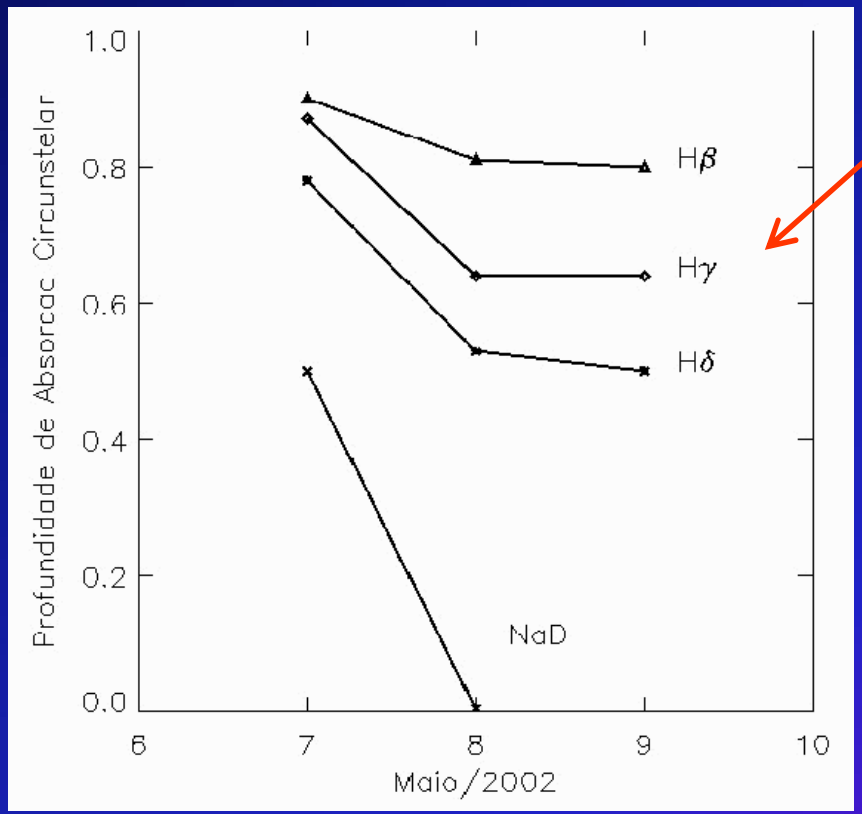
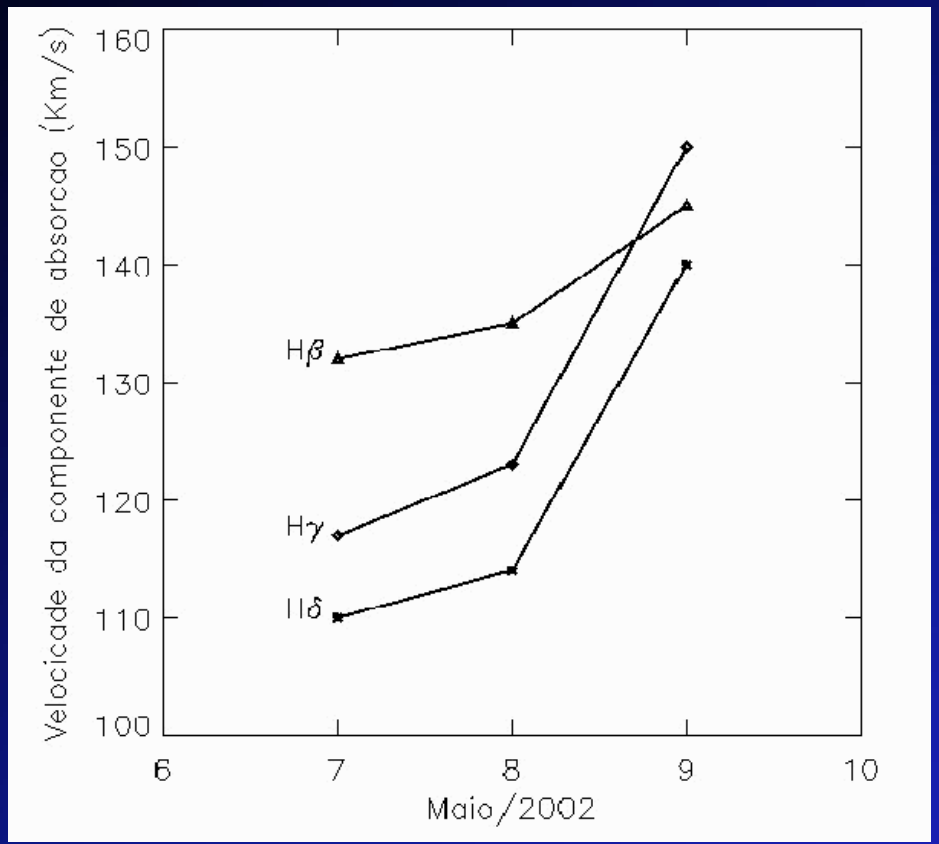
