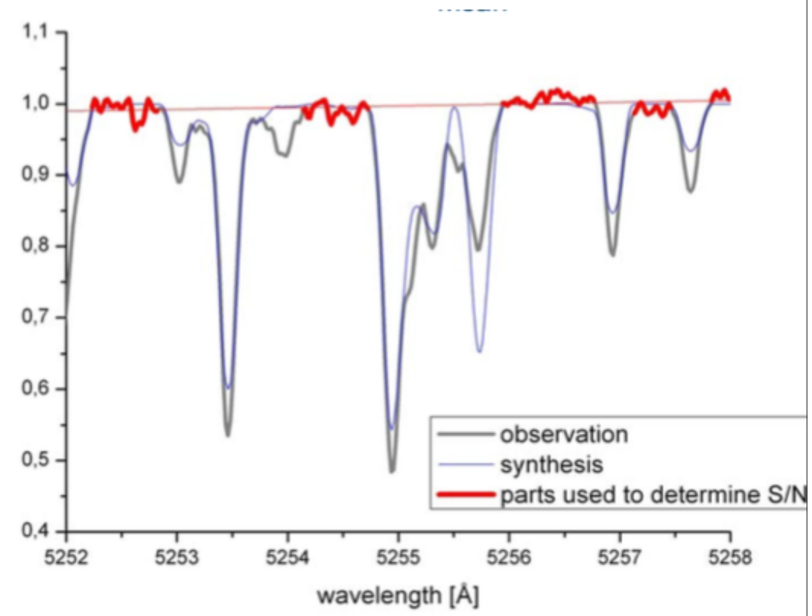
Preparing for observations

S/N

Signal to noise ratio should be calculated in the continuum.

- Use parts where „no“ lines are present
- Linear fit or, if normalization is good enough, $I_{mean} = 1$
  - Calculate standard deviation σ
  - $SNR = I_{mean} / \sigma$

$I_{mean} = 0.99808$
$\sigma = 0.01026$
$\Rightarrow SNR = I_{mean} / \sigma = 97.3$

