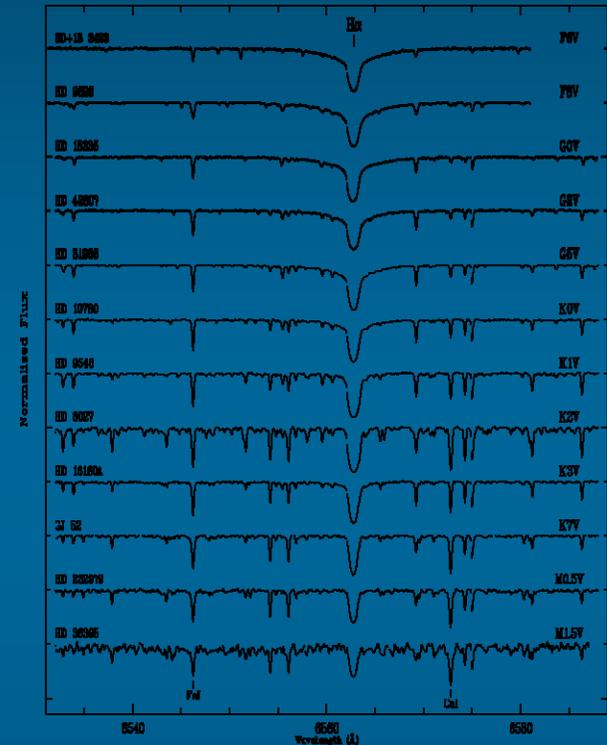
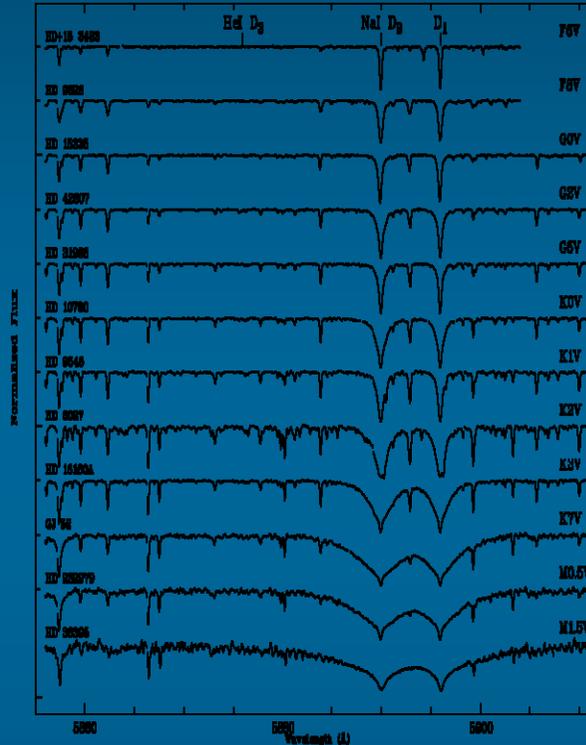
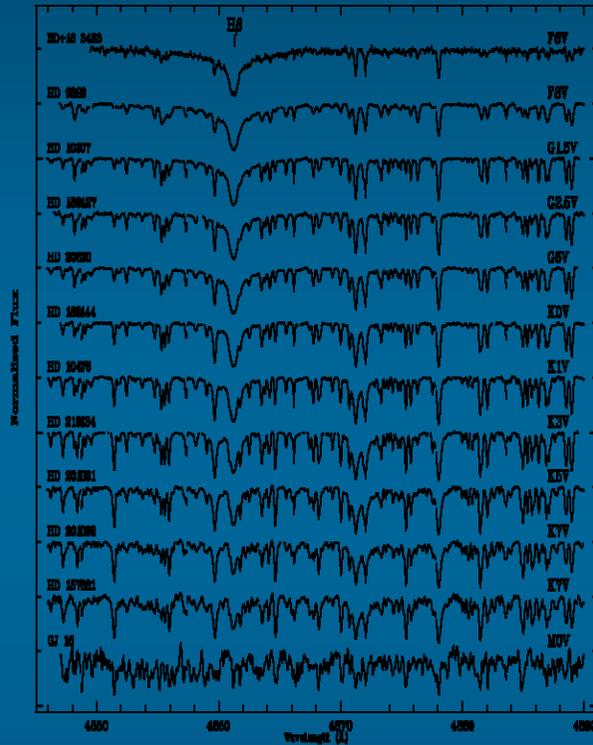


Librerías de Espectros de Alta Resolución de Estrellas Frías



Dpto. Astrofísica, F. Físicas
Universidad Complutense de Madrid, UCM

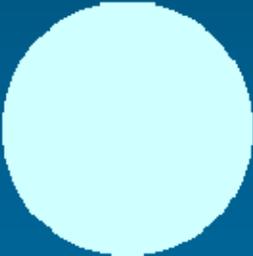
David Montes



"Red Temática del Observatorio Virtual Español" – 7 abril 2006

Estrellas Calientes (Primeros tipos)

Estrellas Frías (Últimos tipos)

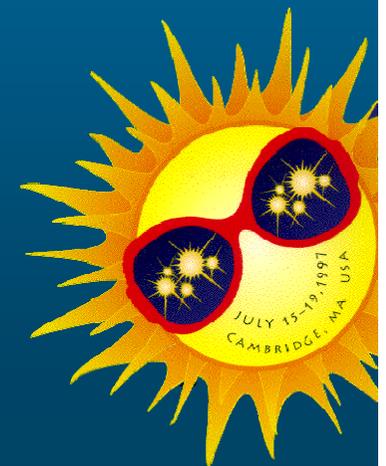
	<u>Main Sequence Stars</u>						
							
Spectral Type:	O	B	A	F	G	K	M
Temperature:	40 000K	20 000K	8500K	6500K	5700K	4500K	3200K
Radius (Sun=1):	10	5	1.7	1.3	1.0	0.8	0.3
Mass (Sun=1):	50	10	2.0	1.5	1.0	0.7	0.2
Luminosity (Sun=1):	100 000	1000	20	4	1.0	0.2	0.01
Lifetime (million yrs):	10	100	1000	5000	10 000	50 000	100 000
Abundance:	0.00001%	0.05%	0.3%	1.5%	4%	9%	80%

Esta denominación no es arbitraria

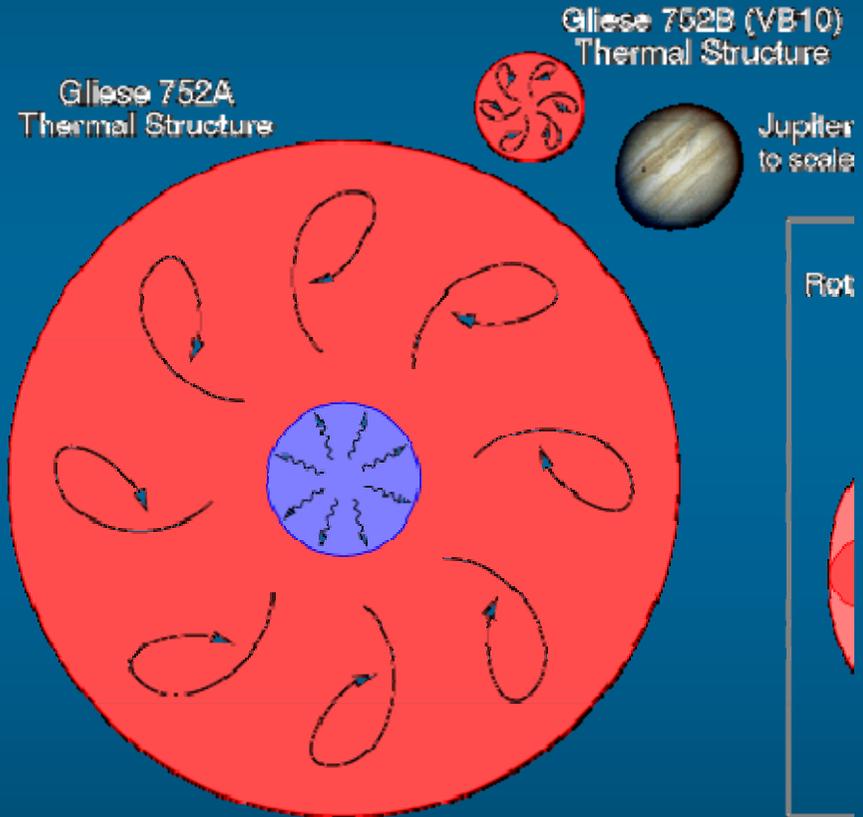
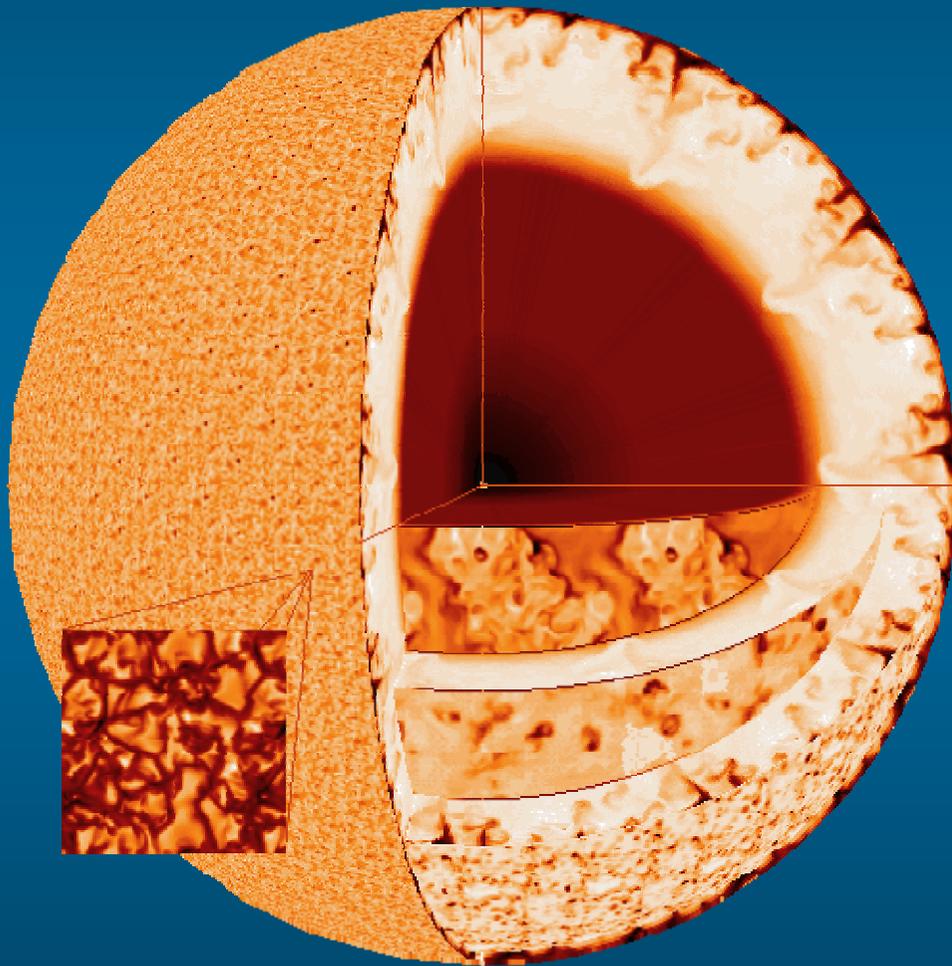
- cambio fundamental en la estructura interna de las estrellas



Inicio de la zona convectiva



Estrellas Frías



Estrellas Frías

➤ Observaciones solares:

• Corona

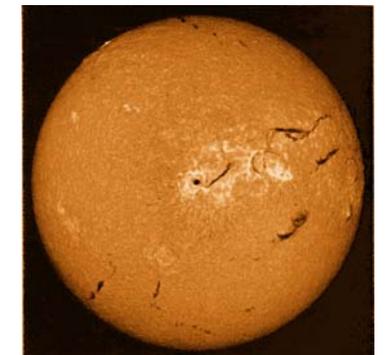
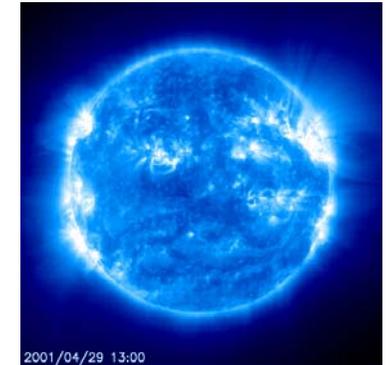
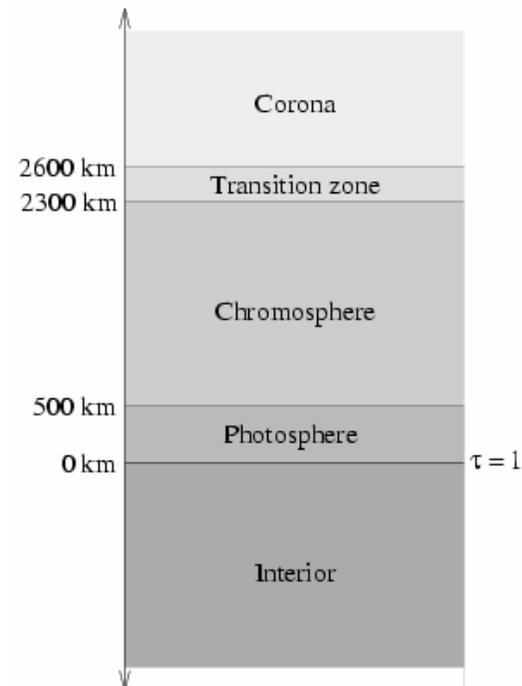
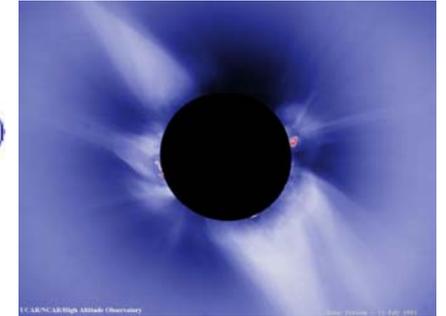
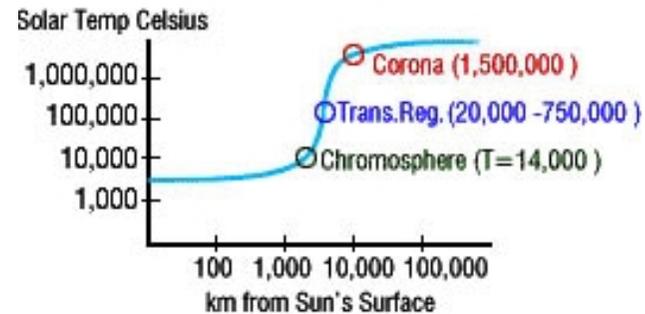
- $T \approx 1 \times 10^6 - 5 \times 10^6$ K
- emisión en rayos X
- (FeVI, Fe XVIII, OVIII, etc.)
- elipses de Sol o coronógrafo
- satélites rayos X

• Región de transición

- $T \approx 20000 - 7.5 \times 10^5$ K
- emisión en el UV
- (CII, SiII, CIII, CIV, SiIV, etc.)
- satélites UV

• Cromosfera

- $T \approx 6000 - 20000$ K
- emisión en el óptico y UV
- transparente en el continuo
- ópticamente opaca en líneas intensas
- (CaII H&K, H α , H β , MgII h&k, etc.)