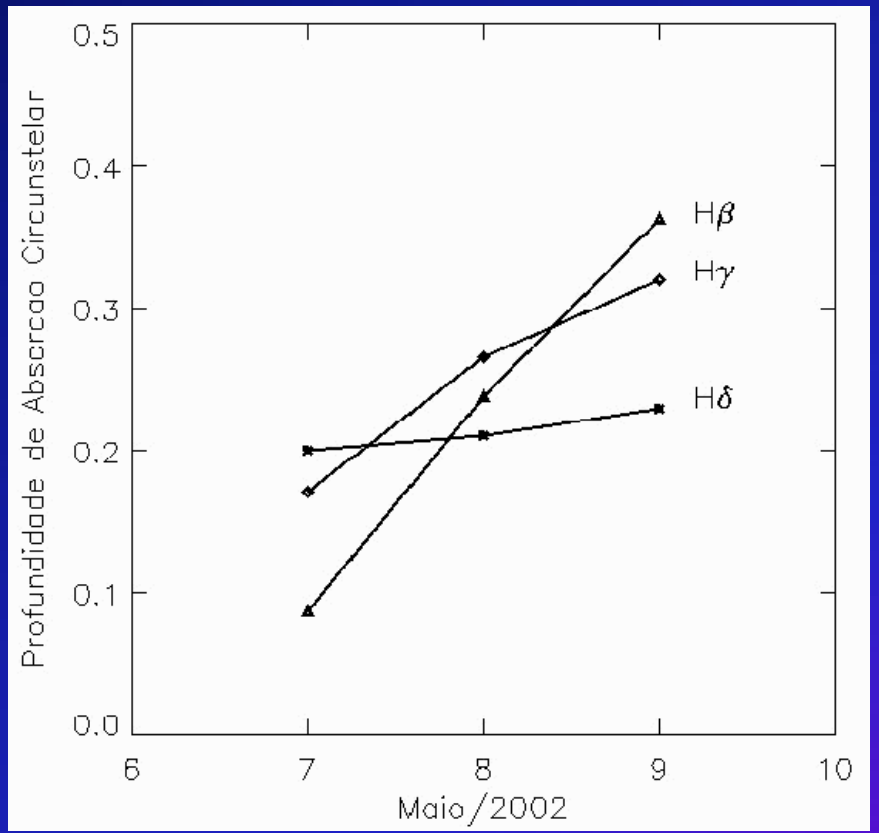