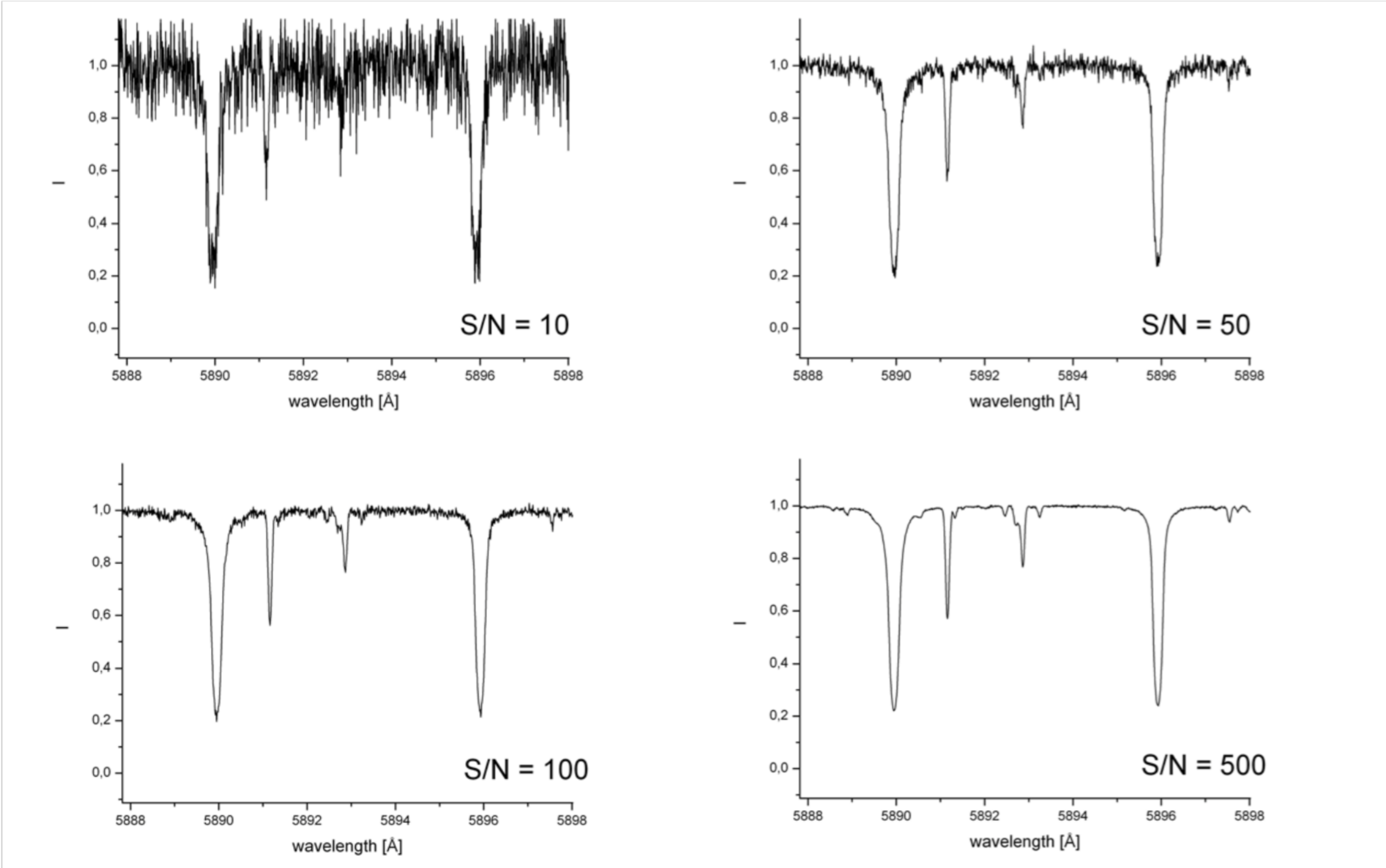


Ways to increase SNR:

- longer exposure time
- sum up spectra
- combine similar lines (LSD technique)

http://www.ast.obs-mip.fr/users/donati/multi.html
Least Squares Deconvolution (LSD) technique (Donati et al. 1997)

based on slides by Richard Neunteufel

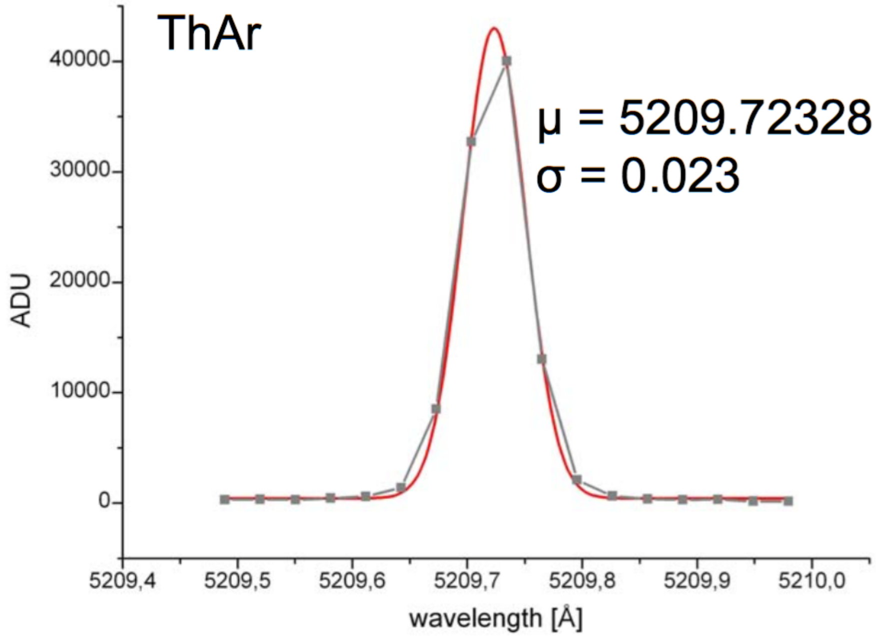


based on slides by Richard Neunteufel

- Resolution: $$R = \frac{\lambda}{\Delta\lambda}$$

$\Delta\lambda$ ... width of resolved spectral element

$$f(x) = \frac{1}{\sigma\sqrt{2\pi}} \exp\left(-\frac{1}{2}\left(\frac{x-\mu}{\sigma}\right)^2\right)$$



