Review of existing and future observational libraries of stellar spectra

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IWSSL 2013 - International Workshop on Spectral Stellar Libraries
October 14th - 17th 2013, Lyon (France)
IWSSL 2013
International Workshop on
Spectral Stellar Libraries

Program
Overview
The observational stellar libraries over the electromagnetic spectra

- **Review of existing and future observational libraries of stellar spectra**
  David Montes (UCM, Spain)

- **The HST/STIS Advanced Spectral Library (ASTRAL)**
  Thomas Ayres (Univ. Colorado, USA)

- **The SpeX Spectral Libraries: Low-Res NIR Spectroscopy of 1000 M, L, T Dwarfs**
  Adam Burgasser (Univ. California [San Diego], USA)

- **The X-Shooter Spectral Library (XSL) in the optical - First Year of the Survey**
  Yanping Chen (Kapteyn Astron. Inst., Groningen, Netherlands)

- **The X-shooter Spectral Library (XSL) in the near-infrared**
  Anais Gonneau (Obs. Strasbourg, France)
Theoretical libraries

- Synthetic spectra (TSAP, Theoretical Spectra Access Protocol)
- Model atmospheres
- Model for telluric absorption
- Atomic lines calibration

Dissemination of libraries and spectra

- Archives of spectra
- Virtual Observatory tools (SSAP, Simple Spectra Access Protocol)
- Spectroscopic framework

→ Round table on the virtual observatory and archives of spectra
Usages of libraries to study stellar populations

- Stellar population applications
- Stellar population modelling
- Galaxy Star Formation Histories

Characterization of stellar spectra

- Benchmark stars
- Fundamental stellar parameters
- Spectral fitting
- Abundances
- Metallicity trends

Round table on the characterization of stellar spectra
Surveys

- New spectral libraries from different surveys
- Use of archived spectra (ESO, ELODIE, etc…) (AMBRE Project)
- GES, Gaia-ESO Survey (UVES, GIRAFFE)
- XSL, X-Shooter Spectral Library
Review of existing and future observational libraries of stellar spectra

Talk Overview

- Summary of existing observational libraries of stellar spectra
- Spectral coverage (optical, NIR)
- Spectral resolutions (low, high)
- Coverage in the space of parameters ($T_{\text{eff}}$, log $g$ and [Fe/H])
- Spectral formats (FITS, orders, merged)
- Availability on the web (VO standards)
- Some future observational libraries of stellar spectra
- Open questions:
  is there an 'ideal' library?, why would it be difficult to create it?,
  it is possible to provide together observed spectra, derived stellar parameters and synthetic spectra?, etc.
Existing observational libraries of stellar spectra
Librerias de espectros estelares
(Libraries of stellar spectra)

Web resources about stellar spectral libraries (papers, links, electronic access to spectra, etc…)

Maintained by David Montes (UCM) from 1995- to present
Libraries of stellar spectra web page

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

- Library of high and mid-resolution spectra in the CaII H&K, Hα, Hβ, and NaI D1, D2, and HeI D3 lines regions of F, G, K and M field stars
  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),
  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)
  Available via WWW

- Library of high-resolution spectra and database of stellar parameters of F, G, K and M stars
  Montes D., et al., 2013
  Available via WWW
Other Libraries of stellar spectra

- Stellar spectrophotometric atlas, wavelengths from 3130 to 10800 Å
  GUNN, J.E.; STRYKER, L.L.
  1983ApJS...52..121 -- Catalog at CDS -- List of spectra -- Spectra in STSDAS table format

- A library of stellar spectra,
  JACOBY, G.H., HUNTER, D.A., CHRISTIAN, C.A.
  1984, ApJS...56..257..Catalog at CDS..FITS images of the spectra

- Spectrophotometric atlas of synthesis standard spectra,
  PICKLES, A. J.
  1985, ApJS...59..33..Catalog at CDS

- Spectra of late-type standard stars in the region 2.0-2.5 microns
  KLEINMANN S.G., HALL D.N.B.
  1986 ApJS...62..501 ..anonymous FTP

- A spectroscopic survey of red dwarf flare star
  PETTERSEN, B. R.; HAWLEY, S. L.
  1989A&A...217..187

- A standard stellar spectral sequence in the red/near-infrared - Classes K5 to M9,
  KIRKPATRICK, J.D.; HENRY, T.J.; MCCARTHY, D.W., JR.
  1991, ApJS...77..417...