Time evolution of velocity and depth of the circumstellar absorption for PDS80.

The depth of the circumstellar absorption component of all lines decrease ⇨ concentration of material has also decreased in the line of sight ⇨ magneto-accretion model (↑ T ↑ $H^+$).

## 2f. Results from Guimarães, Vieira, Alencar & Corradi (2003)




**PDS76 has increasing velocities and depths of the RACs, which can be explained by a free-fall model ($\rho\uparrow$ $v\uparrow$ $\tau\uparrow$).**

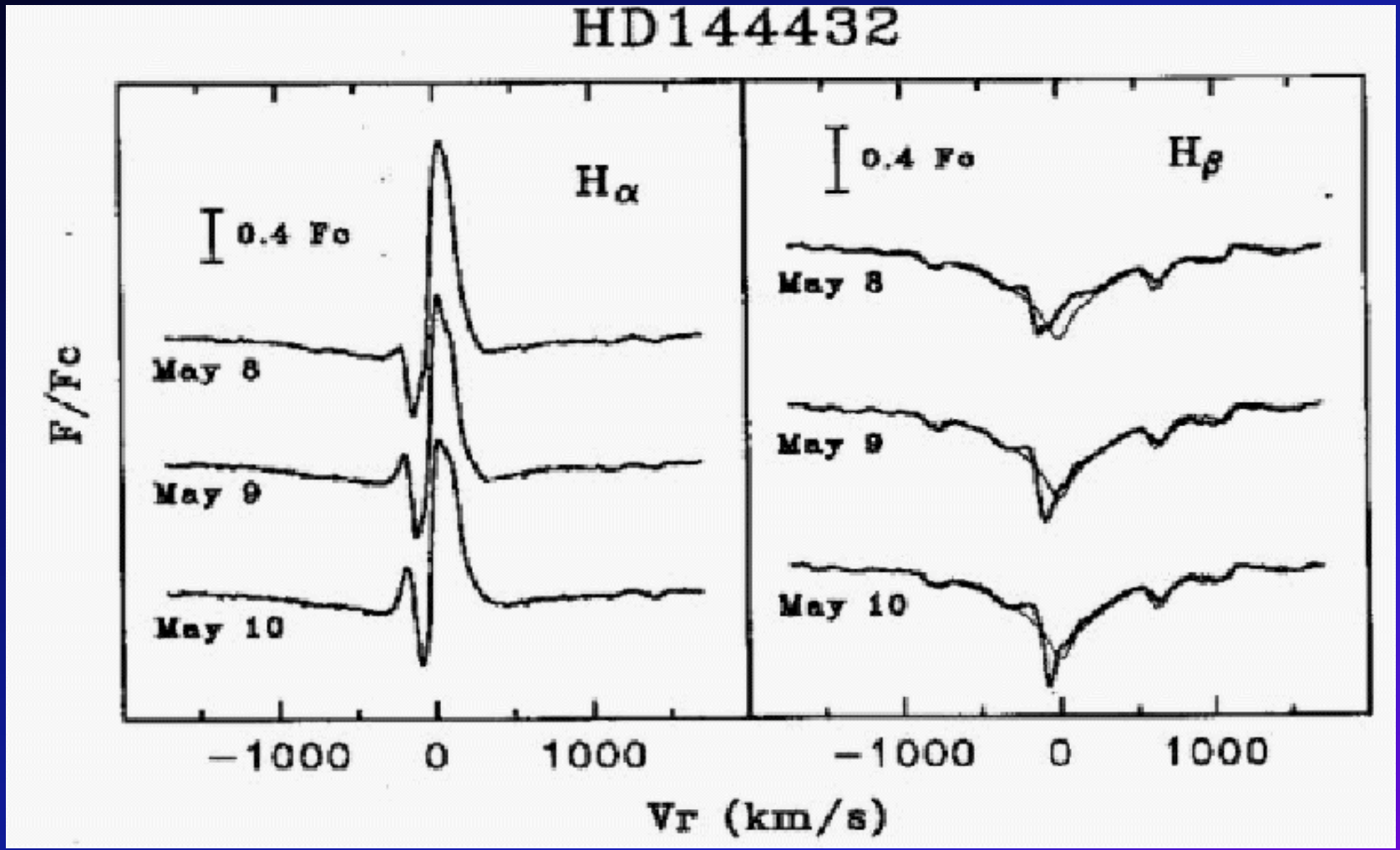
# Young A7e Herbig HD144432 (PDS78)

**Vieira, Pogodin & Guimarães (2003)**

- Report of the typical and unusual characteristics of the spectral behaviour of PDS78.