$$\mathrm{FWHM} = 2\sqrt{2\ln(2)}\,\sigma$$

≈ 2.355 σ = 0.05414 Å

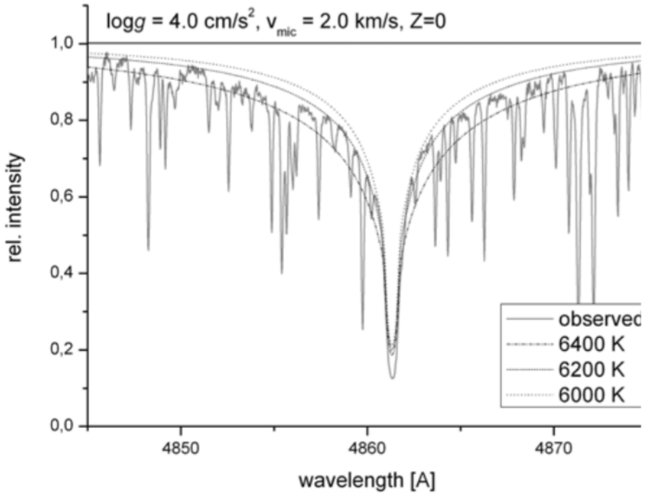
=> R = 96227

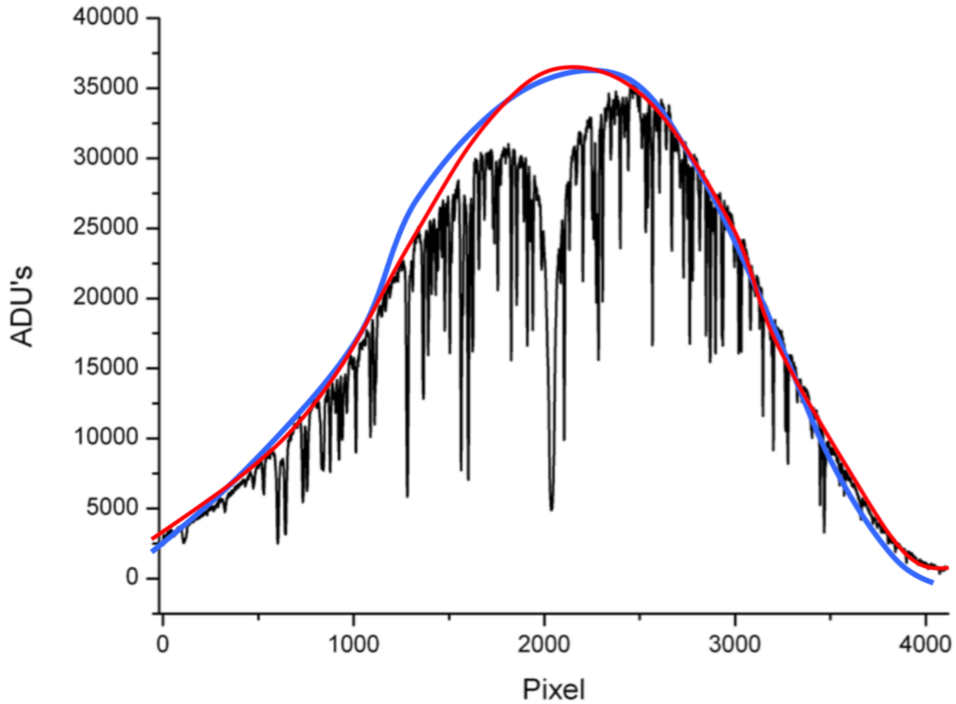
Normalization

Hydrogen lines:

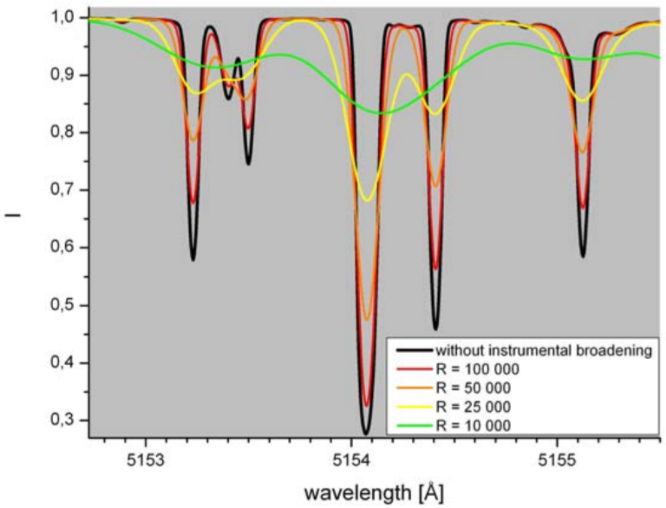
- Continuum normalization tricky
  (→ interpolate continuum between uncontaminated echelle orders;
  check quality of normalization by checking line symmetry)

