

# Spectroscopic properties of nearby late-type stars, members of stellar kinematic groups and associations.

J. Maldonado,<sup>1</sup> R.M. Martínez-Arnáiz<sup>2</sup>, C. Eiroa<sup>1</sup>, D. Montes<sup>2</sup> and B. Montesinos<sup>3</sup>

<sup>1</sup>Universidad Autónoma de Madrid

<sup>2</sup>Universidad Complutense de Madrid

<sup>3</sup>Laboratorio de Exoplanetas - Centro de Astrobiología

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## Outline

- 1 Introduction**
  - About moving groups
  - Observations
- 2 Kinematic Analysis**
  - Identification of moving group candidates
- 3 Age estimates**
  - Lithium abundance
  - Stellar Activity indicators
- 4 Final membership**
- 5 Summary**

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## Why moving groups?

- *Origin and evolution still misunderstood*
- *Classical theory of MGs: stars in open clusters - field stars*
- *Classical MGs: Castor, IC2391, Ursa Major, Local Association, Hyades*
- *Most members of MGs identified only by means of kinematic criteria*  
(contamination of previous MGs lists by old field stars)

## Applications of MGs members

- 1 Solar-analogues.
- 2 Flux-Flux and rotation-activity-age relationships: (e.g. Martínez-Arnáiz et al. 2010)
- 3 Substellar companions: (e.g. Hormuth et al. 2007, direct imaging; Schnupp et al. 2010, lucky imaging)
- 4 Cold faint discs: (e.g. DUNES, Eiroa et al. 2010; Montesinos et al. this meeting)

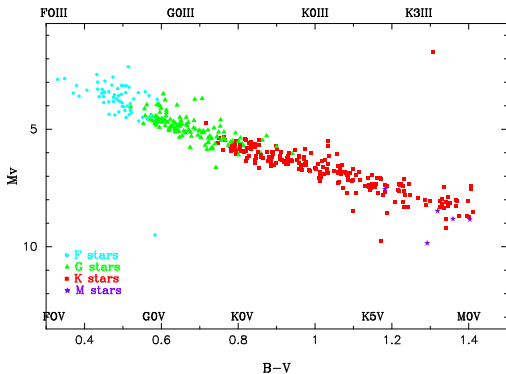
## High-resolution spectroscopy

- *Late-type stars spectra full of narrow absorption lines* ⇒ *Accurate radial velocities*
- *Age-related properties for late-type stars* ⇒ *Li I 6707.8 Å,  $\log R'_{\text{HK}}$ , ...*

**The sample:** Hipparcos main-sequence FGK stars at distances less than 25 pc (405 stars observed up to now)

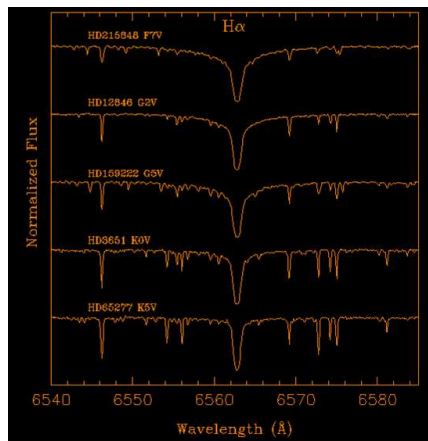
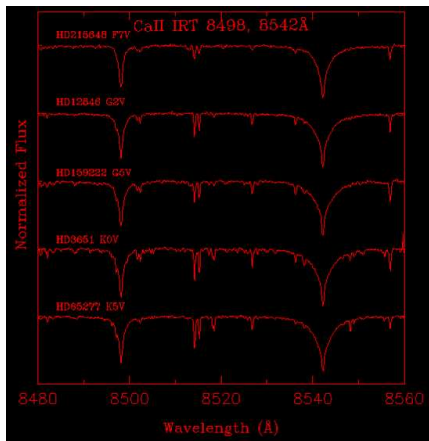
### Observing runs

- FOCES  
Calar Alto  
2.20 m
- SARG-TNG  
La Palma  
3.56 m
- + Public Archives  
S<sup>4</sup>N