The PCyg Hα profile displayed remarkable variations during 3 observing nights (ESO1.5m+FEROS).

## 3a. Results from Vieira, Pogodin & Guimarães (2003)




**The absorption blue position changed from -135 to -90km/s.**

## 3b. Results from Vieira, Pogodin & Guimarães (2003)

- **The residuals from the nightly mean spectra show monotonous changes of intensity resembling "standing waves" ⇨ explained by an envelope containing a jet-like inhomogeneity (Pogodin 1990).**

- **PDS078 also shows a complex structure of D NaI lines, including emission component and a number of local absorptions variable in time.**

## 3c. Results from Vieira, Pogodin & Guimarães (2003)

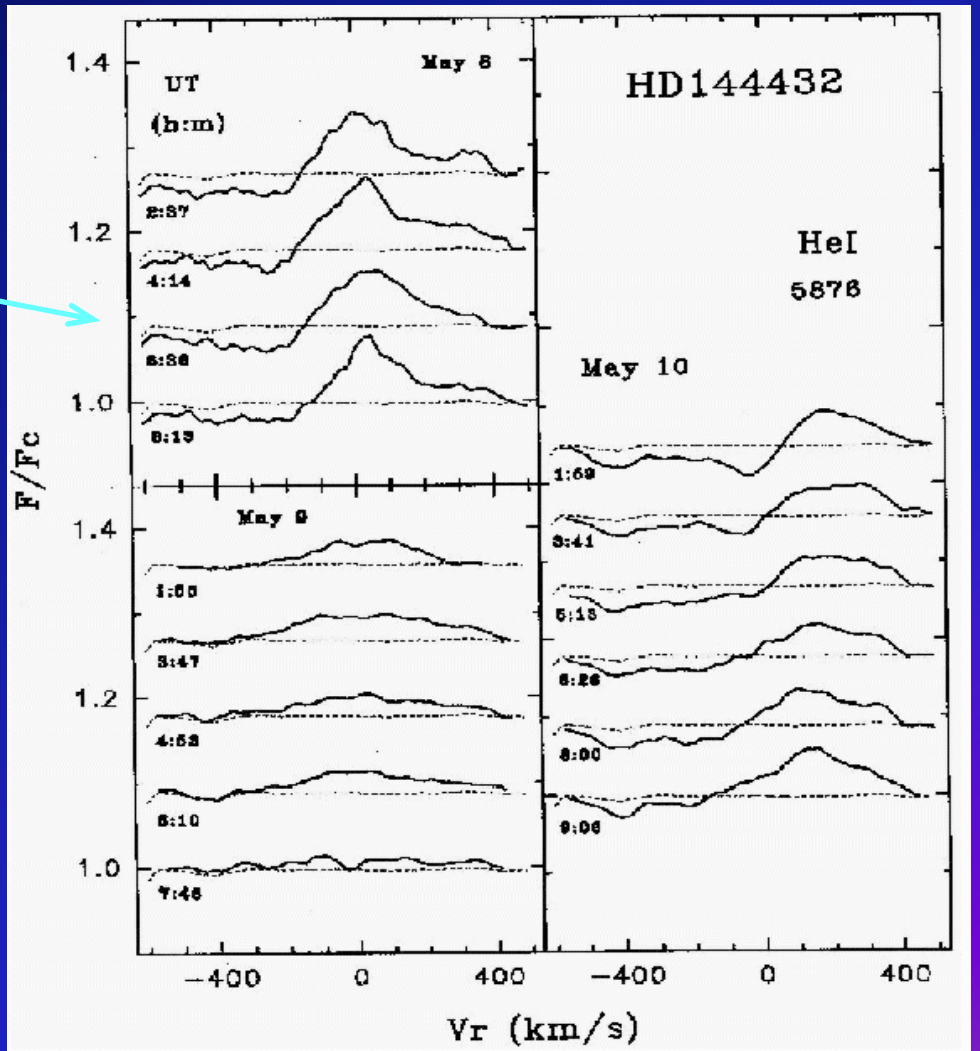
**Time series observations of HeI 5876 line, showing unusual variations in the blue wing of the P Cyg profile.**