- A new library of stellar optical spectra,
  SILVA, D. R.; CORNELL, M. E.
  1992, ApJS...81..865...Catalog at CDS
A library of stellar spectra,
JACOBY, G.H., HUNTER, D.A., CHRISTIAN, C.A.
1984, ApJS...56..257...Catalog at CDS...FITS images of the spectra

\( \lambda \lambda 3510 - 7427 \, \text{Å}, \text{resolution} 4.5 \, \text{Å} \)

Index of ftp://ftp.noao.edu/catalogs/jacobyetal.spec/

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A LIBRARY OF STELLAR SPECTRA

GEORGE H. JACOBY AND DEIDRE A. HUNTER
Kitt Peak National Observatory 1

AND

CAROL A. CHRISTIAN
Canada-France-Hawaii Telescope Corporation and University of Hawaii
Received 1984 March 2; accepted 1984 April 9

ABSTRACT

Spectra for 161 stars having spectral classes O–M and luminosity classes V, III, and I have been incorporated into a library available on magnetic tape. The spectra extend from 3510 to 7427 Å at a resolution of \(~ 4.5 \, \text{Å} \). The typical photometric uncertainty of each resolution element in the spectra is on the order of 1%, while broad-band variations are smaller than 3%.

Potential uses for the library include population synthesis of galaxies and clusters, tests of stellar atmosphere models, spectral classification, and the generation of color indices having arbitrary wavelength and bandpass.

Subject headings: spectrophotometry — stars: catalogs
Low-resolution - Optical

A library of stellar spectra,
JACOBY, G.H., HUNTER, D.A., CHRISTIAN, C.A.
1984, ApJS...56..257...Catalog at CDS...FITs images of the spectra

λλ 3510 - 7427 Å, resolution 4.5 Å
Low-resolution - Optical

A library of stellar spectra,
JACOBY, G.H., HUNTER, D.A., CHRISTIAN, C.A.
1984, ApJS...56..257...Catalog at CDS...FITS images of the spectra

λλ 3510 - 7427 Å, resolution 4.5 Å
Low-resolution - Optical

- Spectrophotometric atlas of synthesis standard spectra,
  PICKLES, A. J.
  1985. ApJS...59...33...Catalog at CDS

λλ 3600 - 10000 Å, resolution 10-17 Å
Low-resolution – UV-Optical-NIR

HILIB: A Digital Stellar Spectral Library Extending From 1150-25000 Å
A Stellar Spectral Flux Library: 1150-25000 Å,
Pickles A.J., 1998, PAPS 110, 863... Data at CDS

Combining different spectra
Wide λλ coverage 1150 - 25000 Å
5 Å/pixel, resolution R = 500

http://www.ifa.hawaii.edu/users/pickles/AJP/hilib.html
"MILES: A Medium resolution INT Library of Empirical Spectra"

- "Evolutionary stellar population synthesis with MILES - I. The base models and a new line index system" (Vazdekis, et al., 2010, MNRAS, 404, 1639)
- "An updated MILES stellar library and stellar population models" (Falcón-Barroso, et al., 2011, 532, A95)

"The atmospheric parameters and spectral interpolator for the MILES stars" (Prugniel, et al., 2011, A&A, 531, A165)

Welcome to the new MILES website

This is a website dedicated to the scientific exploitation of a new set of stellar libraries and stellar population synthesis models for the study of stars and galaxies, and their evolution.

The main emphasis of this page goes into a new stellar library (MILES) developed for stellar population synthesis models. The library consist of ~1000 stars spanning a large range in atmospheric parameters. The spectra were obtained at the 2.5m INT telescope and cover the range 3525-7500Å at 2.5Å (FWHM) spectral resolution. In addition we also provide spectra for the near-IR Ca II triplet stellar library, 8350-9020Å and 1.5Å (FWHM), and SSP models. The spectral resolution, spectral type coverage, flux calibration accuracy and number of stars in both libraries represent a substantial improvement over previous libraries used in population synthesis models.