- Errors in normalization procedure can
  cause errors in temperature determination
  (→ use other methods additionally)

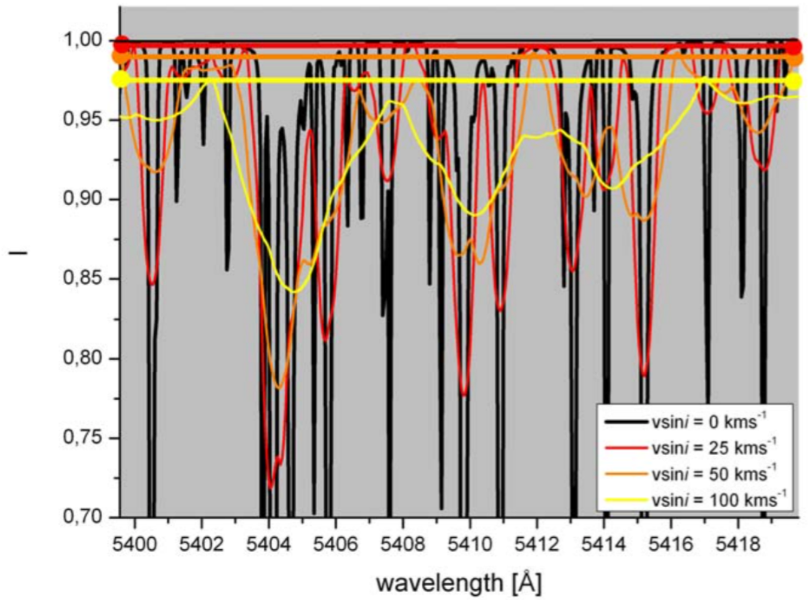




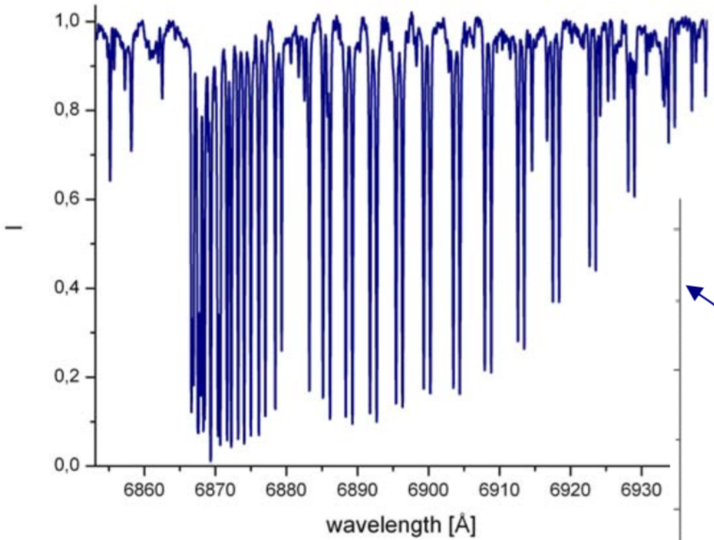
Normalization

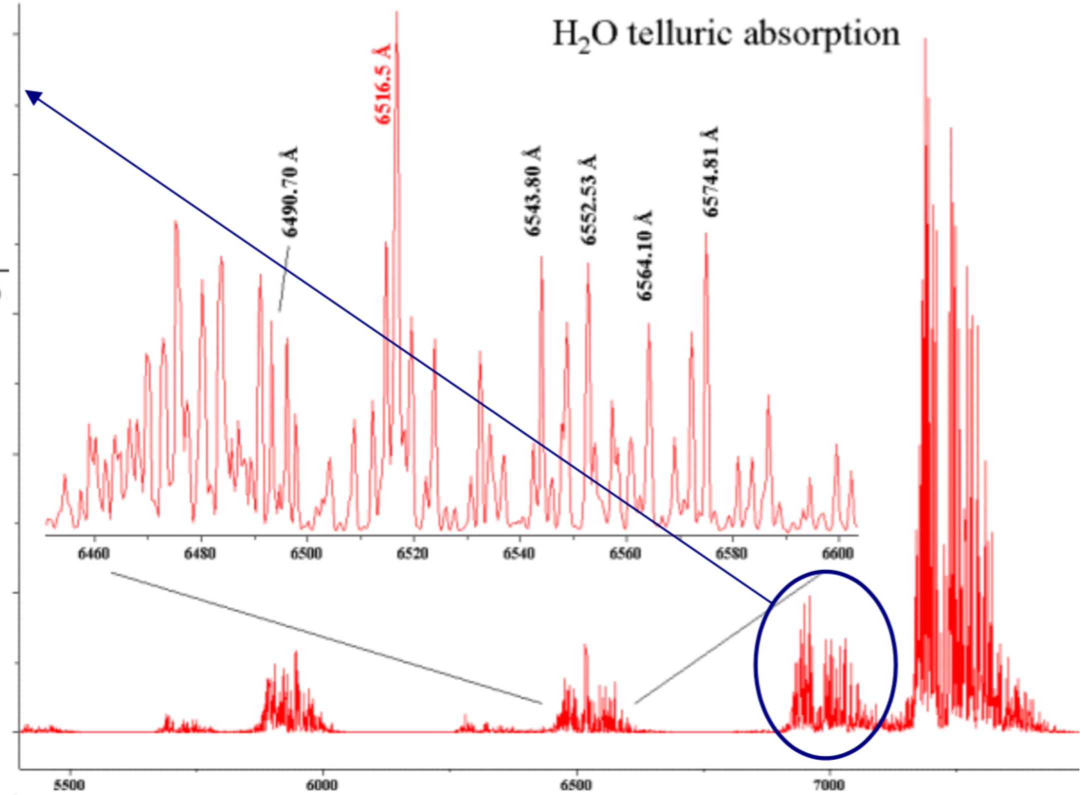


Line broadening leads to underestimation of continuum!



Telluric lines can contaminate spectrum!





H_2O telluric absorption: http://www.astrogeo.va.it/astronom/spettri/atmosferen.htm

The very first steps:

What do I want to study? (Example: `the awesome stellar magnetic fields')

What objects? (Example: roAp stars, Haerbig Ae stars, active FGK stars, ...)

What do I need to know?

1) check literature!!!

2) time series phot./spect. or just a single/few measurements ? how do I want to measure magnetic fields: spectropolarimetry vs. Ca H & K line emission? what about X-rays? ...depends on the object!

e.g. roAp pulsate with periods of few minutes=>

telescope large enough with a CCD fast enough to sample pulsation cycle. does it have a polarimeter? (is my target visible from that hemisphere?)

I need the software to analyze the data! (e.g. Least Square Deconvolution code)

In general:

Think about what you want to understand and which objects will tell you what you want to know.

Think broader! Maybe you need different types of observations at different wavelengths? (Example: identify a PMS star!) Think about the implications of your observations...

Example: Simon (2002) showed that stars show emission in UV up to a Teff ~8500K. So what? They just have magnetic fields like the sun! True, but if you have the magnetic fields they need a dynamo to drive those!... and a dynamo needs diff. rotation between a convective envelope and the radiative layers! => Does this mean that the convective envelope disappears only at Teff~8500K?

Think broader but think critically!!! "Keep their minds open, but not so open that your brains fall out."- Prof. Walter Kotschnig

Do not forget to search public archives for data... maybe your favourite target was already observed!

Do tests if you can! Do tests on artificial data and on other stars (e.g. Sun), prove, if needed, that your method is good and works! Otherwise very hard to get telescope time!

Some archives...