⇩

**This behaviour is explained by the presence of a hot wind detected in TTs (e.g. Beristain et al. 2001 - DG Tau).**

⇩

**Not previously reported for HAes.**



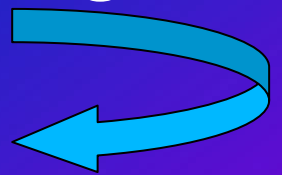
# Polarization of Herbig Ae/Be candidates and their environment

**Rodrigues, Sartori, Gregorio-Hetem, Magalhães, Batalha (2003)**

⇩

**V polarization of 81 HAeBe (PDS candidates)**

- **A large number of objects shows intrinsic polarization ⇨ presence of an envelope showing non-spherical symmetry.**
- **12 stars ⇨ high polarization (P > 3%)**
- **47 stars ⇨ low (P >0.5%)**
- **22 stars ⇨ none**



# Polarization of some PDS stars CoRoT fields

| Prime target | PDS | Comments |
|---|---|---|
| HD171834 | 530 | Very high polarization (12%), asymmetric envelope |
| HD 55265 | 241 | high polarization (3.5%), asymmetric envelope |

| Distance from the center | PDS | Comments |
|---|---|---|
| 4.0º | 520 | high polarization (3.5%), asymmetric envelope |
| 5.6º | 518 | Low polarization |
| 5.0º | 543 | Low polarization |

# Pulsation in Herbig Ae/Be stars PDS76 and PDS78

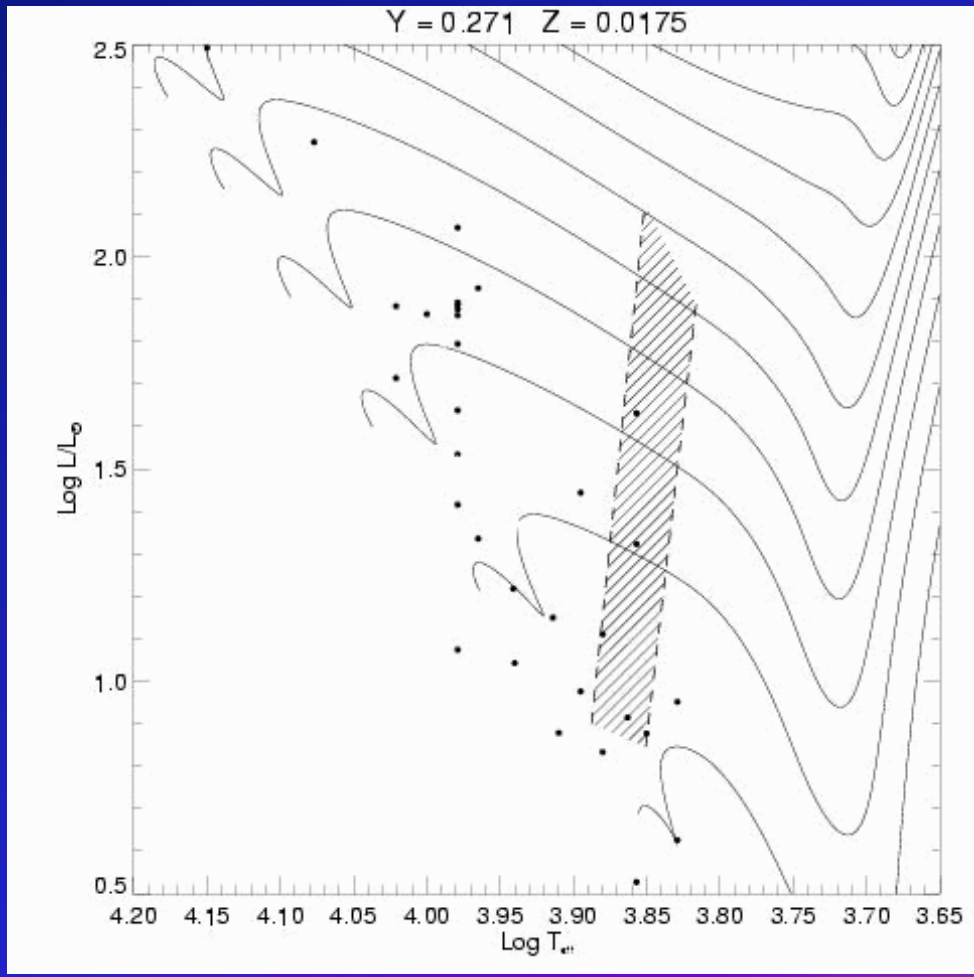
**(Mendes , Vieira, Corradi, Alencar, & Haddad 2004)**