In this website we give access to both the STELLAR LIBRARIES and STELLAR POPULATION MODELS developed by our group, as well as a set of WEBTOOLS to retrieve, handle and transform them.

http://miles.iac.es
Medium-resolution - Optical

Empirical Calibration of the Near-IR Ca II Triplet

- The Stellar Library
- Spectral Database

Calcium II Triplet library
8350-9020 Å at 1.5 Å (FWHM)

http://miles.iac.es
The Spectral Library
This spectral library consists of spectra for 1273 stars obtained with the 0.9m Coudé Feed telescope at Kitt Peak National Observatory. The spectra have been obtained at an original dispersion of 0.44 Angstroms/pixel, at a resolution of ∼1 Angstroms FWHM. To cover the entire wavelength range of 3460 Angstroms to 9464 Angstroms requires five separate observations with different grating settings. These observations have been stitched together to form complete spectra for the individual stars. For 885 stars we have complete coverage over the entire wavelength range, and partial coverage for the remaining stars. The 1273 stars have been selected to provide broad coverage of the atmospheric parameters effective temperature, surface gravity, and [Fe/H], as well as spectral type. The goal of the project is to provide a comprehensive library of stellar spectra for use in automated classification of stellar and galaxy spectra and in galaxy population synthesis.

Reference Paper
The primary reference is The Indo-U.S. Library of Coudé Feed Stellar Spectra by Francisco Valdes, Ranjan Gupta, James Rose, Harinder Singh, and David Bell. The full version of the tables mentioned in the paper are table2, table3, and table4. Links to other formats for the tables are given later.

http://www.noao.edu/cflib/
Medium-resolution - Optical


\[ \lambda \text{ 3460-94640 Å at 1 Å (FWHM)} \]

http://www.noao.edu/cflib/
Libraries of high resolution spectra of cool stars (chromospheric activity)

1997-1999 - 329 FGKM stars

   Intermediate-resolution (0.2-3 Å) CaII H&K, Hβ, NaI D1, D2 & HeI D3, Hα 170 spectra, 116 stars (V, IV, III)

   High-resolution (0.09-0.19 Å) echelle (4800 – 10600 Å) 105 spectra, 83 stars (V)

   Intermediate resolution (0.5 Å) echelle (3900 – 9000 Å) 345 spectra, 130 stars (V, IV, III, II, I)

http://www.ucm.es/info/Astrof/invest/actividad/spectra.html
1) Montes et al. 1997, A&ASS, 123, 473; Intermediate-resolution (0.2-3 Å) CaII H&K, Hβ, NaI D₁, D₂ & HeI D₃, Ha 170 spectra, 116 stars (V, IV, III) IDS/INT, ISIS/WHT, Coude/2.2m Reference stars (low vsini, lor chrom. act.) For spectral subtraction technique.

http://www.ucm.es/info/Astrof/fgkmsl/fgkmsl.html
2) Montes & Martín 1998, A&ASS, 128, 485; High-resolution (0.09-0.19 Å) echelle (4800 – 10600 Å) 105 spectra, 83 stars (V) UES/WHT Reference stars (low $v\sin i$, lor chrom. act.) For spectral subtraction technique.

http://www.ucm.es/info/Astrof/fgkmsl/UESfgkmsl.html
3) Montes, Ramsey & Welty 1999, ApJS, 123, 283; intermediate resolution (0.5 Å) echelle (3900 – 9000 Å) 345 spectra, 130 stars (V, IV, III, II, I) FOE/KPNO Reference stars (low vsini, lor chrom. act.) For spectral subtraction technique.

http://www.ucm.es/info/Astrof/fgkmsl/FOEfgkmsl.html
Libraries of M, L and T stars

Late-M, L and T dwarfs spectral libraries

See: Brown Dwarfs page (D. Montes) and BrownDwarfs.org (A. Burgasser)


- L dwarf and T dwarf spectral classification I. Neill Reid

- Keck LRIS spectra of late-M, L, and T dwarfs I. Neill Reid

- DwarfArchives.org -> Archive of M, L, T, and Y Dwarfs (Chris Gelino, Davy Kirkpatrick, Mike Cushing, David Kinder, Adam Burgasser)


- T dwarfs spectra (Adam Burgasser)

- IRTF/SpeX-Prism Spectra of M, L, and T Dwarfs (Adam Burgasser)

- Near-infrared spectral classification of late M and L dwarfs
  (Reid et al., 2001, AJ 121, 1710)

- M Dwarf and M Giant Standards (Kelle Cruz)

- L and T dwarf data archive (Sandy Leggett)

- Towards Spectral Classification of L and T Dwarfs: Infrared and Optical Spectroscopy and Analysis

- The NIRSPEC Brown Dwarf Spectroscopic Survey (BDSS) Archive (Ian McLean)

- "An Infrared Spectroscopic Sequence of M, L, and T Dwarfs" -> IRTF Spectral Library

- The IAC online catalog for M-, L-, and T-type dwarfs
  (E. Martín, J. Cabrera, E. Cenizo, 2005, Astronomische Nachrichten, 326, 1026)