European Southern Observatory: http://archive.eso.org

NRAO Very Large Array, http://archive.nrao.edu

Royal Greenwich Observatory on La Palma http://archive.ast.cam.ac.uk

Gemini, CFHT: CADC http://cadcwww.dao.nrc.ca

Subaru (NAO-JP): SMOKA Archive Facility http://smoka.nao.ac.jp

NOAO (Cerro Tololo, Kitt Peak): http://archive.noao.edu

NARVAL archive: http://tblegacy.bagn.obs-mip.fr/narval.html

Hubble Space Telescope: STScI http://www.stsci.edu and ST-ECF http://ecf.hq.eso.org

Infrared missions: IPAC http://www.ipac.caltech.edu

High-energy: NASA HEASARC http://heasarc.gsfc.nasa.gov, Harvard

ISO, IUE: VILSPA http://www.vilspa.esa.es

Multipurpose: https://archive.stsci.edu/

Observing facilities

Photometric sky surveys:

Two-Micron All Sky Survey (2MASS):

Sloan Digital Sky Survey (SDSS):

Deep Near Infrared Survey of the Southern Sky (DENIS):

Massive Compact Halo Objects (MACHO) http://wwwmacho.anu.edu.au

OGLE

ASAS

Etc. etc.

Some useful information

A very useful talk on the Virtual Observatory, including MANY links, also the ones provided on the last 2 slides.

http://www.das.uchile.cl/~mhamuy/courses/AS750/talk-calan-vo-mario.pdf

R.O. Gray's 'Digital Spectral Classification Atlas'

List of space telescopes on Wikipedia: http://en.wikipedia.org/wiki/List_of_space_telescopes

List of largest optical telescopes: http://astro.nineplanets.org/bigeyes.html

Multi-wavelengths servers

HEASARC (server for multi-wavelengths search), mainly X-ray and gamma-ray.
http://heasarc.gsfc.nasa.gov/cgi-bin/W3Browse/w3browse.pl

IRSA (Infrared Science Archive) http://irsa.ipac.caltech.edu/

MAST (Mikulski Archive for Space Missions)

MAST Missons

- ASTRO - ASTRO Observatory
  - HUT - Hopkins Ultraviolet Explorer
  - UIT - Ultraviolet Imaging Telescope
  - WUPPE - Wisconsin Ultraviolet Photo-Polarimeter Experiment
- Copernicus - Copernicus
- DSS - Digitized Sky Survey
- EPOCH - Extrasolar Planet Observations and Characterization
- EUVE - Extreme Ultraviolet Explorer
- FUSE - Far Ultraviolet Spectrographic Explorer
- GALEX - Galaxy Evolution Explorer
- GSC - Guide Star Catalogs
- HPOL - Halfwave Spectropolarimeter
- HST - Hubble Space Telescope
- IUE - International Ultraviolet Explorer
- KEPLER - Kepler (search for earth-size planets)
- ORFEUS - Orbiting Retrievable Far and Extreme Ultraviolet Spectrometers-SPAS
  - BEFS - Berkeley Extreme and Far-UV Spectrometer
  - TUES - Tübingen Ultraviolet Echelle Spectrometer
  - IMAPS - Interstellar Medium Absorption Profile Spectrograph
- VLA-FIRST Very Large Array - Faint Images of the Radio Sky at Twenty-cm
- XMM-OM Xray Multi-Mirror Telescope - Optical Monitor data

Variable Star Naming

Catalogues: e.g., the General Catalogue of Variable Stars
(Kukarkin et al., Fourth Edition 1985-1995, Fifth Edition: extragalactic variables)

Naming: first double capital letters according to the following scheme:

R, S, ..., Z,
RR, RS, ..., RZ,
SS, ST, ..., SZ,
...,
AA, AB, ..., AZ,
BB, BC, ..., BZ,
...,
QQ, ..., QZ

NB: no J, no BA, CA, CB, etc. ... 334 possibilities per constellation

then further with V335, V336, ...

V5556: highest number in the GCVS

CDS — Centre de Données astronomiques de Strasbourg

Simbad | VizieR | Aladin | Catalogs | Dictionary | Biblio | Tutorials | Resources

SIMBAD Astronomical Database

Queries
basic search
by identifier
by coordinates
by criteria
reference query
scripts
TAP queries
options
Display all user annotations

Documentation
User's guide
Query by urls
Nomenclature Dictionary
Object types
List of journals
Measurement description
Spectral type coding
User annotations documentation

Information
Presentation
Acknowledgment
Release:
SIMBAD4 1.204 - 03-Dec-2012

Content
The SIMBAD astronomical database provides basic data, cross-identifications, bibliography and measurements for astronomical objects outside the solar system.
SIMBAD can be queried by object name, coordinates and various criteria. Lists of objects and scripts can be submitted.
Links to some other on-line services are also provided.