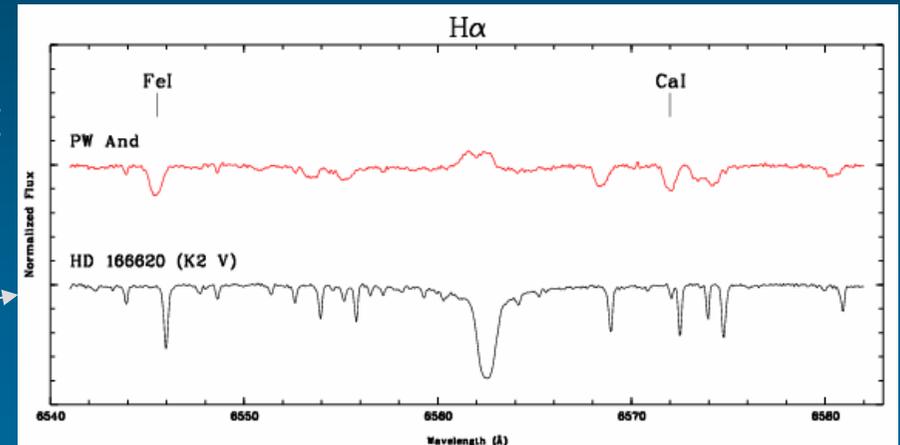
Actividad cromosférica



• Técnica de substracción espectral:

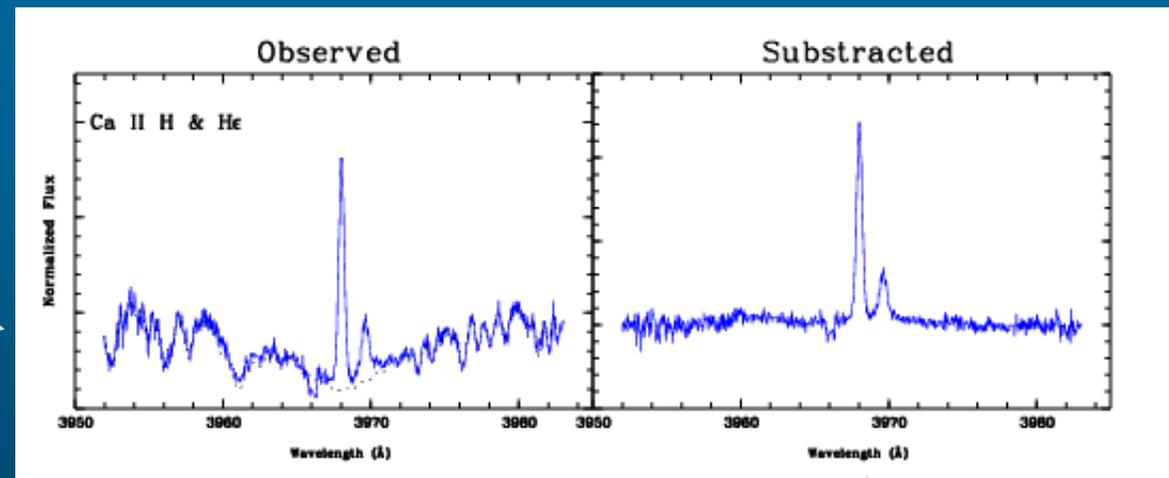
• Espectro sintético:

- Espectros estrellas referencia:
 - no activas (sin emisión en: CaII H&K)
 - v_{seni} pequeño
 - mismo T_{esp} , clase luminosidad
- Desplazamiento en λ
- Ensanchamiento rotacional (v_{seni})
- Peso en intensidad relativa S_H, S_C



• Espectro substraído:

- Esp Observado – Esp Sintético
- Contribución cromosférica



• Indicadores ópticos:

- CaII H&K

- Serie de Balmer:

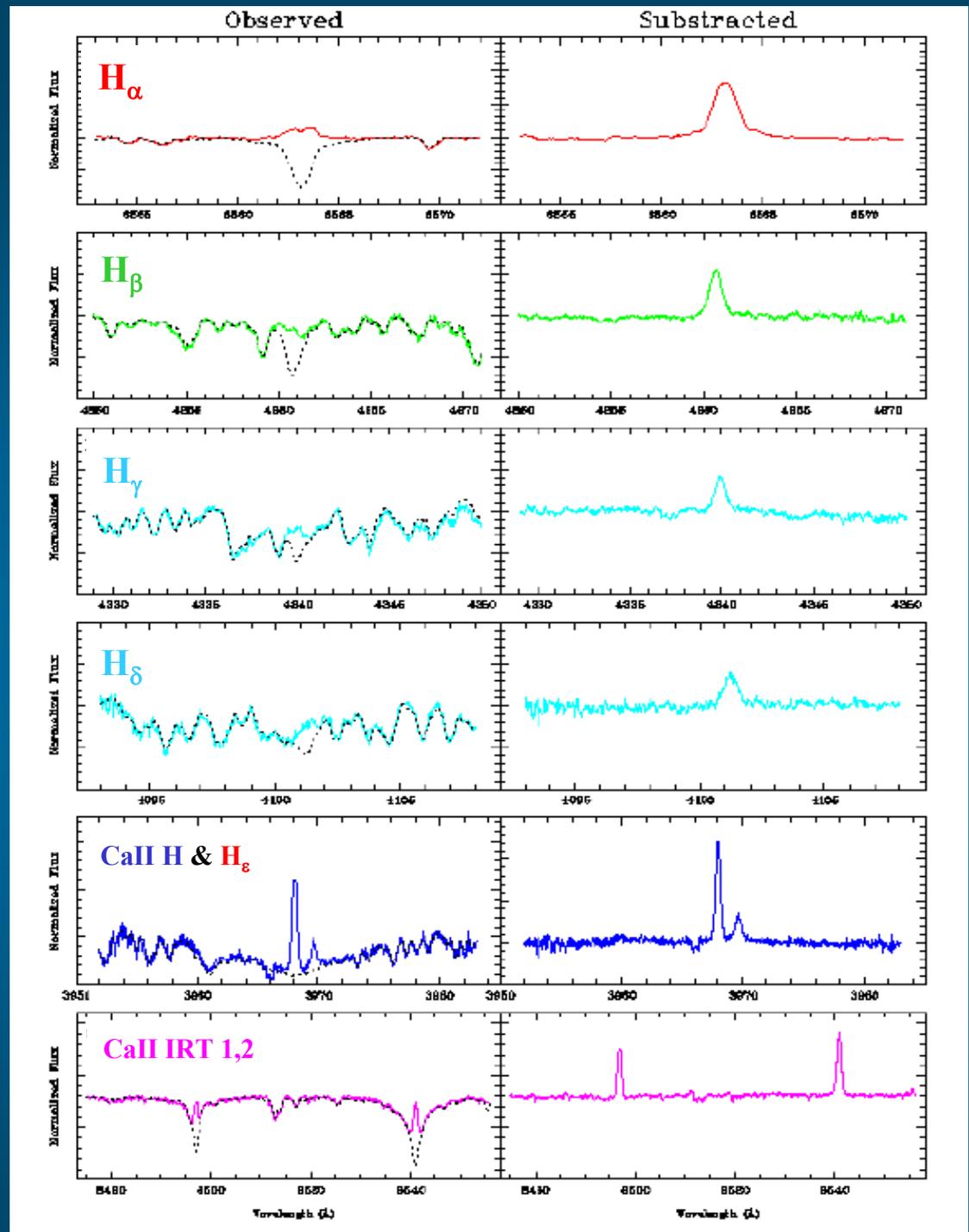
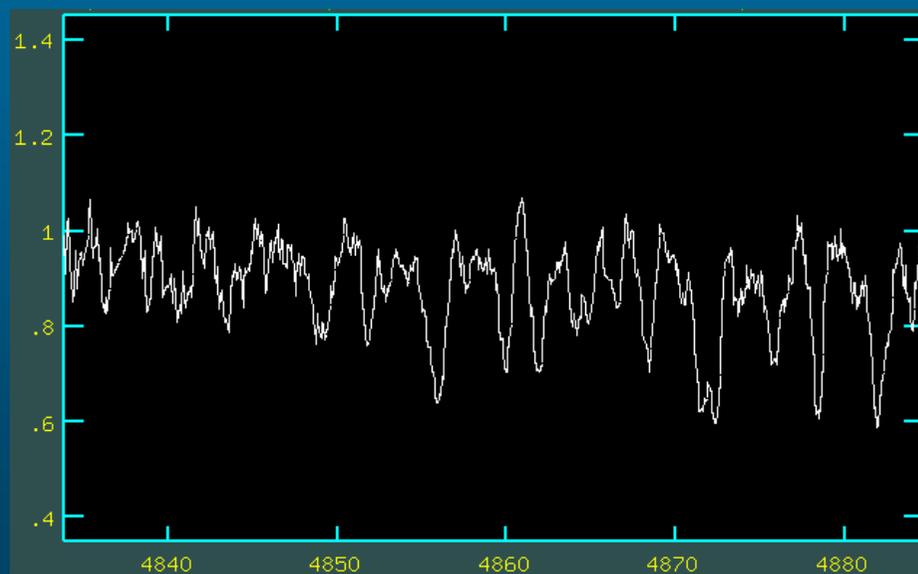
$H\alpha$, $H\beta$, $H\gamma$, $H\delta$, $H\epsilon$, ...

- MgIb

- NaI D₁, D₂

- HeI D₃

- CaII IRT



Librerías de espectros estelares

Espectros procedentes de:

Actividad cromosférica en sistemas binarios y otras estrellas frías (1990 – 1998)

Exploración espectroscópica de estrellas frías en grupos cinemáticos jóvenes (1999 – 2005)

Caracterización espectroscópica y cinemática de las estrellas frías de la vecindad solar + Darwin (2005 -)

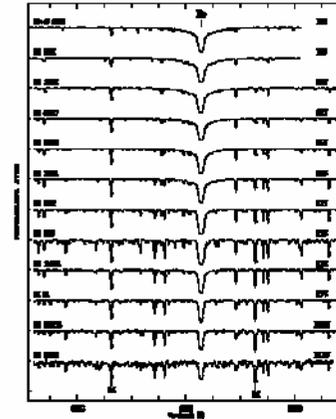
Utilidad:

- Aplicación de la substracción espectral (actividad cromosférica).
- Clasificación espectral.
- Síntesis espectral de sistemas compuestos.
- Modelos de atmósferas.
- Determinación de parámetros atmosféricos (T_{eff} , g , $[\text{Fe}/\text{H}]$)
- Abundancias.
- Calibración de temperaturas
- Síntesis espectral de poblaciones estelares en galaxias.

<http://www.ucm.es/info/Astrof/invest/actividad/spectra.html>



Librerías de espectros estelares (Libraries of stellar spectra)



► Libraries of stellar spectra (late-type stars) by Montes et al.

- Library of high and mid-resolution spectra in the CaII H & K, H α , H β , and NaI D₁, D₂, and HeI D₃ lines regions of F, G, K and M field stars

D. Montes, E.L. Martín, M.J. Fernández-Figueroa, M. Cornide, E. De Castro, (accepted September 1996)

[1997, Astronomy & Astrophysics Supp. S., \(Jun II\), 123, 473](#)

➔ [Available via WWW](#) -- [Available at CDS \(J/A+AS/123/473\)](#)

- Library of high-resolution UES echelle spectra of F, G, K and M field dwarf stars

Montes D., Martín E.L., (accepted August 1997),

[1998, Astronomy & Astrophysics Supp. S., \(Mar II\) 128, 485,](#)

➔ [Available via WWW](#) -- [Available at CDS \(J/A+AS/128/485\)](#)

- Library of medium-resolution Fiber Optic Echelle spectra of F, G, K and M field dwarfs to giants stars

Montes D., Ramsey L.W., Welty A.D., (accepted November 1998)

[1999, Astrophysical Journal Supplement Series, 123, 283 \(July 1999 Vol. 123 #1\)](#)

➔ [Available via WWW](#)

► Other Libraries of stellar spectra

Espectros de estrellas frías (F, G, K, M)

- I. (Montes et al. 1997)**
 resolución intermedia (0.2-3 Å)
 IDS/INT, Coudé/2.2m

CaII H&K,

H β ,

NaI D1, D2 & HeI D3,

H α

170 espectros,
 116 estrellas (V, IV, III)

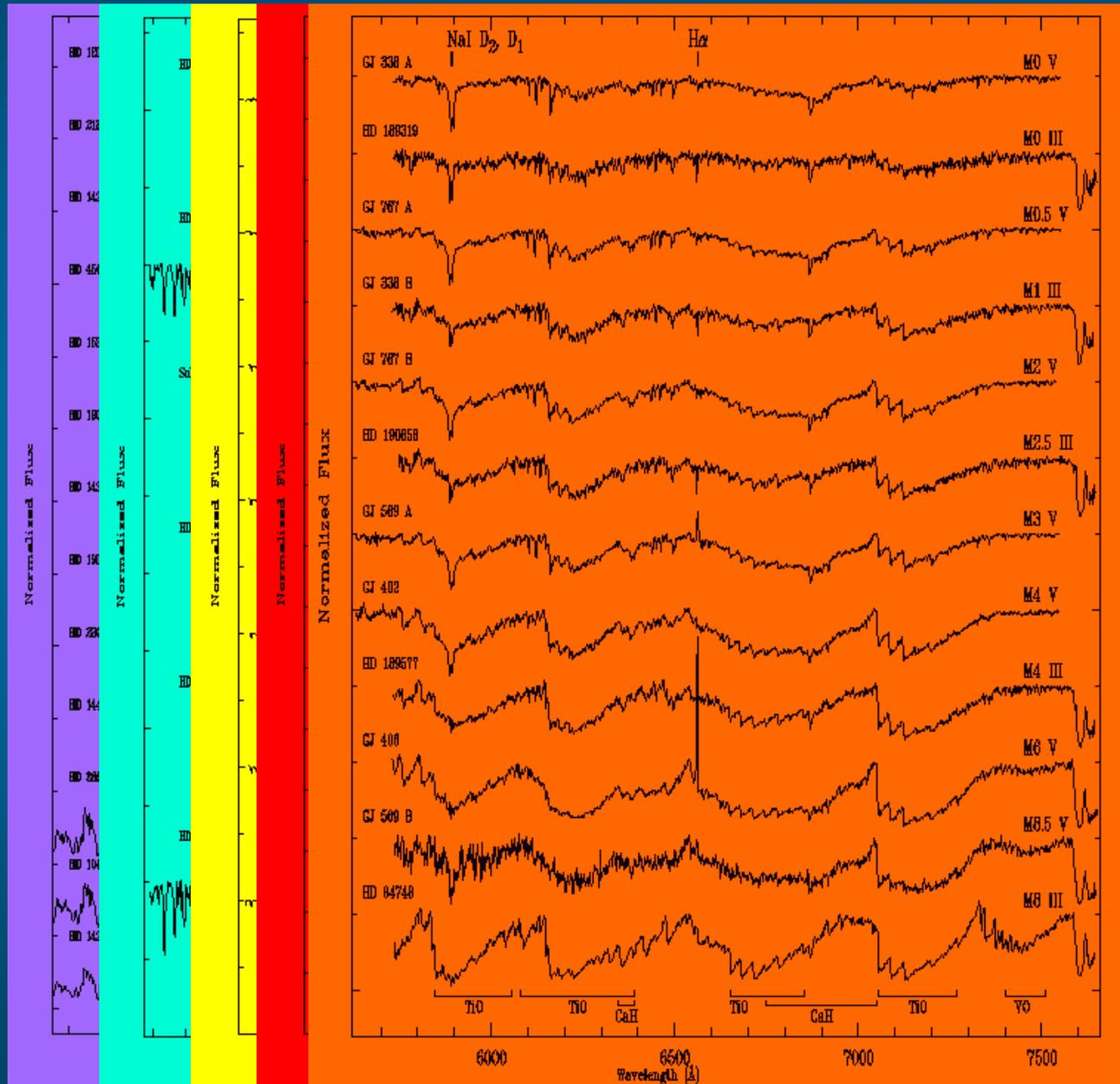
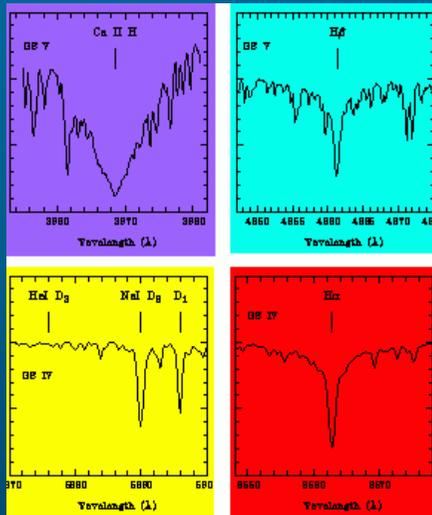