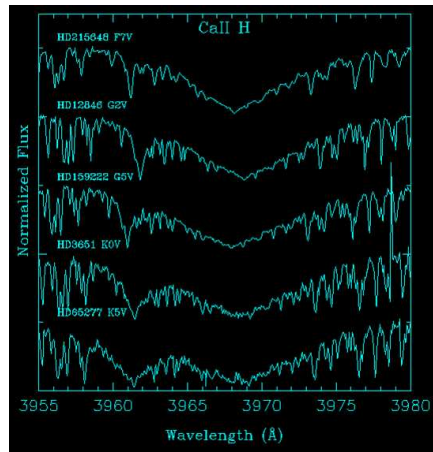
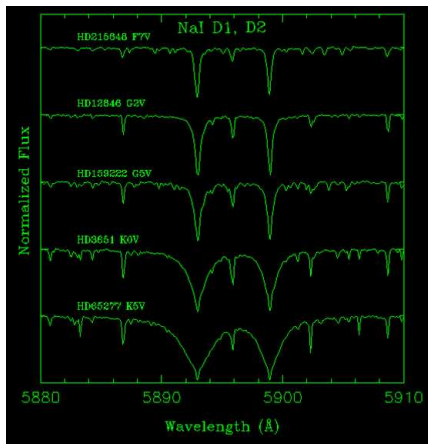


HR diagram

## Example of obtained spectra (I)



## Example of obtained spectra (II)



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## Identification of moving group candidates

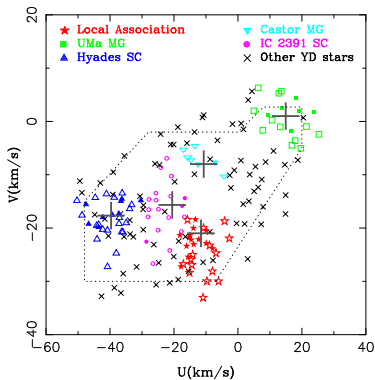
- Radial Velocities by Cross-Correlation (IRAF/Fxcor)
- +  $\pi$  (Hipparcos) +  $\mu_{\alpha}, \mu_{\delta}$  (Tycho 2)  $\Rightarrow$  ( $U, V, W$ )

## Two steps

- 1 Selection of young stars:  
 $-50 \text{ km/s} < U < 20 \text{ km/s}$   
 $-30 \text{ km/s} < V < 0 \text{ km/s}$
- 2 Selection of possible MGs members with small  $V$  dispersion ( $8 \text{ km/s}$ )

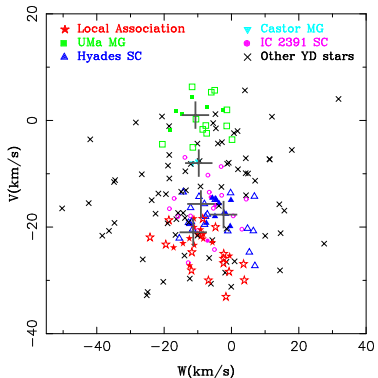
## Binaries

$V_r$  Centre of Mass



( $U, V$ ) plane

## Identification of moving group candidates

**Identifications**

- Local Association: 29
- Hyades: 29
- Ursa Major: 18
- IC2391: 19
- Castor: 7
- Young discs: 78

( $W$ ,  $V$ ) plane

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## Li I 6707.8 Å $\Rightarrow$ age indicator in late-type stars

### Measurement

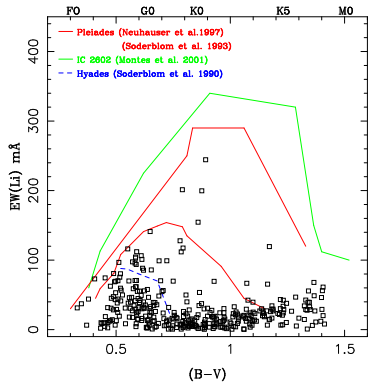
- IRAF-sbands:  
Integration within 1.6 Å band
- Correction for possible Fe I contamination:  
$$\text{Fe I (EW)} = 0.020 \times (B - V) - 0.003 \text{ (Å)}$$

### A very qualitative indicator

Li I EW has a wide-spread at a given age and mass  $\Rightarrow$  Relation lithium-age poorly constrained.

## Results

- 4% stars:  $\sim 80$  Myr
- 8% stars:  $\sim 300$  Myr
- 23% stars:  $> 600$  Myr
- 50% stars:  $> 80$  Myr
- 15% stars: no detection
- Stars with the largest EWs: in the boundaries of the Local Association



Lithium EW vs (B-V)

## Chromospheric emission: Ca II H & K

$$\log(\tau/\text{yr}) = -38.053 - 17.912 \log R'_{\text{HK}} - 1.6675 \log R_{\text{HK}}^2$$

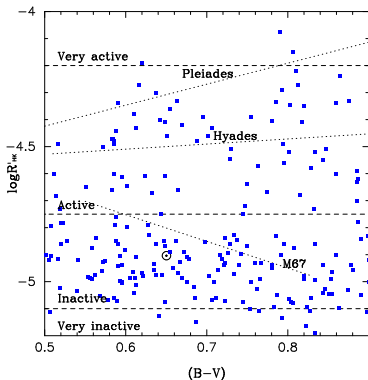
(Mamajek & Hillenbrand 2008)