- SONYC Substellar Objects in Nearby Young Clusters
  (R. Jayawardhana (Univ. of Toronto), K. Muzic (ESO Santiago), V. Geers (DIAS),
  A high resolution spectral atlas of brown dwarfs

- A library of near-infrared integral field spectra of young M-L dwarfs
Libraries of M, L and T stars

Late-M and L field dwarfs spectra

From: "Spectroscopic Classification of Late-M and L Field Dwarfs" , Martín E.L. et al., 1999, AJ 118, 2466

http://www.ucm.es/info/Astrof/fgkmsl/mldwarfs.html
High-resolution - Optical

*S^4N, Spectroscopic Survey of Stars in the Solar Neighborhood*


FGK stars \(\lambda\lambda\ 3620 - 9210 \text{ Å}\), resolution \(R = 50000\)

http://hebe.as.utexas.edu/s4n/
High-resolution - Optical

- The ELODIE archive An on-line database of high-resolution stellar spectra
  \( \lambda \lambda 4100 - 6800 \ \text{Å}, \) resolution \( R = 42000 \)

The ELODIE archive
An on-line database of high-resolution stellar spectra

- Archive News | Publications using ELODIE Archive

Enter a designation or coordinates

Examples:
HIP117998, 104 14 57 15 32 10, simbad:procyon, HD190007, HD190073, GJ%

- For identifiers you can choose to query:
- For coordinate and around object queries, define a radius:
- Choose a sample in the list:

Submit  Reset

http://atlas.obs-hp.fr/elodie/
High-resolution - Optical

A database of high and medium-resolution stellar spectra

- Part of the Spectrophotometric resources available in HYPERCAT
- LH_ELODIE\high-resolution\ELODIE archive Resolution 0.013 nm (FWHM); W-range: 410 - 680 nm
- LL_ELODIE\low-resolution\ELODIE archive Resolution 0.055 nm (FWHM); W-range: 410 - 680 nm

ELODIE: The Stellar Library

- New release of the ELODIE library (Ph. Prugniel, C. Soubiran, 2004)

ELODIE: THE STELLAR LIBRARY

Philippe Prugniel and Caroline Soubiran

We present ELODIE.3.1, an updated release of the ELODIE library originally published in 2001A&A...369.1048P (astro-ph/0101378). It is part of the spectrophotometric resources available in HyperLeda. The spectra can be visualized or downloaded in FITS format in HyperLeda (current version) or Vizier (old published version).

The ELODIE library includes 1962 spectra of 1388 stars obtained with the ELODIE spectrograph at the Observatoire de Haute-Provence 193cm telescope in the wavelength range 390 to 680 nm. It provides a large coverage of atmospheric parameters: Teff from 3000 K to 60000 K, log g from -0.3 to 5.9 and [Fe/H] from -3.2 to +1.4. The library is given at two resolutions:

http://www.obs.u-bordeaux1.fr/m2a/soubiran/elodie_library.html
UVES-POP (Paranal Observatory Project),
A Library of High-Resolution Spectra of Stars across the Hertzsprung-Russell Diagram
(Bagnulo S., et al., 2003, The Messenger 114, 10)

http://www.eso.org/sci/observing/tools/uvespop.html
CRIRES-POP (Paranal Observatory Project) -
A Library of High Resolution Spectra in the
Near-infrared
Lebzelter, et al., 2010, The Messenger, 139, 33