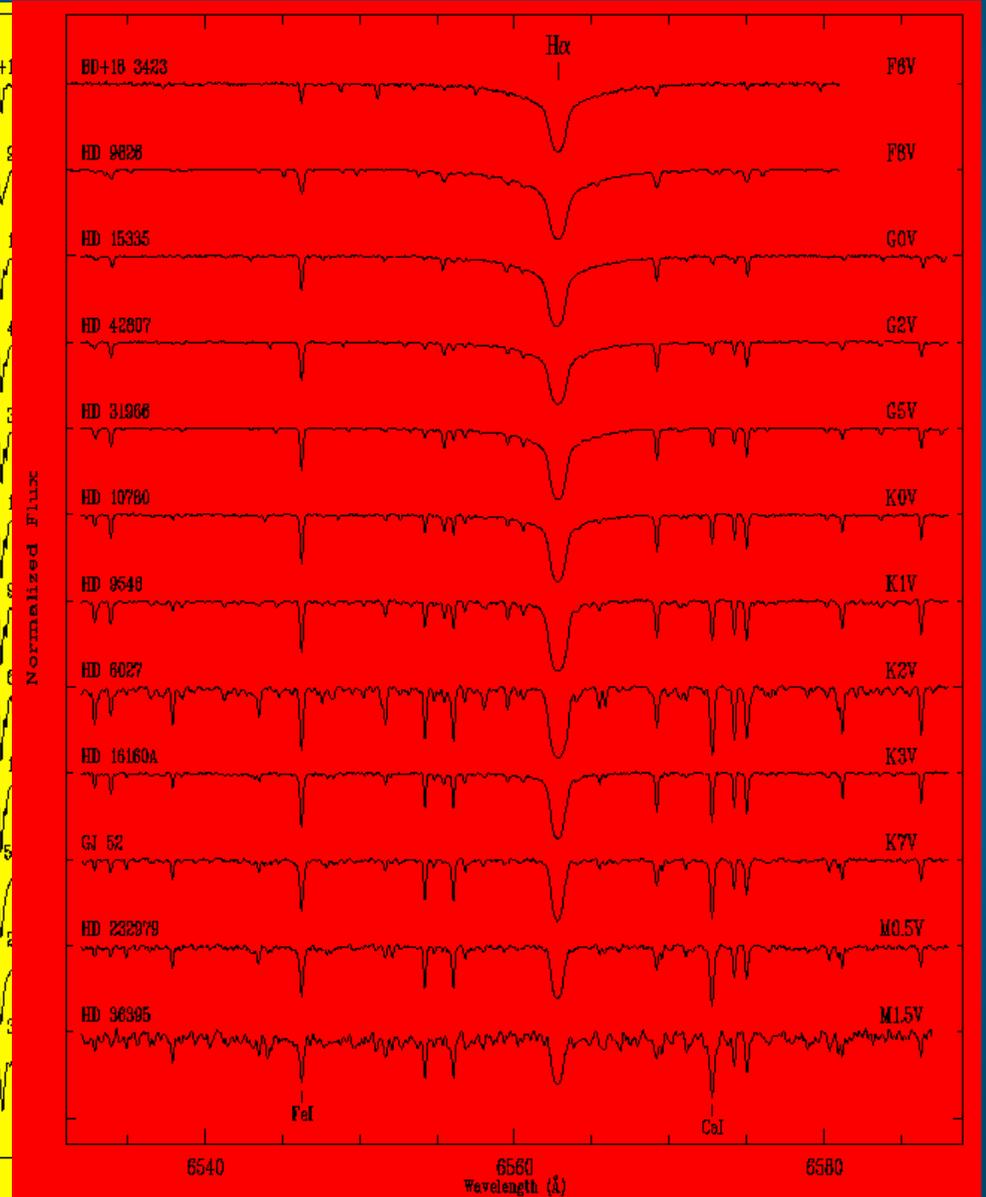
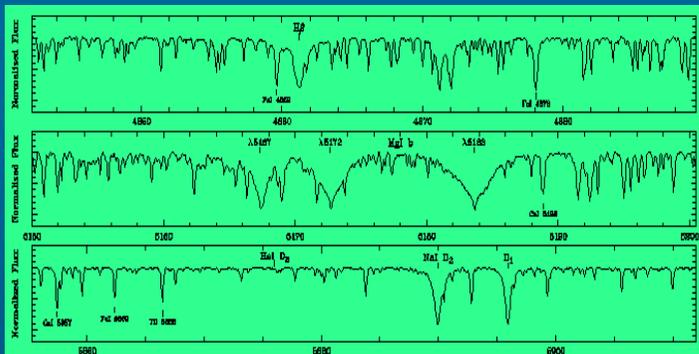
Fig. 1. High Fig. 3. High Fig. 4. Fig. 5 Fig. 6. continue

Espectros de estrellas frías (F, G, K, M)

- II. (Montes & Martín 1998)**
 alta resolución (0.09-1.19 Å)
 UES/WHT

echelle (4800 – 10600 Å)

105 espectros,
83 estrellas (V)

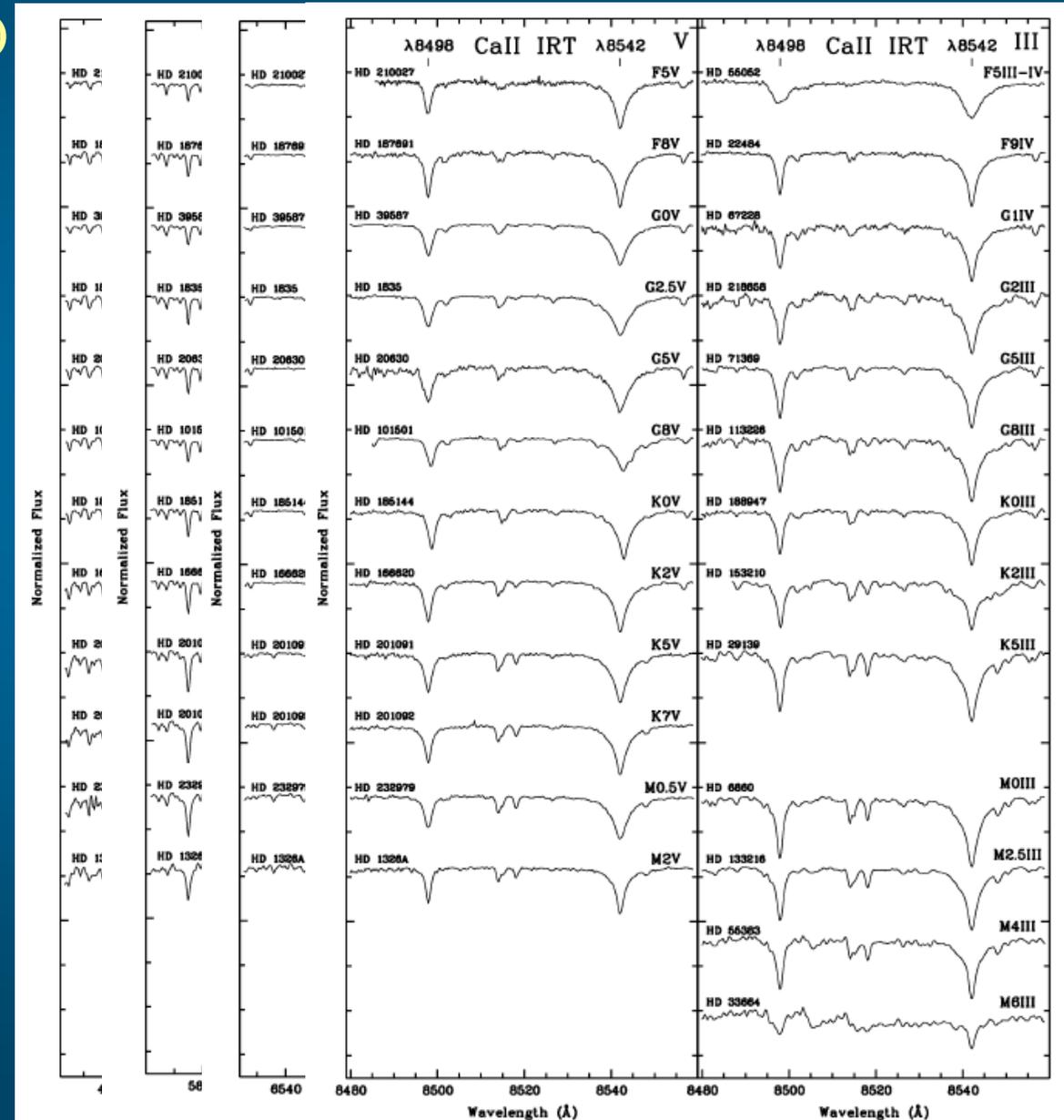
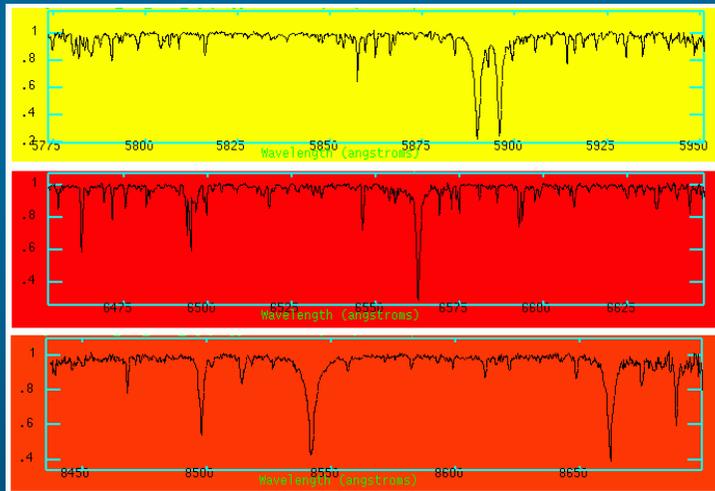


Espectros de estrellas frías (F, G, K, M)

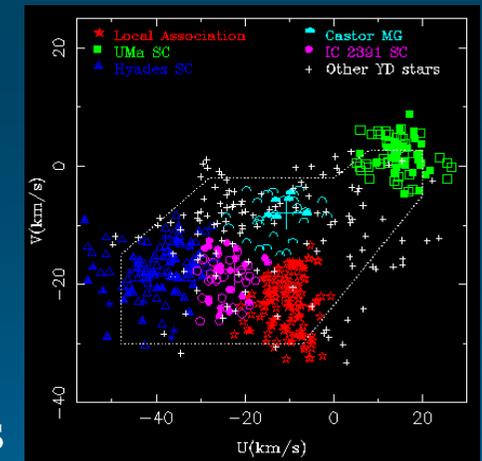
- III. (Montes, Ramsey & Welty 1999)**
resolución intermedia (0.5 Å)
 FOE/0.9m-2.1m KPNO

echelle (3900 – 9000 Å)

345 espectros,
130 estrellas (V, IV, III, II, I)



Grupos Cimemáticos Jóvenes



- Grupos con edades < 600 Myr.
- Comparten los mismos movimientos espaciales que cúmulo abiertos jóvenes bien conocidos.

Nombre / Name	Cúmulos / Clusters	Edad / Age	U	V	W
<ul style="list-style-type: none"> • Local Association (Pleiades moving group) (Stream 0) 	Pleiades (M45, Melotte 22) α Persei (Melotte 20) M34 (NGC 1039) delta Lyr (Stephenson 1) NGC 2516 (Mel 82) IC 2602 (theta Carinae)	20 – 150 Myr	-11.6	-20.7	-10.5
<ul style="list-style-type: none"> • IC 2391 supercluster 	IC 2391 (o Velorum)	35 – 55 Myr	-22.4	-17.5	-9.4
<ul style="list-style-type: none"> • Castor Moving Group 	–	~200 Myr	-10.7	-8.0	-9.0
<ul style="list-style-type: none"> • Ursa Mayor group (Sirius supercluster) (Stream II) 	Ursa Mayor (Collinder 285) M39 (NGC 7092)?	~300 Myr	+14.7	+1.5	-10.0
<ul style="list-style-type: none"> • Hyades supercluster (Stream I) 	The Hyades (Melotte 25) Praesepe (M44) NGC 1901 (Bok 1)	~600 Myr	-41.4	-18.5	-1.9

<http://www.ucm.es/info/Astrof/invest/actividad/skg/skg.html>

Estrellas frías en grupos cinemáticos jóvenes

(Montes et al. 2001, MNRAS 328, 45; López-Santiago 2005 PhD; López-Santiago et al. 2006, ApJ)

- Espectros *echelle* de alta resolución (0.1-0.3 Å)
- Observaciones (11 campañas 1999 – 2002)