### Results

- ~ 8% very inactive
- ~ 47% inactive
- ~ 41% active
- ~ 4% very active
- Most very active stars are MG candidates

### CABS

Activity/Rotation enhanced by tidal interaction



$\log R'_{\text{HK}}$  vs  $(B-V)$

## Coronal emission: ROSAT data

$$L_X = 6.3 \times 10^{-4} L_{\text{Bol}} \quad (\tau < \tau_i)$$

$$L_X = 1.89 \times 10^{28} \tau^{-1.55} \quad (\tau > \tau_i)$$

$$\tau_i = 2 \times 10^{20} L_{\text{Bol}}^{-0.65}$$

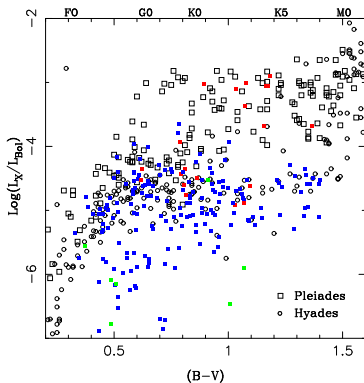
(Garcés et al. 2010)

### Results

- ~ 23% Pleiades region
- ~ 51% Hyades region
- ~ 26% Below the Hyades' sequence

### Saturated regime

Upper limit to the age



$\log(L_X/L_{\text{Bol}})$  vs  $(B-V)$

## Stellar rotation: Gyrochronology

$$P_{\text{Rot}} = 0.407((B - V) - 0.495)^{0.325} \times t^{0.566}$$

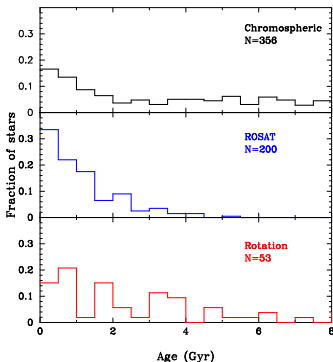
(Mamajek & Hillenbrand 2008)

### Results

- Only ~ 17% stars have periods
- ~ 22% Pleiades-like
- ~ 28% Hyades-like
- ~ 50% old-stars

### Comparison

The agreement between the 3 stellar-activity indicators is overall good.



Age distributions

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## Comparison kinematic - age estimates

### Classification

- **Probable non-member:** If the derived ages from the different indicators agree, but they are in conflict with the object having an age as an MG member.
- **Doubtful member:** If there is important disagreement among the different age indicators, including here the assigned age of the corresponding MG, or there is lack of information (i.e., some age indicators are not available)
- **Probable member:** If age indicators agree and also do with the position of the star in the  $(U, V)$  plane.

## Results

- *25% of the stars can be classified by means of their kinematics as MGs members*
- *40% of them have ages in agreement with the corresponding MG age*

### Probable members

- Local Association: 14 out of 29
- Hyades: 11 out of 29
- Ursa Major: 6 out of 18
- IC2391: 6 out of 19
- Castor: 4 out of 7

## Some interesting stars (HIP numbers)

### Stars with debris discs

13402 (LA), 18859 (LA),  
19335 (too young to be HS!),  
42438 (UMa), 71395 (UMa),  
22263 (IC2391)

### Stars with planets

7 out of 19 stars candidates to  
MGs, but most of them  
doubtful or non-members,  
e.g. 21483, 43587 (HS). Only  
71395 (UMa) is probable  
member.

### Spectroscopic binaries

Cas: 45383, 110778, 117712  
(CMD as additional age  
indicator)  
LA: 86346, M-type star, close  
companion + SB, all  
chromospheric indicators in  
emission, X-ray emission  
saturated

### Chromospheric-ROSAT

Discrepancies found in  
several stars, e.g. 12110,  
67105 (Cas)

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## High-resolution spectra of 405 nearby late-type stars

- 1 Kinematic data:** Parallaxes, proper motions, radial velocities,  $(U, V, W)$ 
    - 102 stars kinematic candidates of MGs + 78 possible young discs stars
  - 2 Age-related properties:** Li I 6707.8 Å ,  $\log R'_{\text{HK}}$ ,  $L_X$ , rotation
    - 41 probable members; 36 doubtful members; 25 probable non-members
- Some bona fide MGs members identified here not reported before, specially in IC2391 and Castor
  - Some previously claimed members, discarded by our results