http://www.univie.ac.at/ciratespop/
## Resources about available libraries

### Standard Objects For Astronomy

#### 3. Spectroscopy

**Stellar Spectra Databases**

<table>
<thead>
<tr>
<th>Database</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A large collection of stellar spectral libraries</td>
<td>Includes some links from this page</td>
</tr>
<tr>
<td>High-Dispersion Spectra Collection of Nearby F-K Stars at Okayama</td>
<td>160 F-K dwarfs and subgiants at 5000-6200Å, 5800-7000Å, and 7600-8800Å (R ~ 70000)</td>
</tr>
<tr>
<td>Astrophysical Observatory</td>
<td></td>
</tr>
<tr>
<td>Y. Takeda et al. (2005)</td>
<td></td>
</tr>
<tr>
<td>The ELODIE archive</td>
<td>Many spectra obtained with the ELODIE spectrograph (R ~ 48000)</td>
</tr>
<tr>
<td>THE INDO-US LIBRARY OF COUDE FEED STELLAR SPECTRA</td>
<td></td>
</tr>
<tr>
<td>Valdes et al. (2004)</td>
<td></td>
</tr>
<tr>
<td>Archive of high-resolution spectral observations of bright stars at</td>
<td>&gt;3000 spectra of 334 stars obtained in 1993-2002</td>
</tr>
<tr>
<td>Ritter Observatory of the University of Toledo</td>
<td></td>
</tr>
<tr>
<td>A Digital Spectral Classification Atlas</td>
<td>Atlas of stellar spectra at the 3.6 Å / 2 pixel resolution</td>
</tr>
<tr>
<td>R.O. Gray</td>
<td></td>
</tr>
<tr>
<td>IRAS low resolution spectra (at CDS)</td>
<td>5425 spectra from 8 to 22 microns</td>
</tr>
<tr>
<td>The same database at Univ. of Calgary</td>
<td></td>
</tr>
<tr>
<td>A new library of stellar optical spectra</td>
<td>72 spectra from 3510 to 8930 Å at 11 Å resolution, classes O-M and</td>
</tr>
<tr>
<td>Silva &amp; Cornell (1992)</td>
<td>luminosity classes I-V</td>
</tr>
<tr>
<td>Optical spectra of Praesepe and M67 stars</td>
<td>107 spectra (R=1500) of Praesepe MS stars (F1-M4) from 5600 to 9000 Å</td>
</tr>
<tr>
<td>Allen &amp; Strom (1995)</td>
<td></td>
</tr>
<tr>
<td>A library of stellar spectra</td>
<td>161 spectra from 3510 to 7427 Å classes O-M and luminosity classes I, III, V</td>
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<tr>
<td>Jacoby et al. (1984)</td>
<td></td>
</tr>
<tr>
<td>An atlas of the infrared spectral region. I. The early type</td>
<td>76 spectra for O, B, A and F type stars between 8375 and 8770 Å</td>
</tr>
<tr>
<td>stars (O-G0)</td>
<td></td>
</tr>
<tr>
<td>Andrillat et al. (1995)</td>
<td></td>
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</tbody>
</table>

Available libraries of observed spectra.
(U. Munari & R. Sordo, 2005, MSAIS, 8, 170)

The Asiago Database of Spectroscopic Databases (ADSD)

http://web.pd.astro.it/adsd/
### Resources about available libraries

Available libraries of observed spectra.

(U. Munari & R. Sordo, 2005, MSAIS, 8, 170)

The Asiago Database of Spectroscopic Databases


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**Montes et al. (1999)**

An atlas of echelle spectra of F-M stars characterized by a low chromospheric activity. Inter-order gaps differ among the surveyed stars.


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### Electronic data

**General information**

<table>
<thead>
<tr>
<th>Spectral range (Å)</th>
<th>3900 … 9000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resolving power</td>
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</tr>
<tr>
<td>Sampling (Å)</td>
<td>0.15–0.35</td>
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<tr>
<td>Dispersion (Å/pix)</td>
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<td>Available data</td>
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<td>Detector data type</td>
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<td>Counts</td>
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**Data table**

<table>
<thead>
<tr>
<th>No. card</th>
<th>Catalog</th>
<th>Spectral Range</th>
<th>R or Rp</th>
<th>Sampling</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>Adelman et al. (1989)</td>
<td>3300–10800</td>
<td>5</td>
<td></td>
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<tr>
<td>7</td>
<td>Alekseeva et al. (1997)</td>
<td>3200–7350</td>
<td>50</td>
<td></td>
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<tr>
<td>7</td>
<td>Alekseeva et al. (1997)</td>
<td>3200–10800</td>
<td>100</td>
<td></td>
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<tr>
<td>8</td>
<td>Allen, Strom (1995)</td>
<td>5600–9600</td>
<td>6</td>
<td>1.97</td>
</tr>
<tr>
<td>9</td>
<td>Allende Prieto et al. (2004)</td>
<td>3620–10440</td>
<td>50000</td>
<td>0.01</td>
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<tr>
<td>9</td>
<td>Andrilat et al. (1995)</td>
<td>3620–9210</td>
<td>45000</td>
<td>0.01</td>
</tr>
<tr>
<td>10</td>
<td>Appelquist et al. (1983)</td>
<td>8375–8770</td>
<td>1–1.5</td>
<td>0.8</td>
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<tr>
<td>11</td>
<td>Appelquist et al. (1983)</td>
<td>5185–8700</td>
<td>0.195</td>
<td>0.04</td>
</tr>
<tr>
<td>12</td>
<td>Bagnulo et al. (2003)</td>
<td>3040–10400</td>
<td>80000</td>
<td>0.012–0.026</td>
</tr>
<tr>
<td>13</td>
<td>Barnbaum (1994)</td>
<td>5080–7650</td>
<td>47000</td>
<td>0.043–0.065</td>
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<tr>
<td>14</td>
<td>Barnbaum et al. (1996)</td>
<td>4000–7000</td>
<td>1.6–6.5</td>
<td>0.85–3.25</td>
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<td>15</td>
<td>Biryukov et al. (1998)</td>
<td>3425–7525</td>
<td>50</td>
<td>50</td>
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<td>16</td>
<td>Breger (1976)</td>
<td>3200–12000</td>
<td>10–100</td>
<td>50–200</td>
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<td>Burgasser et al. (2003a)</td>
<td>6300–10100</td>
<td>7</td>
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**Link:** [http://www.ucm.es/info/Astrof/fgkm/FOEfgkm.html](http://www.ucm.es/info/Astrof/fgkm/FOEfgkm.html)
**Resources about available libraries**