• 2.2m-FOCES 1999/07

• NOT-SOFIN 1999/11



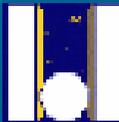
• INT-MUSICOS 2000/01

• INT-MUSICOS 2000/08



• NOT-SOFIN 2000/11

• 2.2m-FOCES 2001/09



• TNG-SARG 2001/10

• HET-HRS 2001/12

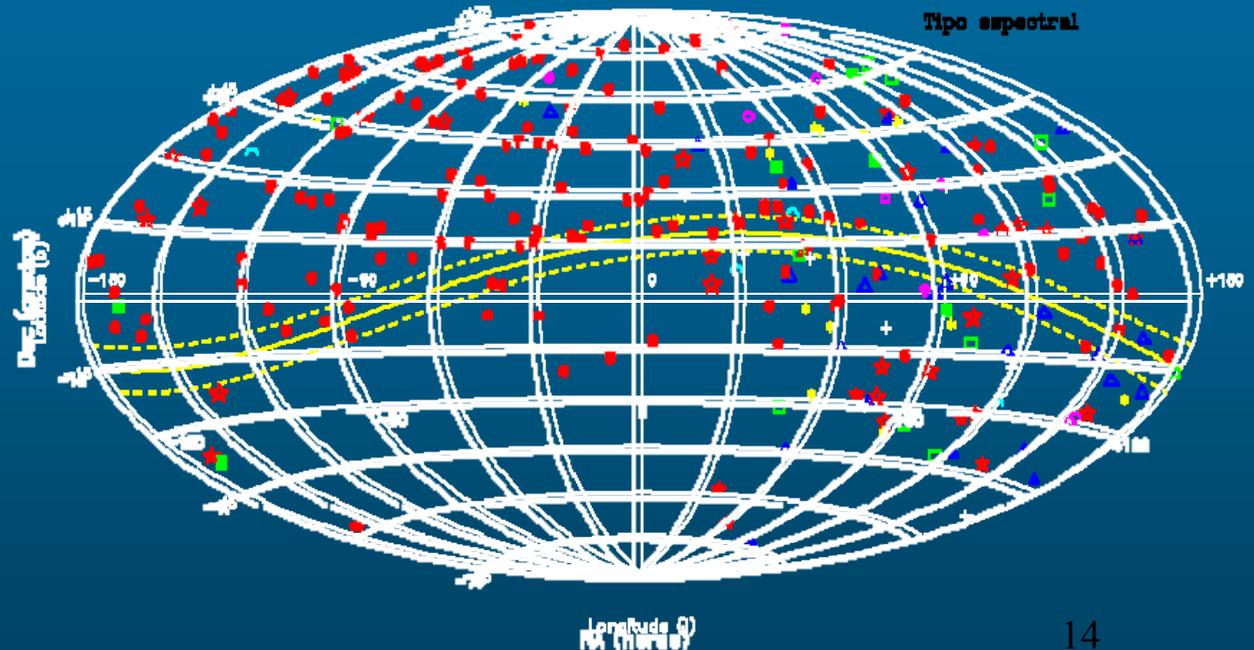
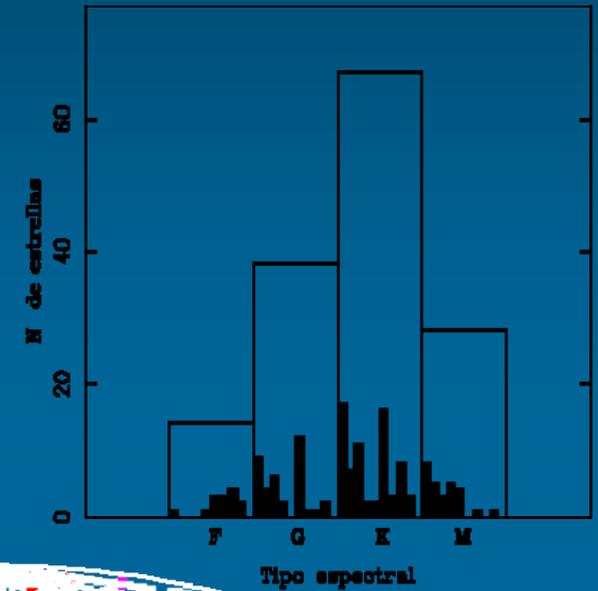


• 2.2m-FOCES 2002/04

• 2.2m-FOCES 2002/07

• NOT-SOFIN 2002/08

- 150 estrellas observadas



http://www.ucm.es/info/Astrof/invest/actividad/skg/skg_SS.html

Spectroscopic Survey of Late-type Stars in Young Stellar Kinematic Groups

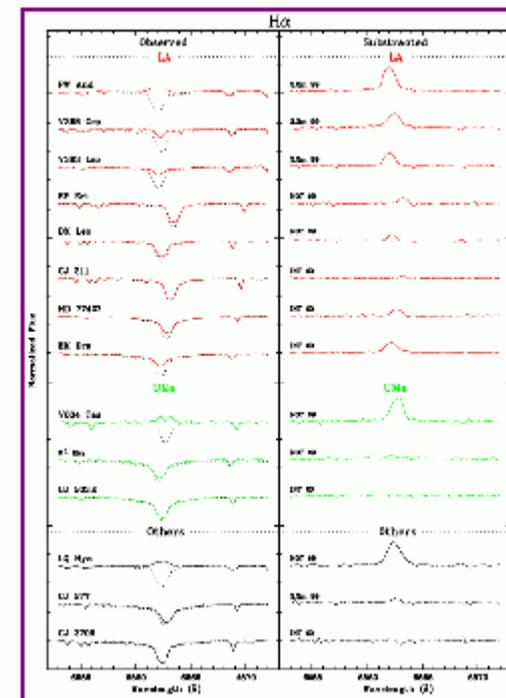
David Montes, Javier López Santiago, et al. [Dpto Astrofísica, UCM](#)

We describe here our ongoing high-resolution spectroscopic survey of single late-type stars identified in Paper I: ([Montes et al. 2001, MNRAS 328, 45](#)) as members of [young stellar kinematic groups](#) (SKG) (Local Association (20 - 150 Myr), Ursa Mayor group (300 Myr), Hyades supercluster (600 Myr), IC 2391 supercluster (35 Myr) and Castor Moving Group (200 Myr)) or as other young disk stars.

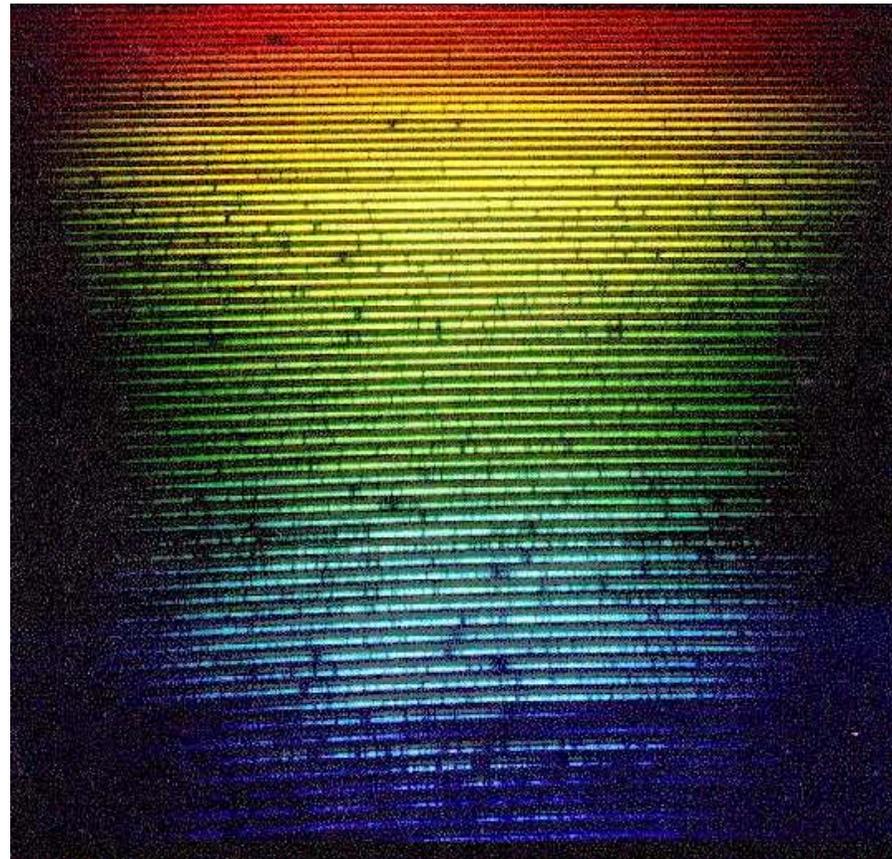
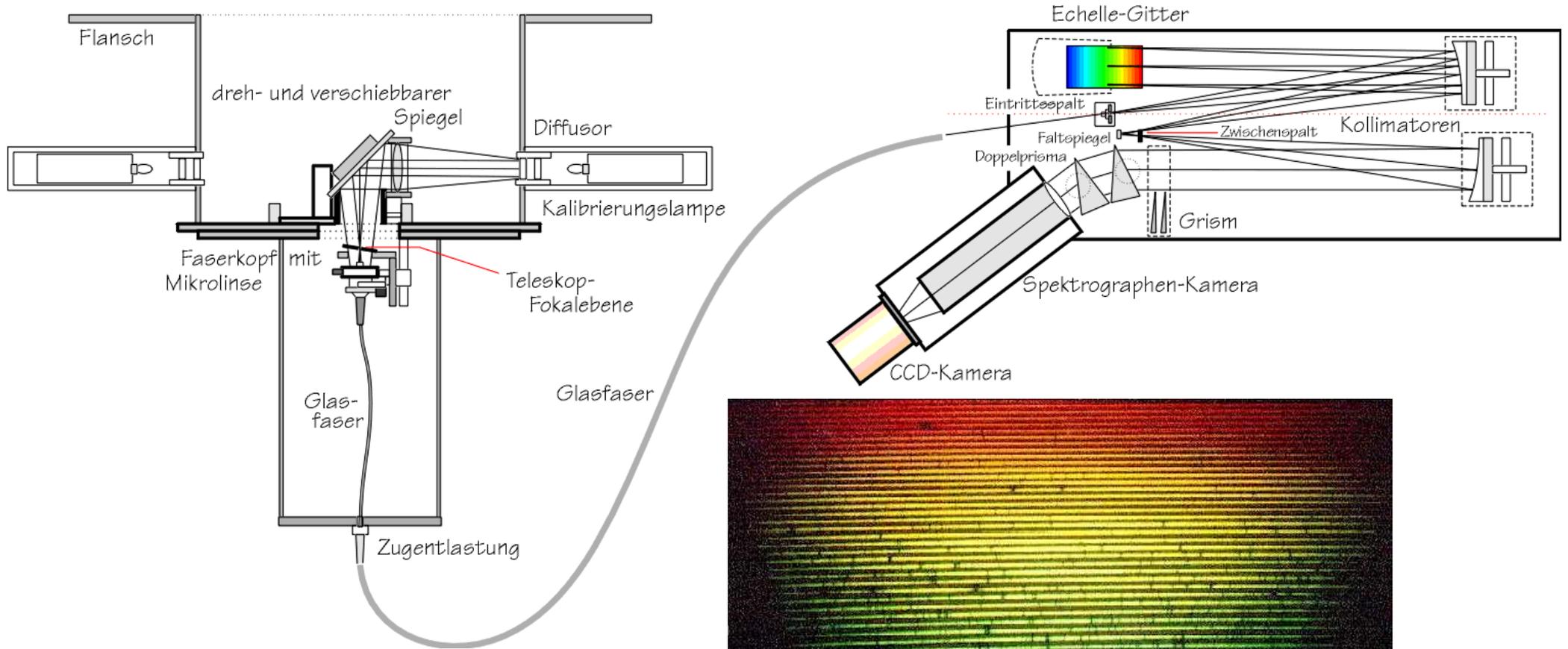
Information about this spectroscopic study can be found in [Montes et al. 2001, A&A 379, 976](#); [Montes et al. 2002, 12th Cool SSS](#); [Montes & López-Santiago, 2003, Kluwer Acad. Pub., p. 293](#); [López-Santiago, et al., 2003, A&A, 411, 489](#); [López-Santiago & Montes, 2004, Calar Alto Newsletter N.7](#); [López-Santiago 2005, Ph.D. thesis, UCM](#); [López-Santiago, et al. 2006, ApJ, in press](#); López-Santiago et al. 2006, in preparation.

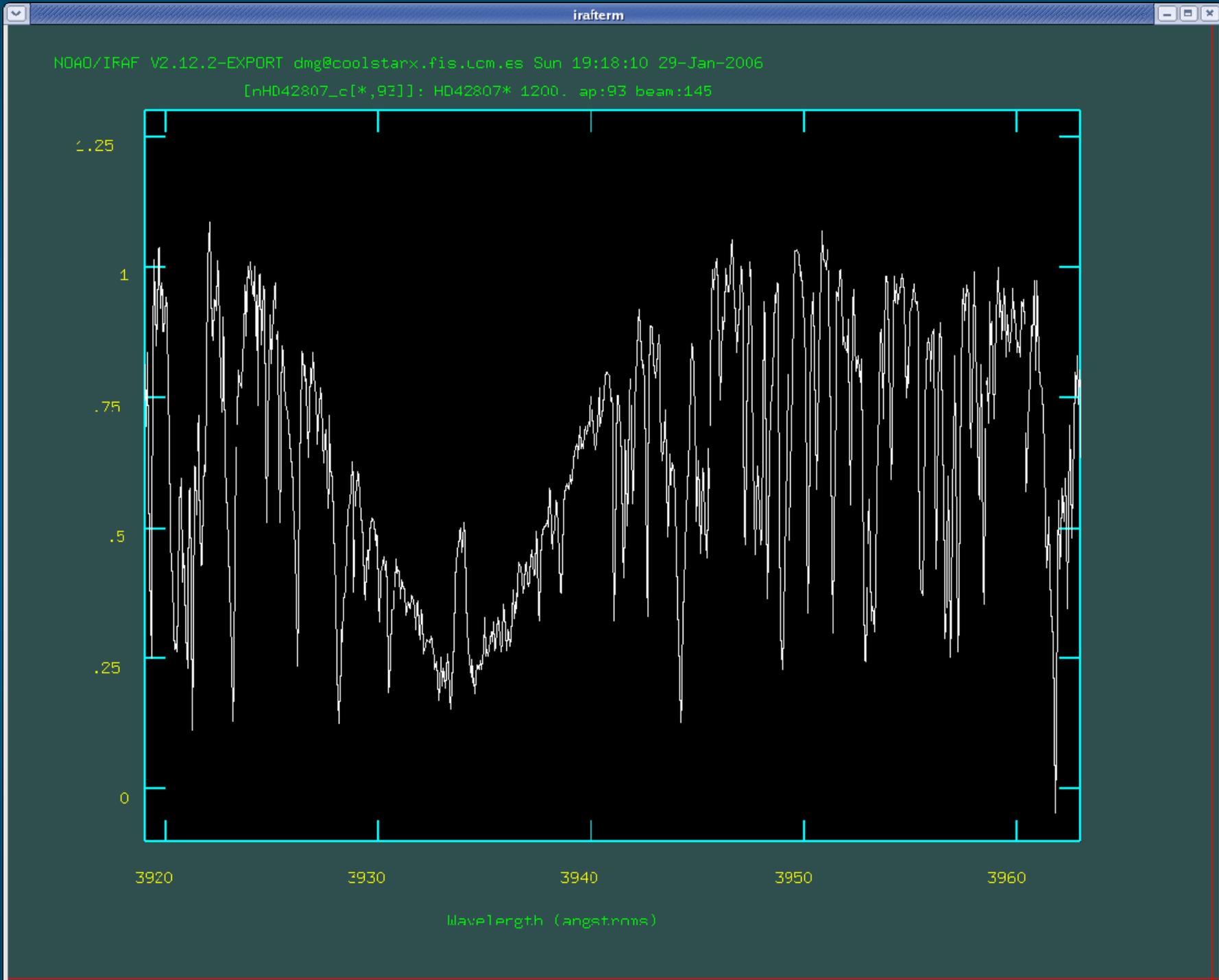
The spectra and derived parameters database will be publicly released in these pages.