**Selection of PDS HAeBes candidates to present non-linear pulsations**

⇩

**comparison with the instability strip for intermediate mass PMS stars (Marconi & Palla 1998).**

**PDS76 & 78 were observed at OPD during 4 nights ⇨ preliminary results ⇨ Corradi et al.'s poster.**




HR Diagram showing the position of PDS HAeBe candidates compared with the instability strip.

# Ground based observations of PMS candidates to CoRot Additional Programme

(Vieira, Corradi, Gregorio-Hetem, Rojas, Lépine, Alencar, Santos)

**See posters:**

**Rojas et al. ⇨ candidate selection**

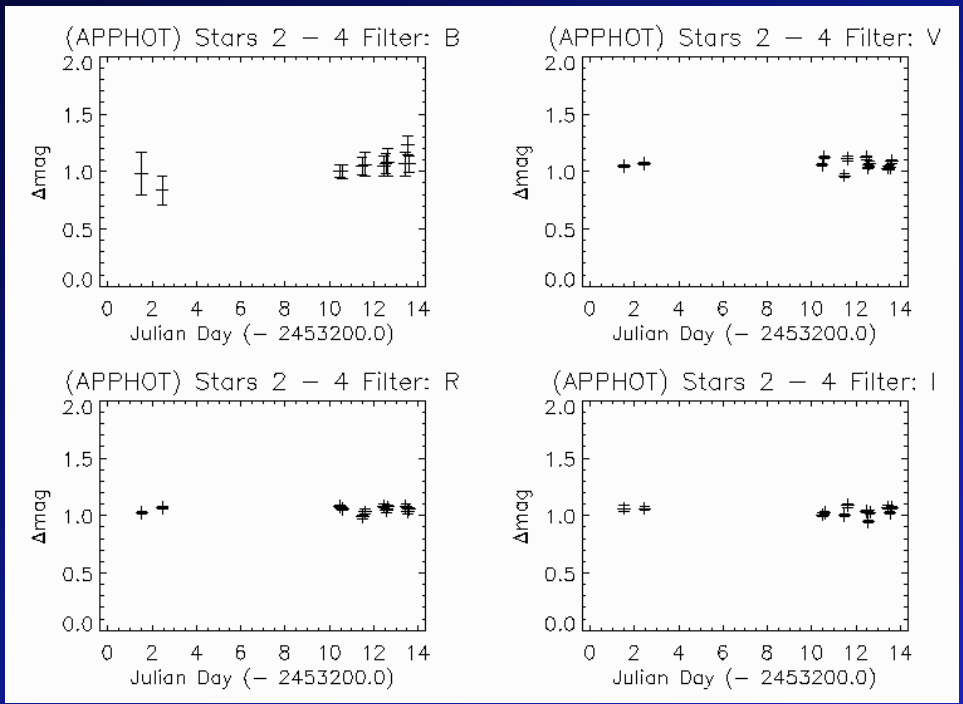
**&**

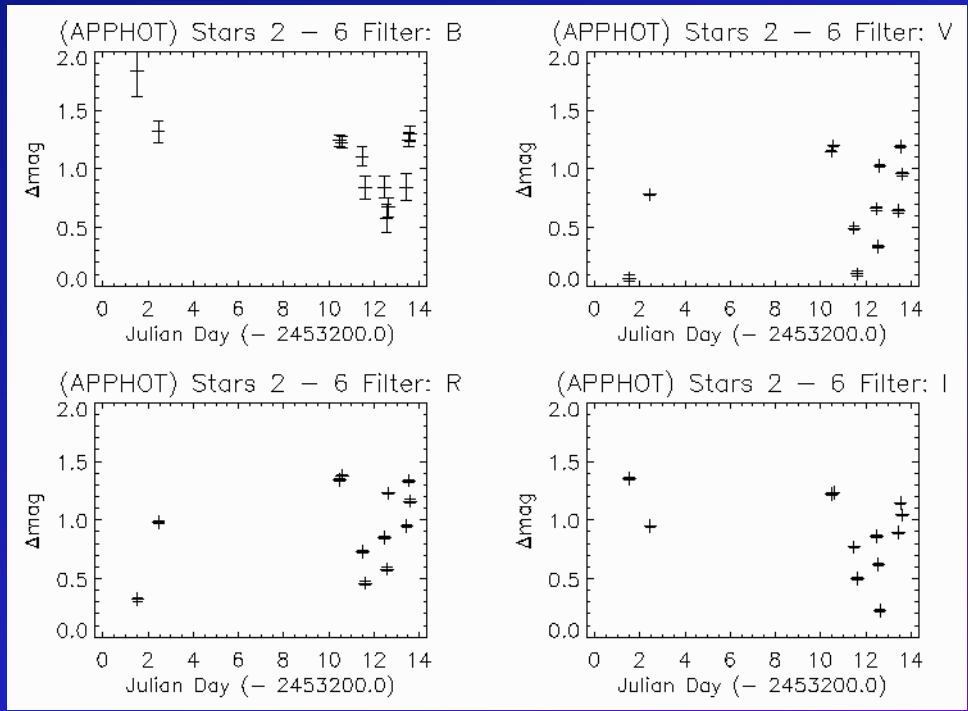
**Vieira et al. ⇨ BVRI photometry**

| file name | Object | Data / observing run | | | |
|---|---|---|---|---|---|
| | | June 09-13 | June 22-26 | July 14-18 | July 22-26 |
| tt1 | PDS090, PDS091 | 2 | 4 | 10 | 2 |
| tt2 | PDS498 | | 4 | 10 | 3 |
| pms1 | NGC6633 | 8 | 12 | 7 | 3 |
| pms2 | IC4756a | | 11 | 7 | 2 |
| pms3 | IC4756b | | 11 | 7 | 1 |
| pms4 | PDS530 | 4 | 11 | 4 | 1 |
| pms5 | Berkeley 81 | 12 | 11 | 7 | 1 |
| pms6 | J190418.9+000 | | 11 | 7 | 1 |
| pms7 | J190534.6-003 | | 11 | 7 | 1 |
| pms8 | HBC684 | | 4 | 7 | 1 |
| pms9 | J191329.9+022 | | 3 | 7 | 1 |
| pms10 | IC4756c | | 1 | | 1 |

## Ground observations of PMS candidates to CoRot Additional Programme

# BVRI photometry: Preliminary Results




Comparison between light curves of a field star and PDS91 (classical T Tauri)

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