**SpectroWeb:** An Interactive Graphical Database of Digital Stellar Spectral Atlases

*Lobel, 2007, 26th IAU GA, Joint Discussion 4, p. 167*

**http://spectra.freeshell.org/spectroweb.html**
Future observational libraries of stellar spectra

- New spectral libraries from different surveys
- Use of archived spectra (ESO, ELODIE, etc…) (AMBRE Project)
- GES, Gaia-ESO Survey (UVES, GIRAFFE)
- XSL, X-Shooter Spectral Library
The goal of the AMBRE project is to homogeneously determine the stellar parameters (and chemical indices) from all the stellar high and medium resolution spectra (from the FEROS, HARPS, UVES and FLAMES spectrographs) available in the ESO archive. The results of the AMBRE project will be made available to the international community through the ESO archive and the Virtual Observatory.

MATrix Inversion for Spectral SynthEsis (MATISSE, Recio-Blanco et al., 2006) algorithm.

→ constrained to parameters of FGKM stars only.

**FEROS (published)**
- The AMBRE Project: Stellar parameterisation of the ESO:FEROS archived spectra
  C. C. Worley, P. de Laverny, A. Recio-Blanco, V. Hill, A. Bijaoui, C. Ordenovic
  *2012A&A...542A..48W*

**UVES (talk this meeting)**
- The AMBRE Project: Stellar Parameters for the UVES Archived Spectra
  Clare Worley, (IoA, Univ. Cambridge, Obs. de la Cote d'Azur)
High resolution échelle spectra FGKM stars

R = 85000 – 22000 (0.08-0.3 Å) – Different échelle spectrographs

Observations:
- WHT-UE, WHT-UES,
- INT-MUSICOS,
- 2.2m-FOCES,
- NOT-SOFIN,
- NOT-FIES,
- TNG-SARG,
- HET-HRS,
- 2.2m ESO- FEROS,
- Mercator-HERMES.

From archives:
- 3.5m ESO-HARPS,
- VLT ESO-UVES,
- OHP - ELODIE,
- OHP - T193/Sophie
- MacDonald - 2dcoudé (S4N),
- 2.2m ESO- FEROS (S4N).
Survey of FGK stars in MGs

★ Survey late-type stars in Moving Groups (MGs)

1999-2002 - 144 FGKM stars

- López-Santiago et al. 2005, PhD Thesis UCM;

A high-resolution spectroscopic survey of late-type stars: chromospheric activity, rotation, kinematics, and age*,...

J. López-Santiago1, D. Montes1, M. C. Gálvez-Ortiz2, I. Crespo-Chacón1, R. M. Martínez-Arnáiz1, M. J. Fernández-Figueroa1, E. de Castro2, and M. Comías2

http://www.ucm.es/info/Astrof/invest/actividad/skg/skg_SS.html
FGK stars in the solar neighbourhood \((d < 25 \text{ pc})\) which include the DUNES sample, an approved Herschel OTKP with the aim of detecting cool faint dusty disks \((\text{Eiroa et al. 2010})\).
Chemical Tagging FGK stars

★ Survey for Chemical Tagging of FGK stars in MGs
Hyades and Ursa Major MGs
2010-2011 – 61 F6-K4 stars
- Tabernero, Montes, González Hernández 2012A&A...547A..13T

Chemically tagging the Hyades Supercluster.
A homogeneous sample of F6-K4 kinematically-selected northern stars