1. High resolution echelle spectra.
2. List of observed stars.
3. Spectral type and luminosity class.
4. Radial velocity.
5. Rotational velocity ($v \sin i$).
6. Lithium (LiI 6707.8 Å) EW.
7. Chromospheric activity.
8. Flare stars

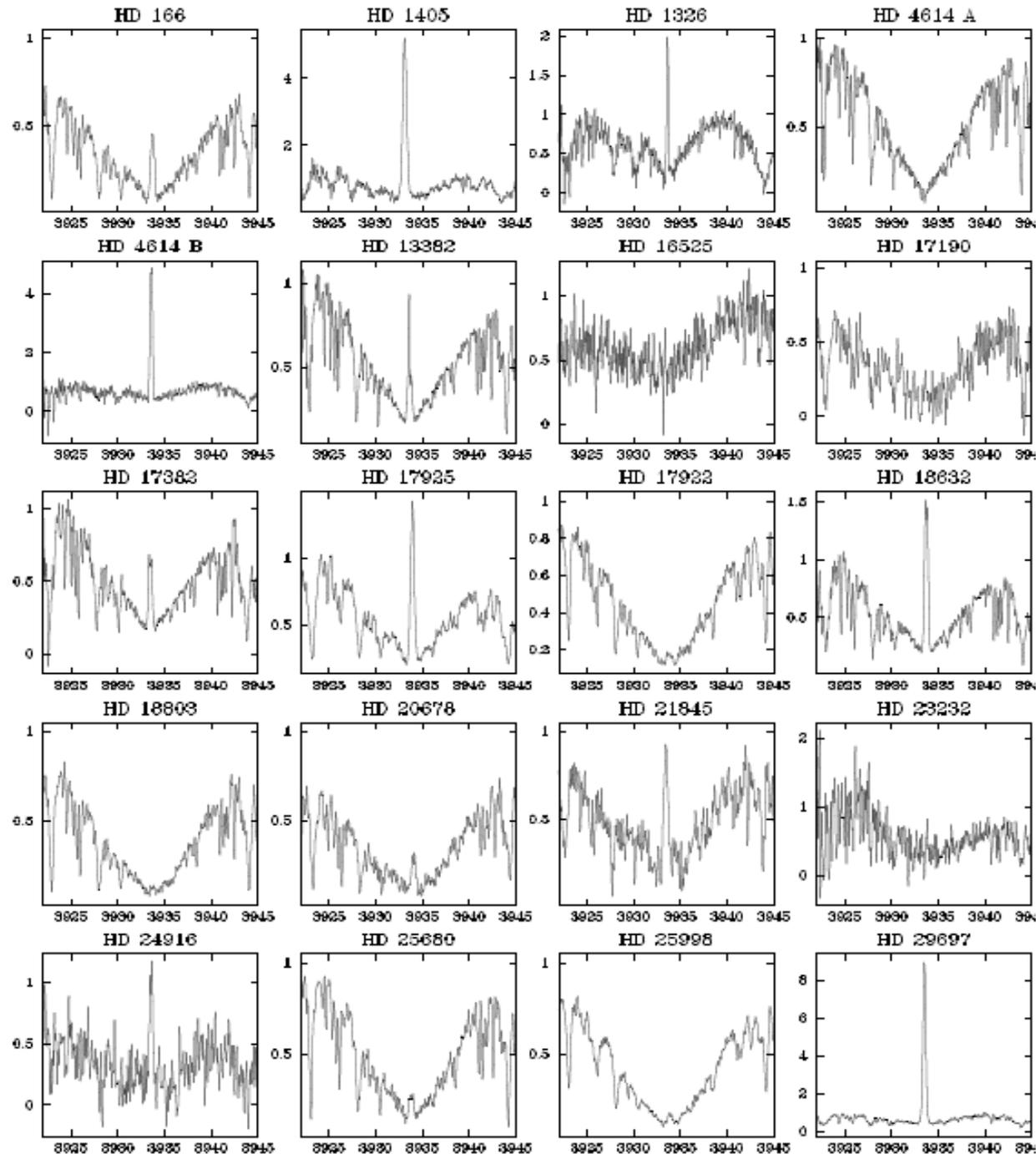


FOCES (Fibre Optic Cassegrain Echelle Spectrograph)



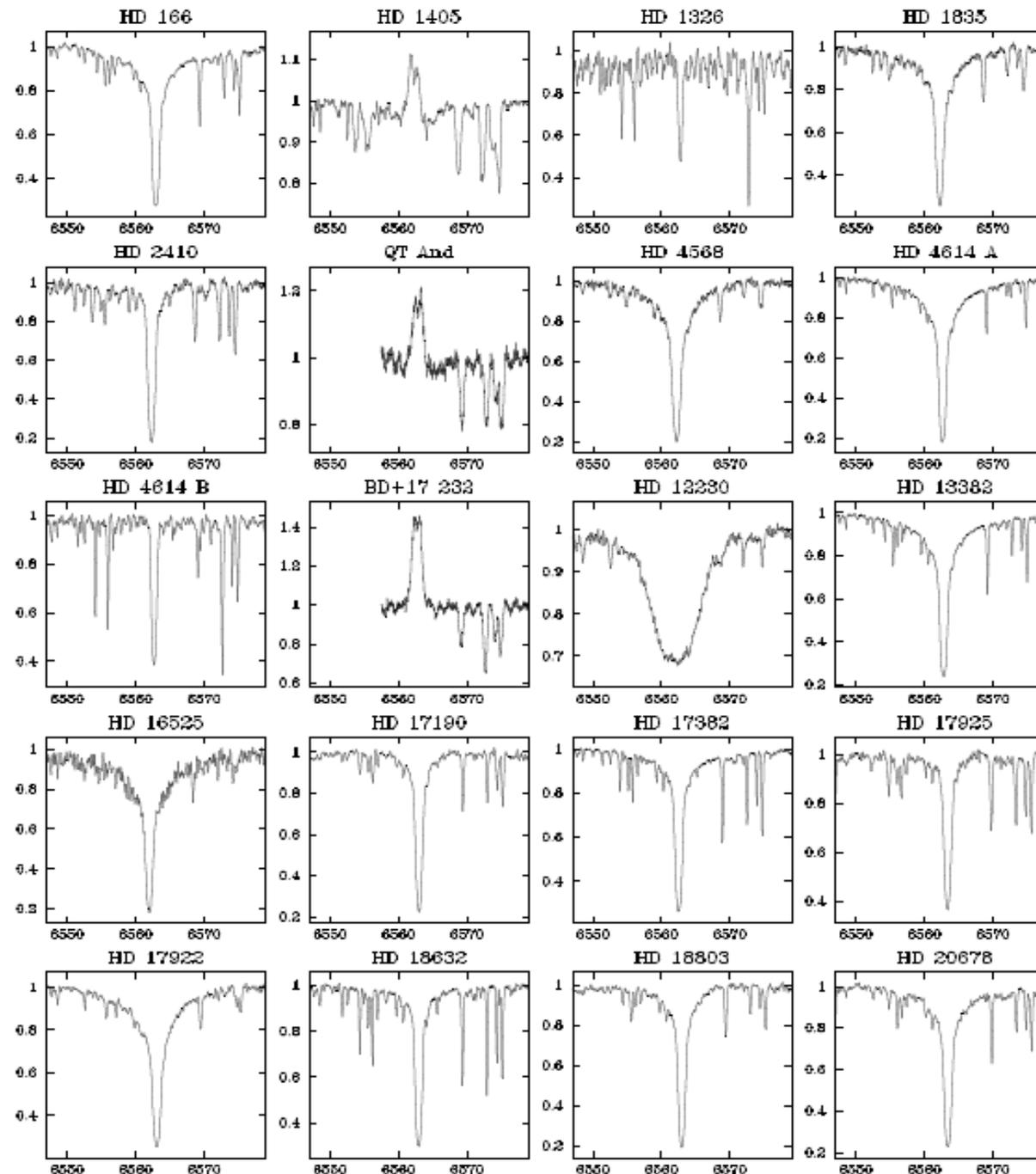


CaII K



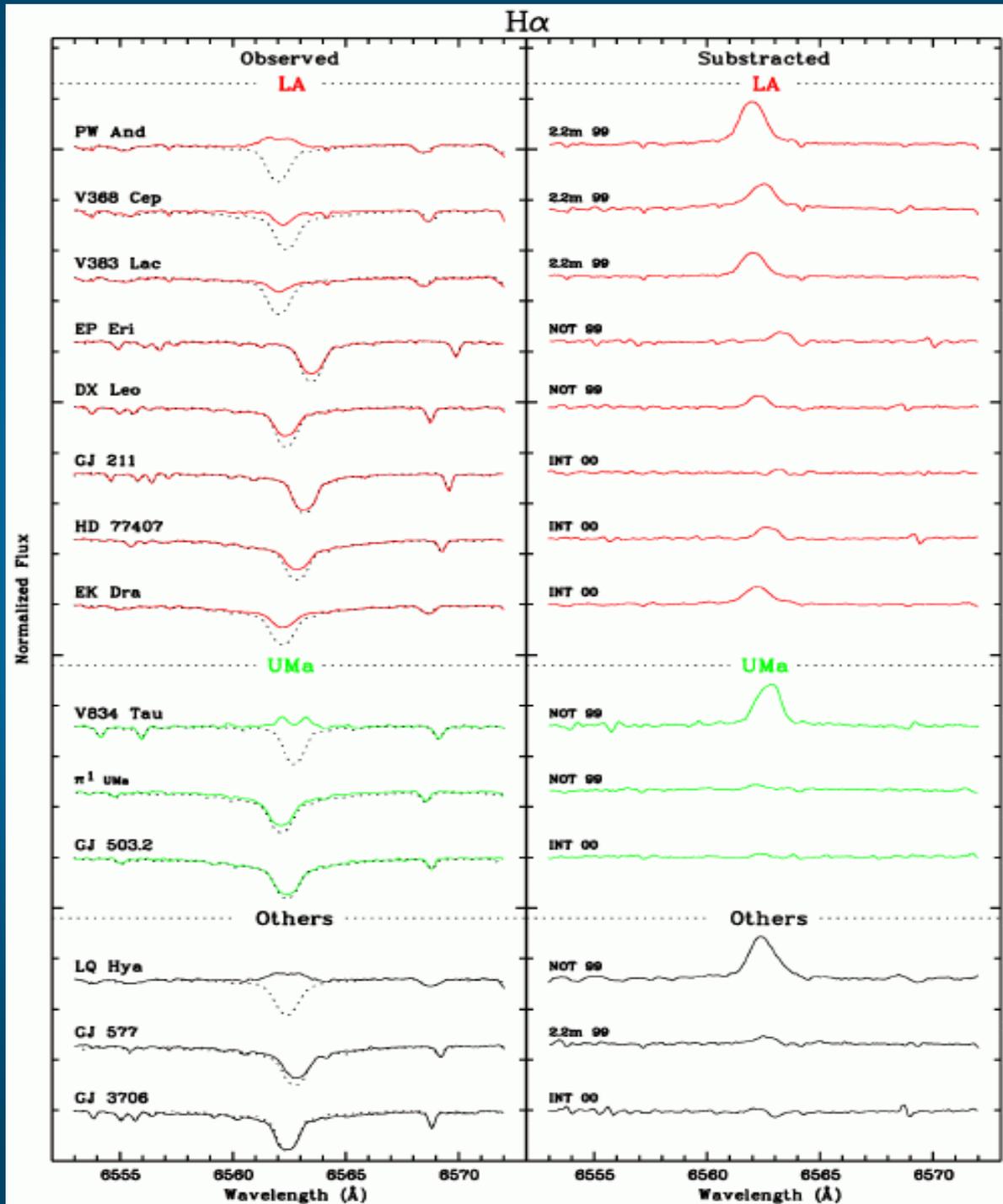
Estrellas frías en grupos cinemáticos jóvenes

H α

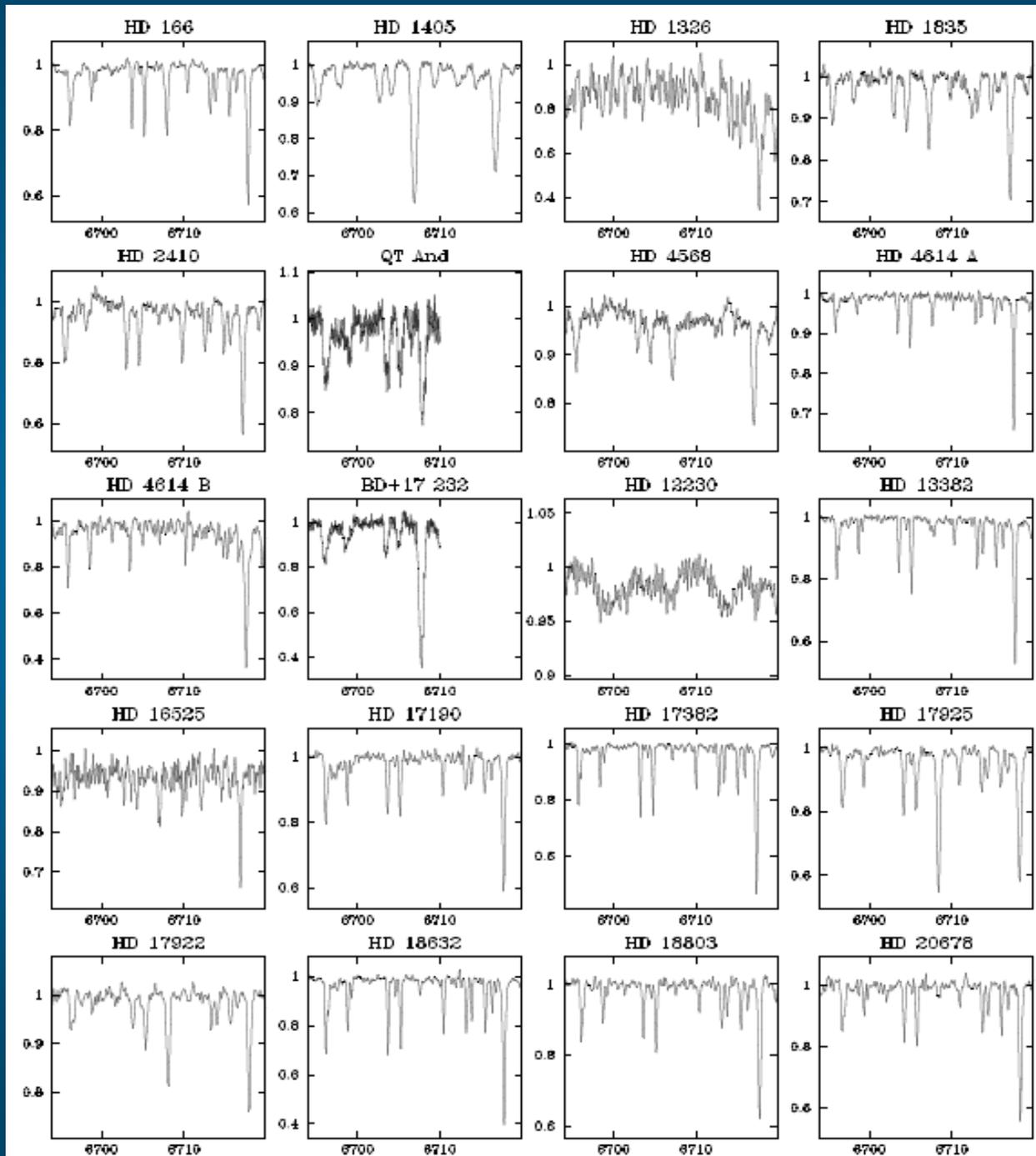


Estrellas frías en grupos cinemáticos jóvenes

H α

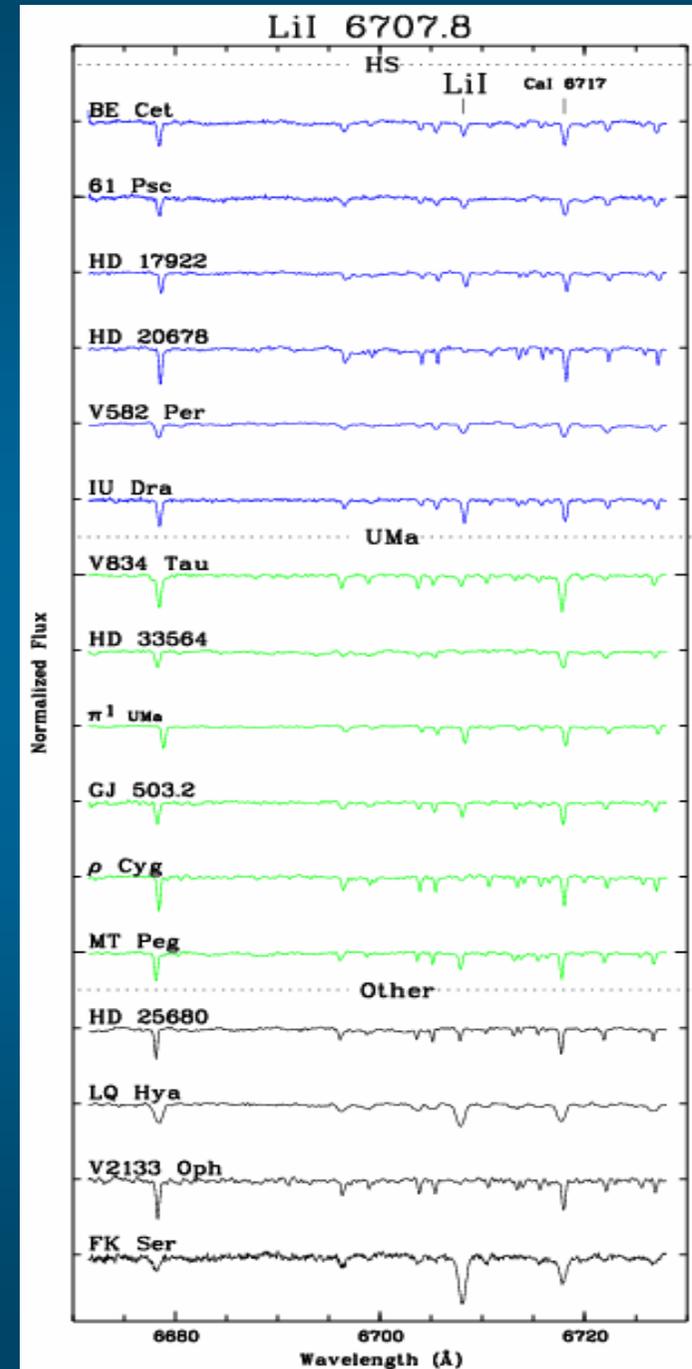
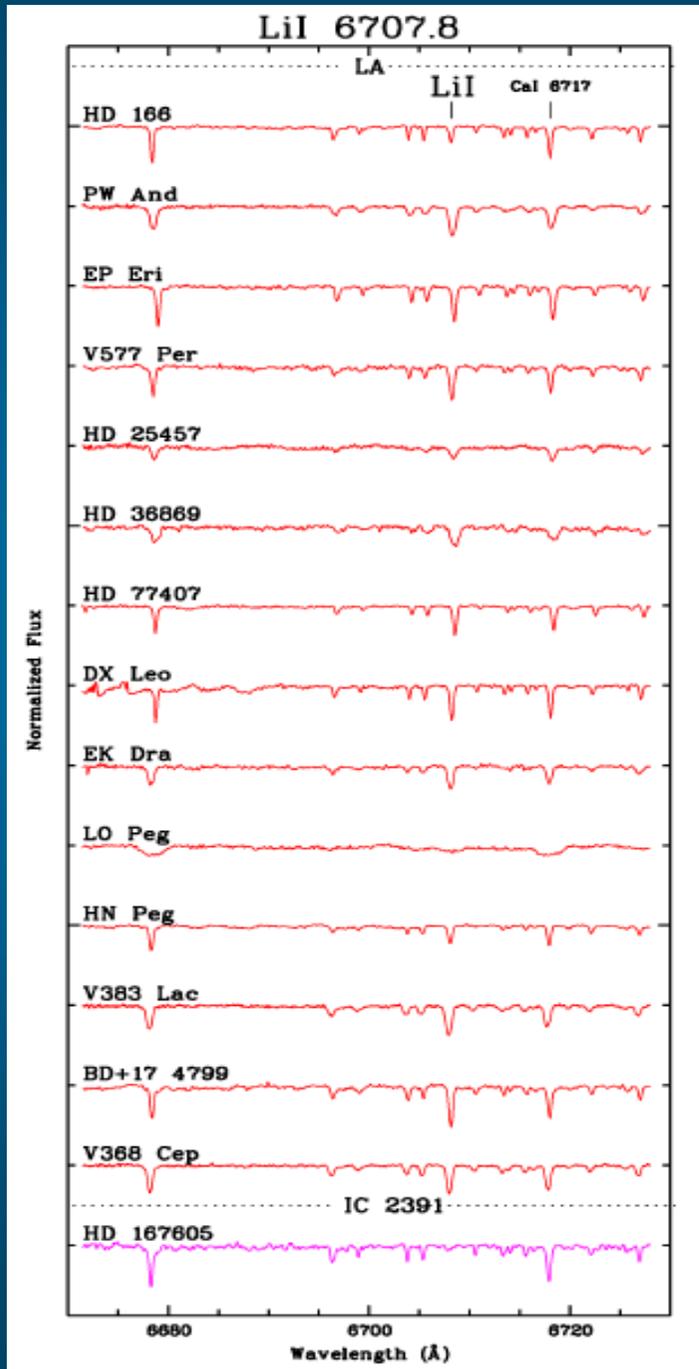


Li I



Estrellas frías en grupos cinemáticos jóvenes

Li I



Caracterización espectroscópica y cinemática de las estrellas frías de la vecindad solar

Estrellas F, G, K observables por Darwin

Criterios de selección:

- Estrellas de la vecindad solar (distancia < 25 pc) ($\pi > 40$ mas según Hipparcos)
- Tipos espectrales F, G, K y M con clase de luminosidad V y IV/V
- En un cono de $\pm 45^\circ$ del plano de la eclíptica

74 F

143 G

288 K

- Estrellas relativamente aisladas
(sin planetas, componentes estelares ($d < 5''$), material circumestelar)
- Propiedades de la atmósfera de planeta (radiación de la estrella)
propiedades estelares (edad, actividad, variabilidad, etc..)

51 F

103 G

237 K

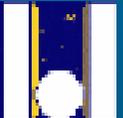
Caracterización espectroscópica y cinemática de las estrellas frías de la vecindad solar

Observaciones Espectroscópicas

- Espectros *echelle* de alta resolución (0.1-0.3 Å) R: 40000 - 50000
- 4 campañas 2005 – 2006
- Estrellas del Norte



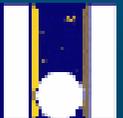
- Calar Alto **2.2m-FOCES** 6 noches (23 - 28 julio 2005) **95%** (80 estrellas)



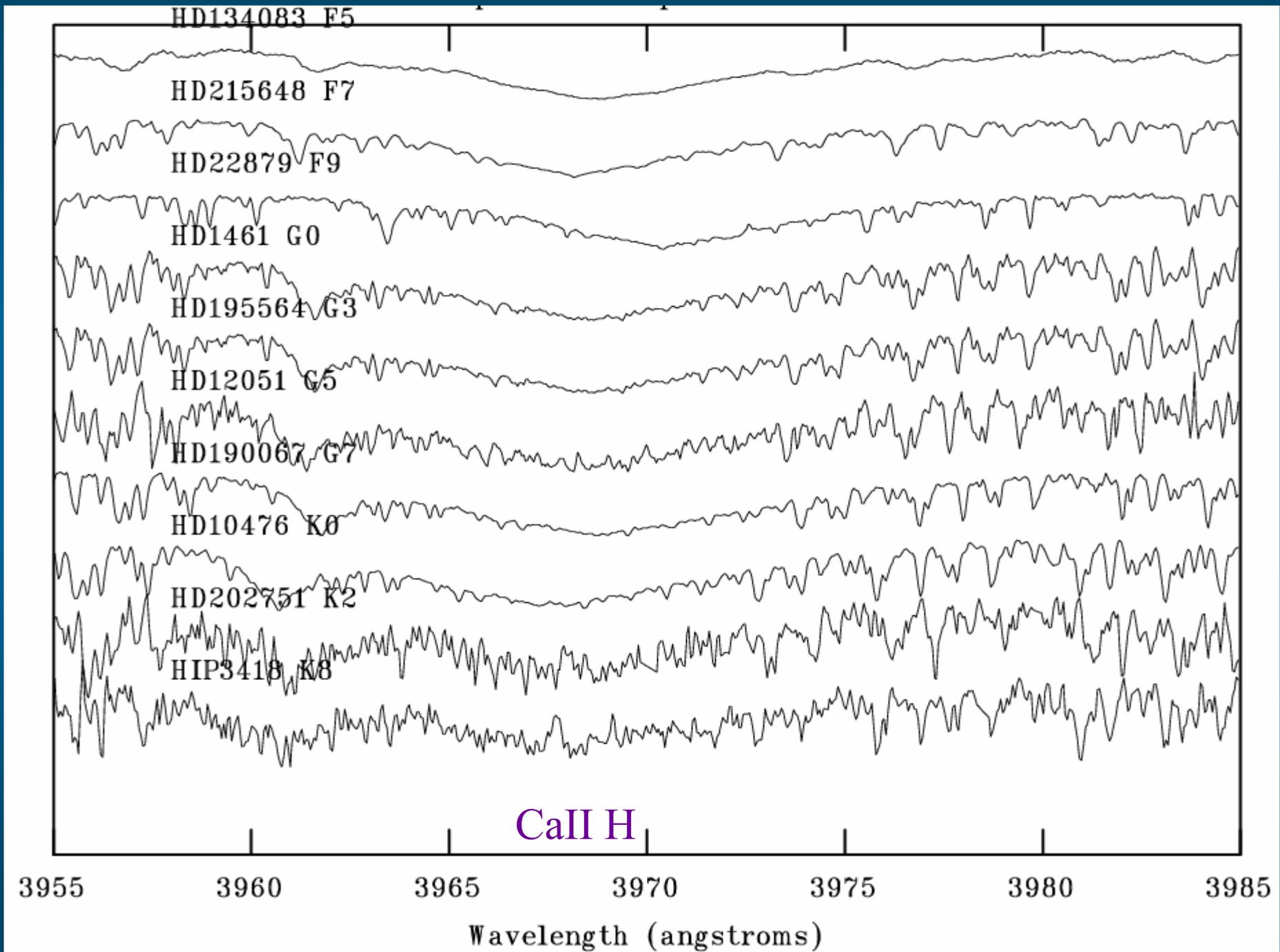
- La Palma **TNG-SARG** 4 noches (11 - 14 noviembre 2005) **0%**