H.M. Tabernero,1 D. Montes1 and J.I. González Hernández1,2
Spectroscopic Analysis

- Kinematics (U, V, W).
  - Radial velocity (Vr)
- Age (Li I 6707.8Å).
- Chromospheric activity
  - CaII H&K to CaII IRT
- Rotation ($v_{\text{seni}}$).
  - Activity – rotación relation
- Stellar parameters.
  - $T_{\text{eff}}$, log $g$, $\xi$ and $[\text{Fe/H}]$
- Absolute and differential abundances.
  - Chemical tagging
Stellar parameters

Stellar atmospheric parameters ($T_{\text{eff}}$, log $g$, $\xi$ and [Fe/H])

StePar (Tabernero Montes, González Hernández 2012A&A...547A..13T):

- 2002 version of the MOOG code (Sneden 1973).
- a grid of Kurucz ATLAS9 plane-parallel model atmospheres (Kurucz 1993).

- The EW determination of the Fe lines with the ARES code (Sousa et al. 2007).
- 263 Fe I and 36 Fe II lines (Sousa et al. 2008).

The code iterates until obtain:

- **excitation equilibrium:**
  the slopes of $\chi$ vs log($\epsilon$(Fe I))
  and log(EW/$\lambda$) vs log($\epsilon$(Fe I)) where zero

- **ionization equilibrium:**
  log($\epsilon$(Fe I)) = log($\epsilon$(Fe II)).

- 2-$\sigma$ rejection of Fe I and Fe II lines after a first determination of the parameters

- **Limitations:** spectral types F6 to K4, slow rotators, no veiling.
Stellar parameters

We introduce a new automatic code (StePar) for determining stellar atmospheric parameters ($T_{\text{eff}}$, $\log g$, $\xi$ and [Fe/H]) in an automated way. StePar employs the 2012 version of the MOOG code (Sneden 1973) and a grid of Kurucz ATLAS9 (plane-parallel) model atmospheres (Kurucz 1993). The atmospheric parameters are obtained from the Ew of 264 Fe I and 38 Fe II lines (extracted from Sousa et al. 2008) fitting until the excitation and ionization equilibrium are fulfilled. StePar uses a Downhill Simplex method (Press et al. 1992) that minimizes a quadratic form composed by the excitation and ionization equilibration conditions. Atmospheric parameters determined by StePar are independent of the stellar parameters input-guess for the problem star, therefore we employ the canonical solar values as initial input. StePar can only deal with FGK stars from Fe I to K2, also it can not work with very metal poor stars or signal-to-noise ratio below 30. Optionally StePar can operate with MARCS models (Gustafsson et al. 2008) instead of Kurucz ATLAS9 models, additionally Turbospectrum (Alvarez and Friz 1998) can replace the MOOG code and play its role during the parameter determination. StePar has been used to determine stellar parameters on some studies (Tabernero et al. 2013 and Wünschow et al. 2013). In addition StePar is being used to obtain parameters for FGK stars from the GJAU-ESO Survey.

Methodology

The StePar algorithm and the MOOG code were carried out with the ARPS code (Boes et al. 2012). We followed the approach of Sousa et al. (2008) to handle the bid parameters of ARPS according to the J dwarfs branch parameters. The other ARPS parameters were employed were: $\alpha = 4$, $\beta = 0$, $\text{lim} = 0.1$, and $\text{width} = 2$.

Stellar atmospheric parameters are derived running the following conditions:

** Stellar equilibrium:** $\log g$ (Fe I) and the metallicity of the atmospheric model are the same. This four conditions are combined in a quadratic form that will be reinitialised with a Downhill Simplex Method (Press et al. 1992).

In addition, we performed a 3-runs of the Fe I and Fe II lines after the first determination of the stellar parameters. Therefore we use the StePar program again without the updated lines.

Testing the Sun

Benchmark stars, MARCS/KURucz, MOOG/Turbospectrum

StePar and chemical abundances

References


The authors are grateful to the Gran Foundation for the Financial Support.
Chemical abundances

Fe, Na, Mg, Al, Si, Ca, Sc, Ti, V, Cr, Mn, Co, and Ni

- **EW method** in a line-by-line basis with *ARES* code (Sousa et al. 2007).

- **Line lists and atomic parameters** from (Neves et al. 2009; González Hernández et al. 2010).

- Abundance analysis with *MOOG* (Sneden 1973) using our determined atmospheric parameters and a solar spectrum taken with the same instrumental configuration.