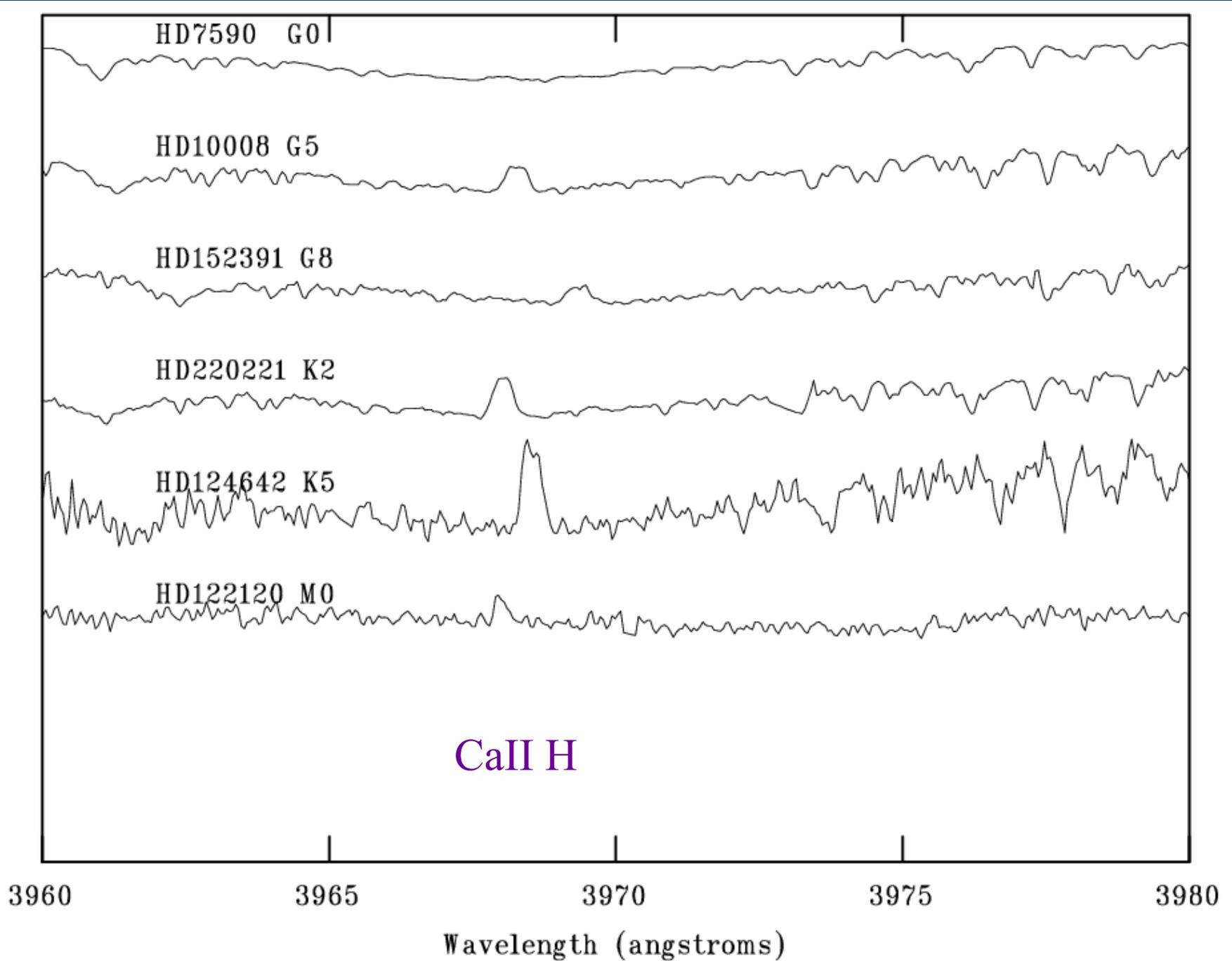


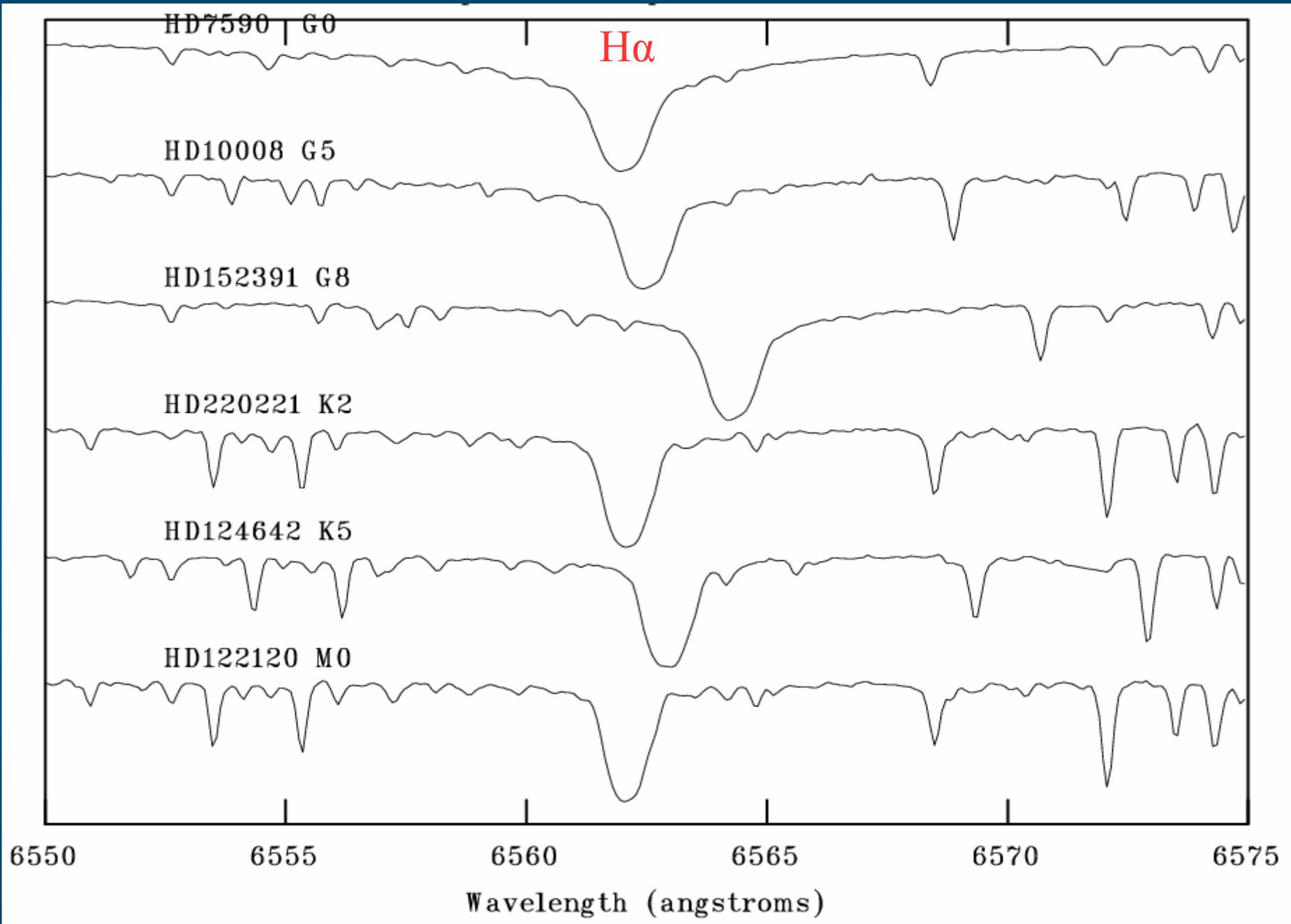
- Calar Alto **2.2m-FOCES** 9 noches (8 - 16 enero 2006) **20%** (38 estrellas)

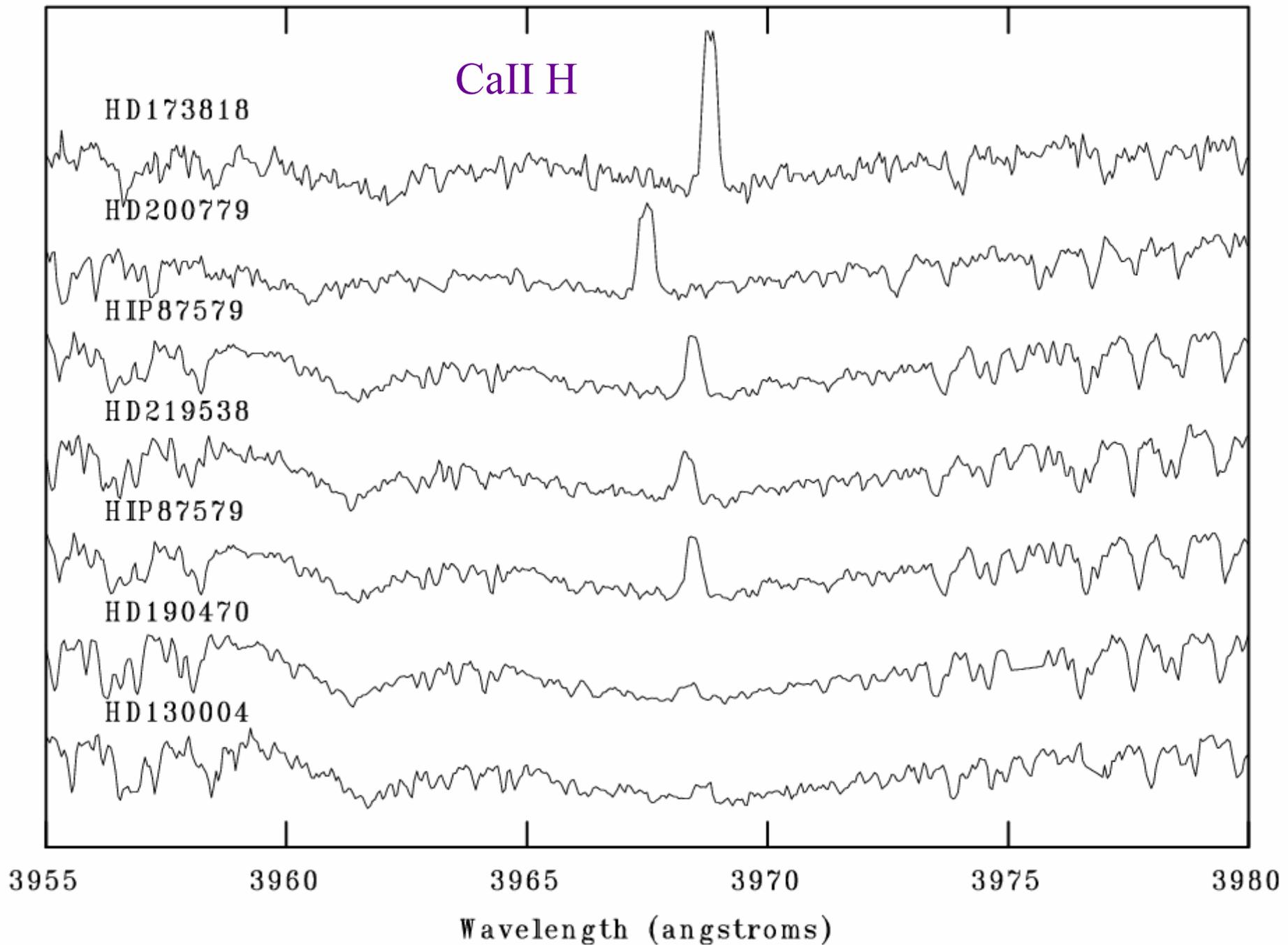


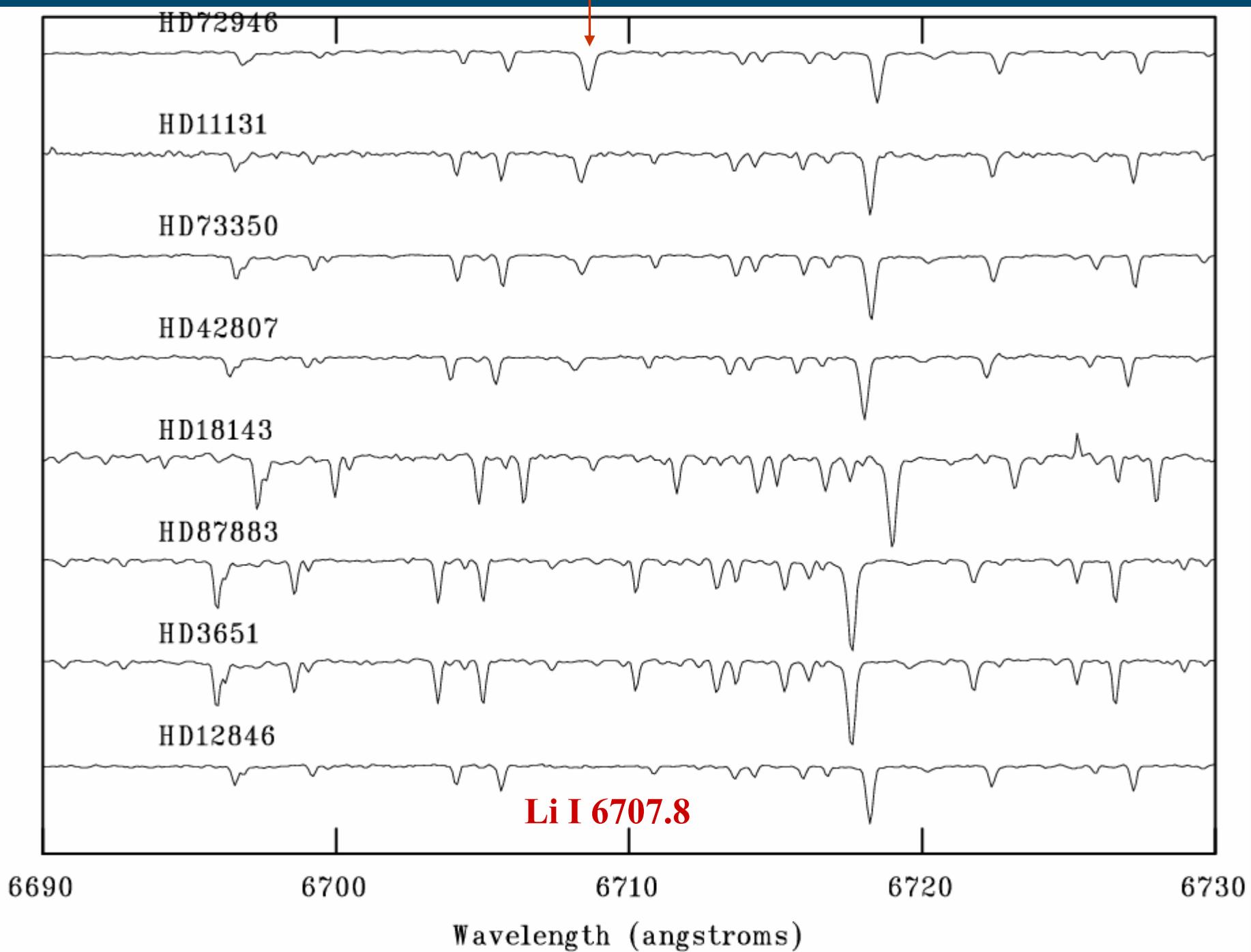
- La Palma **TNG-SARG** 2 medias noches (18 - 19 febrero 2006) **60%** (18 estrellas)











Caracterización espectroscópica y cinemática de las estrellas frías de la vecindad solar

Catálogos y exploraciones existentes:

Dirección http://www.ucm.es/info/Astrof/invest/actividad/cool_NS.html

Las estrellas frías de la vecindad solar / Cool stars in the solar Neighborhood

► Catálogos y exploraciones / Catalogs and surveys

- [Stars within 25 pc of the Sun](#) (Woolley et al. 1970)
- [CNS3, Catalogue of Nearby Stars, Preliminary 3rd Version](#) (Gliese & Jahreiss 1991)
- [CNS3R \(CNS3 Revised Version of 1998\)](#) Available only at ARI Database for Nearby Stars (ARI, Astronomisches Rechen-Institut Heidelberg)
- [NStars, Nearby Stars Project](#) (NASA/JPL Nstars project)
 - [NStars Database](#)
 - [NStars Spectra](#) (Appalachian State University)
 - Contributions to the Nearby Stars (NStars) Project:
[Spectroscopy of Stars Earlier than M0 within 40 parsecs: The Northern Sample I](#) (R.O. Gray et al., 2003, AJ, 126, 2048) **NEW**
 - [Spectroscopy in the Local Neighborhood](#) (Warner and Swasey Obs.) **NEW**
 - [Stars within 15 parsecs: Abundances for a northern sample](#) (Luck & Heiter, 2005, AJ, 129, 1063) **NEW**
- [NEXXUS - The ROSAT Database for Nearby X-Ray and extreme UV emitting Stars](#) (Schmitt & Liefke, 2004, A&A, 417, 651) **NEW**
- [SolStation.com](#)
 - [Notable nearby stars](#)
- [RECONS \(Research Consortium on Nearby Stars\)](#)

The Solar Neighborhood

- [The Geneva-Copenhagen survey of the Solar neighbourhood](#)
 - [Ages, metallicities, and kinematic properties of ~14 000 F and G dwarfs](#) (Nordström B., et al., 2004, A&A 418, 989) **NEW**
 - [Milky Way Past Was More Turbulent Than Previously Known](#) (ESO, 6 Abril 2004) **NEW**

Caracterización espectroscópica y cinemática de las estrellas frías de la vecindad solar

Observaciones espectroscópicas ya disponibles:

- **S⁴N: A Spectroscopic Survey of Stars in the Solar neighborhood - The Nearest 15 pc**
(Allende Prieto C., et al., 2004, A&A 420, 183)
- **Nearby stars of the Galactic disk and halo III.**
(Fuhrmann, K., 2004, AN, 325, 3)
- **Nearby young stars**
(Wichmann, Schmitt, & Hubrig, 2003, A&A 399, 983)
- **Spectroscopic Properties of Cool Stars (SPOCS). I. 1040 F, G, and K Dwarfs from Keck, Lick, and AAT Planet Search Programs**
(Valenti & Fischer, 2005, ApJS, 159, 141)

Caracterización espectroscópica y cinemática de las estrellas frías de la vecindad solar