![Graph](image)

[Ni/Fe] vs [Fe/H]: open diamonds represent the thin disk data (González Hernández et al. 2010), black filled triangles represent Hyades cluster data (Paulson et al. 2003). **Red points** are our stars compatible with Hyades Fe abundance, and the **green** ones not compatible. BZ Cet and HD19902 Hyades cluster members are marked with **blue circles**. **Purple** starred points represent the giant stars. Black starred points are the candidates selected stars in De Silva et al. (2011), black circles are those selected in Pompéia et al. (2011).
Library of high-resolution spectra and database of stellar parameters of F, G, K and M stars
Montes D., et al., 2013
Available via WWW

\( \lambda \lambda \) 3800 to 10000 Å,
resolution \( R = 40000 \) to 80000.

The database will provide in addition the stellar parameters determined for these spectra.

http://www.ucm.es/info/Astrof/fgkmsl/UCMcoolstars.html
Gaia ESO Spectroscopic Survey (GES)

- **PIs**: Sofia Randich (INAF-Arcetri) & Gerry Gilmore (IoA, Cambridge)
- Public large spectroscopic survey with **FLAMES@VLT**
- Limiting mag. (R): 16.5 (UVES), 19 (Giraffe)
- **300 nights** (30n/semester) over 5 (4+1) years; start 1/2012 (P88), end 9/2016 (P97)+; visitor mode
- **GES spectroscopy** complements and completes Gaia astrometry and viceversa

http://www.gaia-eso.eu
Gaia ESO Spectroscopic Survey (GES)

Will start to provide large amount of data

For the stars that will be observed in the Gaia ESO Spectroscopic Survey (GES) with VLT-FLAMES, UVES and Giraffe:

- **Stellar atmospheric parameters** ($T_{\text{eff}}$, $\log g$, $\xi$ and $[\text{Fe/H}]$)
- **Abundance determination.**
- DR1, iDR2.....

- **WG1**: Cluster Membership Analysis
- **WG11**: UVES FGK-star Spectrum Analyses
- **WG12**: Pre-Main-Sequence Stars Spectrum Analyses

$\rightarrow$ Combined Gaia and homogeneous spectroscopic dataset full 6D phase space $f(x,y,z,v_x,v_y,v_z)$, plus stellar parameters, and chemistry for a very large number and variety of stars down to the 19 mag: core science plus legacy science
Gaia ESO Spectroscopic Survey (GES)

Will start to provide large amount of data

Related talks during this meeting:

- **Stellar libraries in the Gaia era**
  *Rosanna Sordo, INAF - Padova Observatory*

- **Benchmark stars - defining reference parameters for the Gaia-ESO Survey**
  *Paula Jofre, IoA, Cambridge*

- **An integrated spectroscopic framework for the creation of stellar libraries**
  *Sergi Blanco Cuaresma, Lab. d'Astroph. Bordeaux*

- **Future spectral libraries: what we can expect from the Gaia-ESO Survey**
  *Anna Hourihane, IoA, Cambridge*
New Spectral Libraries

Related talks during this meeting:

- The X-Shooter Spectral Library (XSL) in the optical - First Year of the Survey
  Yanping Chen (Kapteyn Astron. Inst., Groningen, Netherlands)

- The X-shooter Spectral Library (XSL) in the near-infrared
  Anais Gonneau (Obs. Strasbourg, France)

- XSL, the X-Shooter Spectral Library: Overview and status
  Scott Trager, (Kapteyn Astron. Inst., Groningen, Netherlands)
Characterization of the CARMENES sample

Calar Alto high-Resolution search for M dwarfs with Exoearths with Near-infrared and optical Échelle Spectrographs

• Characterization of late-type M-dwarfs
  (possible new CARMENES targets from Lepine & Gaidos 2011 catalog)
  Observations 2011 -2013

• Low-res - CAFOS/2.2m (CAHA)
  (G100 – R =1500, 4250-8600 Å)
  → Tsp, activity
  754 stars observed and analysed

• High-res - CAFE/2.2m (CAHA) & FEROS (ESO)
  (R =60000, 3950-8600 Å) (R =40000, 3950-8600 Å)
  → vsini
  212 stars observed

http://carmenes.caha.es
Other surveys – archives of spectra

Archives of spectra and derived parameters:

- SDSS
- APOGEE
- RAVE
- LAMOST
- Open questions:

is there an 'ideal' library?,

why would it be difficult to create it?,

it is possible to provide together observed spectra, derived stellar parameters and synthetic spectra?,

Etc…
The End