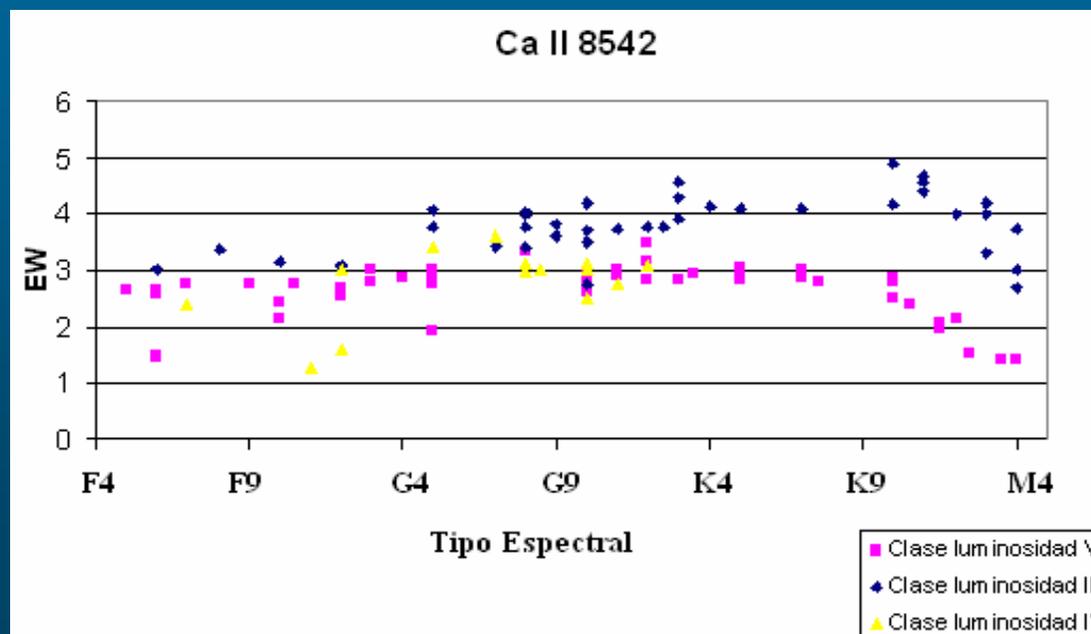
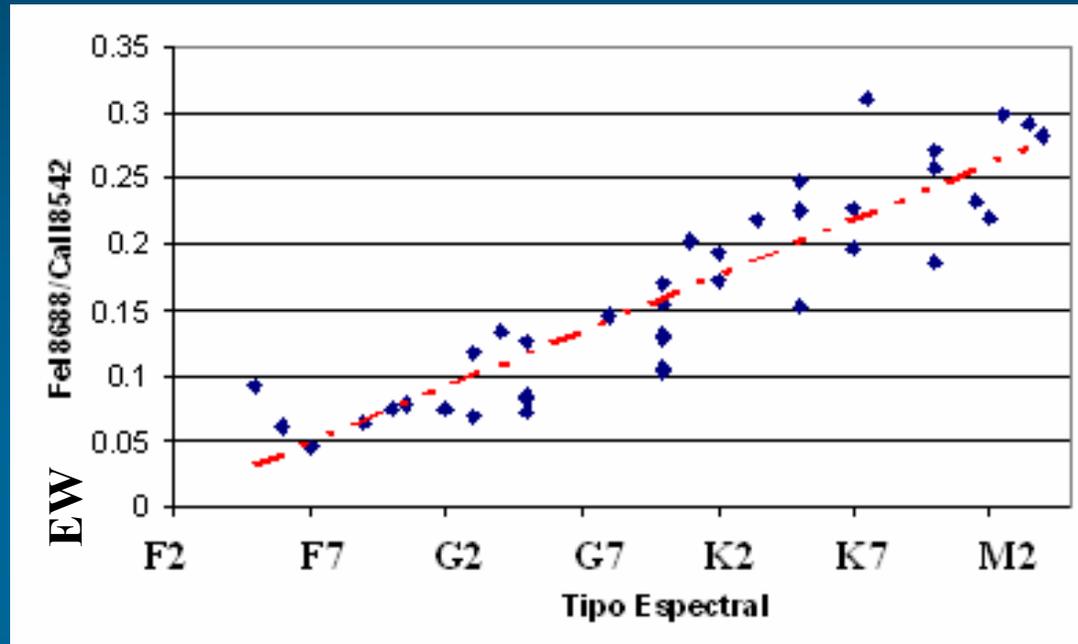
Librerías de espectros ya disponibles:

- The ELODIE archive An on-line database of high-resolution stellar spectra
(Moultaka J., Ilovaisky S.A., Prugniel Ph., Soubiran C., 2004, PASP, 116, 693)
- A Library of High-Resolution Spectra of Stars across the Hertzsprung-Russell Diagram
(Bagnulo S., et al., 2003, The Messenger 114, 10) UVES Paranal Observatory Project (POP)
- GAUDI: The COROT Ground-based Asteroseismology Uniform Database Interface (LAEFF)
- Library of flux-calibrated echelle spectra of southern late-type dwarfs with different activity levels
(Cincunegui C., and Mauas P.J.D., 2004, A&A, 414, 699)
- High-Dispersion Spectra Collection of Nearby F--K Stars at Okayama Astrophysical Observatory: A Basis for Spectroscopic Abundance Standards
(Takeda Y., et al., 2005, PASJ 57, 13)
- **NStars, Nearby Stars Project** (NASA/JPL Nstars project)
Spectroscopy in the Local Neighborhood (Warner and Swasey Obs.)
Stars within 15 parsecs: Abundances for a northern sample (Luck & Heiter, 2005, AJ, 129, 1063)

Librerías de espectros estelares

Clasificación espectral

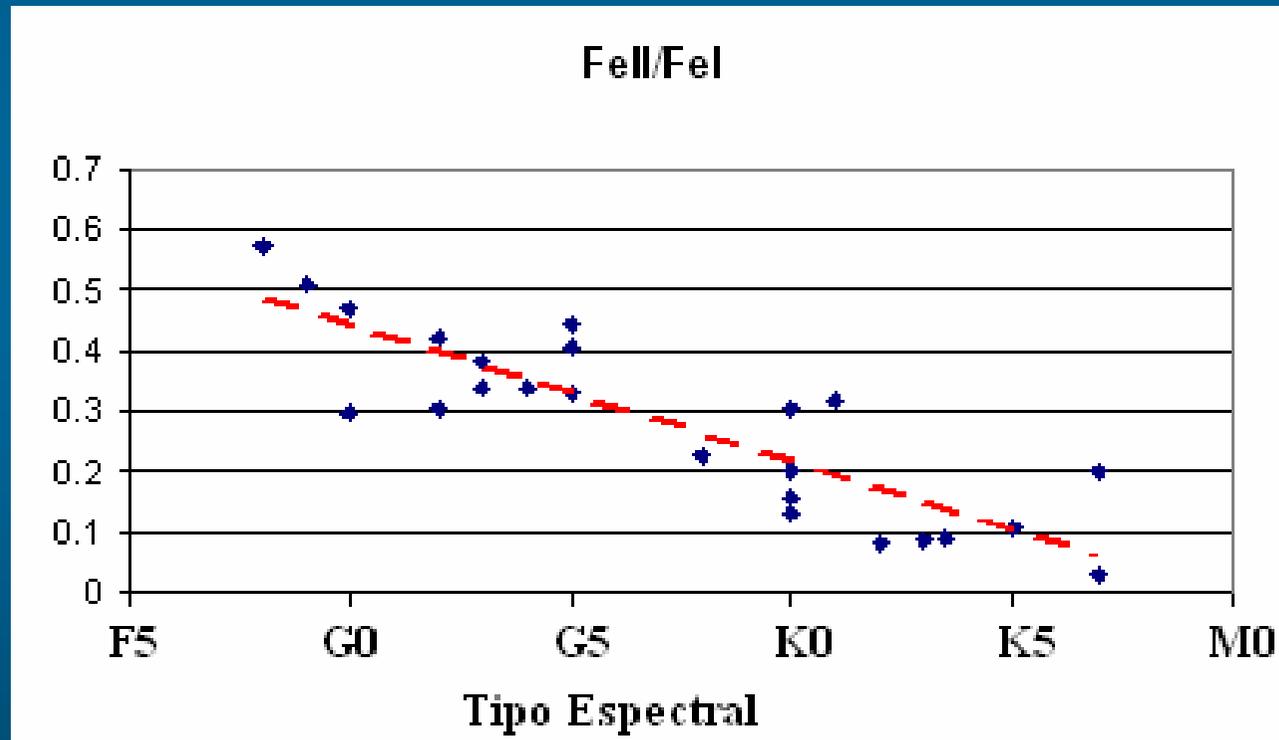
Fe I 8688/ Ca II 8542



Librerías de espectros estelares

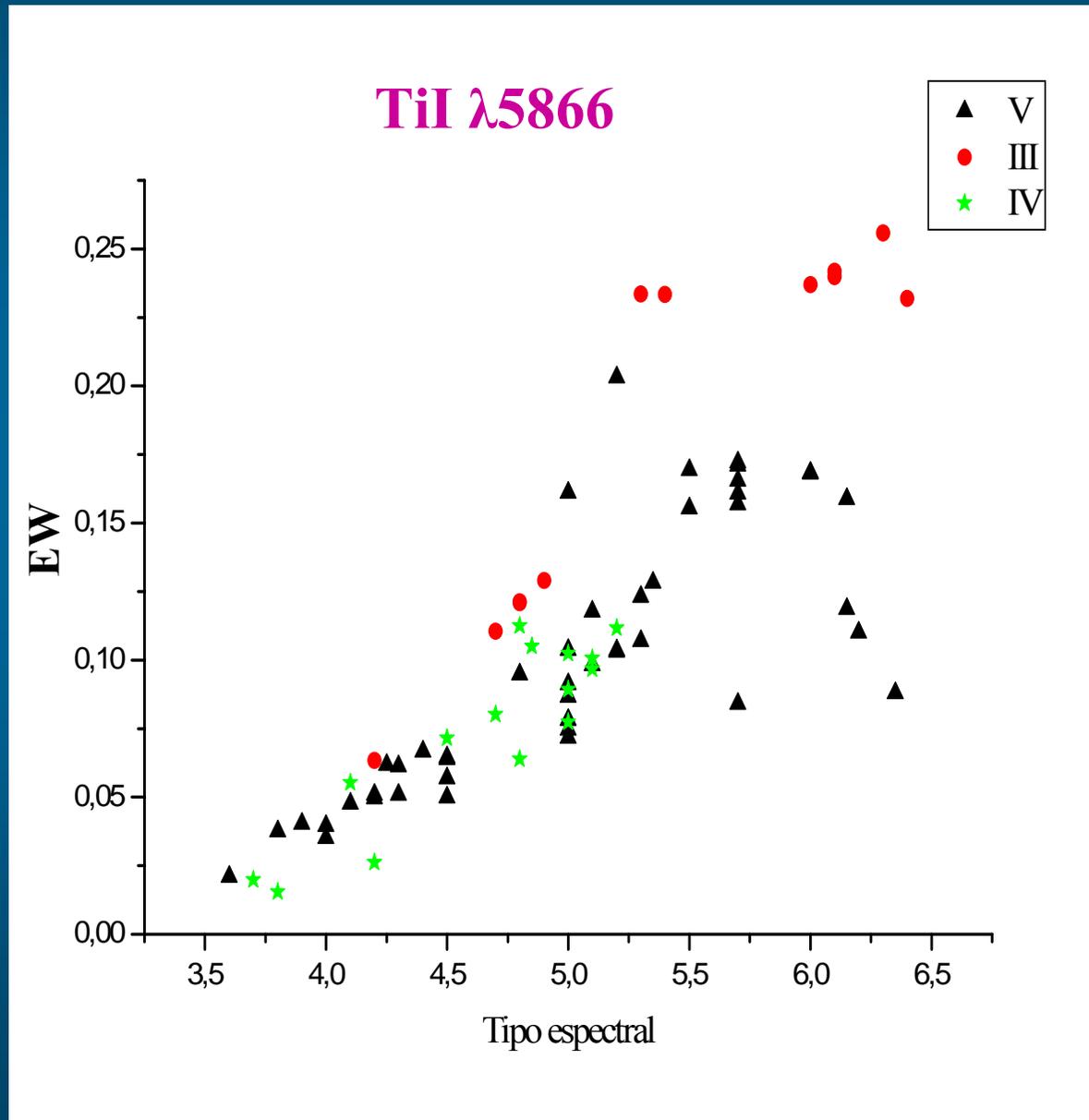
Clasificación espectral

Fe II 5432/ Fe I 6430



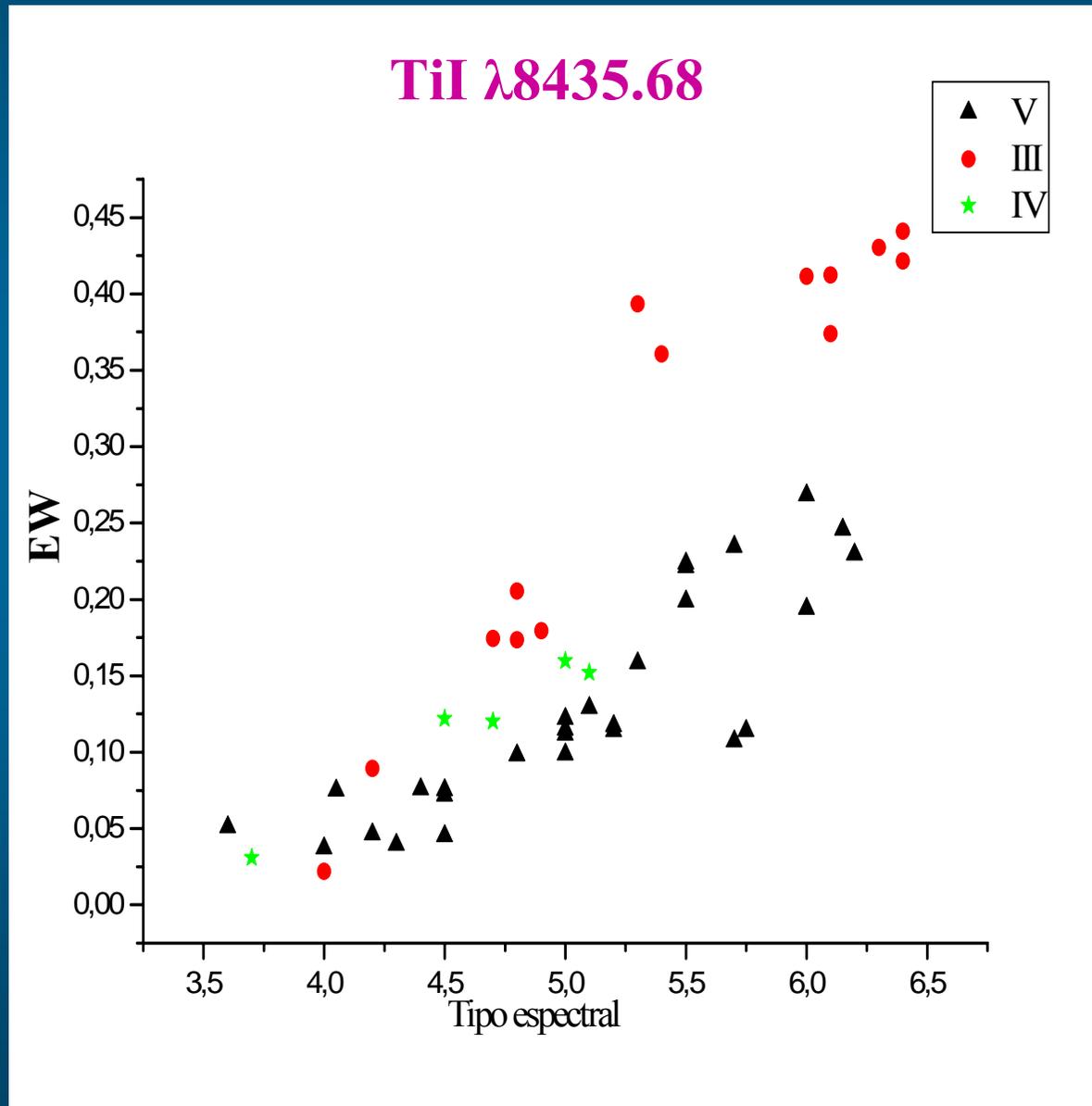
Librerías de espectros estelares

Clasificación espectral



Librerías de espectros estelares

Clasificación espectral



Librerías de espectros estelares

Preparación de los espectros para poder ser accesibles a través del Observatorio Virtual (SSAP, Simple Spectra Access Protocol).

VOTable SSAP format