Statistics	
Simbad contains on *2013.01.27*	
7,034,619	objects
17,521,135	identifiers
276,457	bibliographic references
9,336,355	citations of objects in papers

Acknowledgment
If the Simbad database was helpful for your research work, the following acknowledgment would be appreciated: *This research has made use of the SIMBAD database, operated at CDS, Strasbourg, France*

Basic search
identifier, coordinates (radius=10 arcmin), or bibcode
SIMBAD search · clear · help
Install the Simbad basic search in your tool bar

Object query : Altair

C.D.S. - SIMBAD4 rel 1.204 - 2013.01.27CET19:18:49

Available data : Basic data • Identifiers • Plot & images • Bibliography • Measurements • External archives • Notes • Annotations

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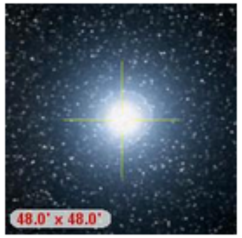
Basic data :

V* alf Aql -- Variable Star of delta Sct type

query around with radius 2 arcmin

Other object types:	dS* () , * (*,AG,ASCC,BD,CSI,FK5,GAT,GC,GCRV,GEN#,GJ,GSC,HD,HIC,HIP,HR,JP11,N30,8pc,PLX,PMC,PPM,ROT,SAO,SKY#,TYC,UBV,USNO,uvby98,Zkh) , PM* (Ci,LFT,LHS,LSPM,LTT,NLTT,PM) , ** (ADS,CCDM,IDS,WDS) , IR (IRAS,IRC,2MASS,RAFGL) , X (2E,1ES,1RXS) , V* (V*,NSV) , UV (TD1)
ICRS coord. (ep=J2000) :	19 50 46.99855 +08 52 05.9563 (Optical) [4.48 4.12 81] A 2007A&A...474..653V
FK5 coord. (ep=J2000 eq=2000) :	19 50 46.999 +08 52 05.96 (Optical) [4.48 4.12 0] A 2007A&A...474..653V
FK4 coord. (ep=B1950 eq=1950) :	19 48 20.59 +08 44 05.6 (Optical) [25.83 23.92 0] A 2007A&A...474..653V
Gal coord. (ep=J2000) :	047.7441 -08.9092 (Optical) [4.48 4.12 0] A 2007A&A...474..653V
Proper motions *mas/yr* [error ellipse]:	536.23 385.29 [0.51 0.47 0] A 2007A&A...474..653V
Radial velocity / Redshift / cz :	V(km/s) -26.1 [0.9] / z(-) -0.000087 [0.000003] / cz -26.10 [0.90] (-) A 1979IAUS...30...57E
Parallaxes *mas*:	194.95 [0.57] A 2007A&A...474..653V
Spectral type:	A7V C -
Fluxes (7) :	B 0.99 [-] C - V 0.77 [-] C - R 0.8 [-] E 2003AJ....125..984M I 0.6 [-] E 2003AJ....125..984M J 0.313 [0.168] C 2003yCat.2246....0C H 0.102 [0.220] C 2003yCat.2246....0C K 0.102 [0.248] C 2003yCat.2246....0C



Identifiers (57) :

V* alf Aql	GC 27470	LSPM J1950+0852	1RXS J195047.0+085159
* alf Aql	GCRV 12193	LTT 15795	SAO 125122
* 53 Aql	GEN# +1.00187642	2MASS J19504698+0852060	SKY# 37134
ADS 13009 A	GJ 768	N30 4388	TD1 25537
AG+08 2636	GSC 01058-03399	NAME ALTAIR	TYC 1058-3399-1
ASCC 1075038	HD 187642	NLTT 48314	UBV M 24205
BD+08 4236	HIC 97649	NSV 24910	UBV 16885
CCDM J19508+0852A	HIP 97649	8pc 194.44	USNO-B1.0 0988-00511792
Ci 20 1169	HR 7557	PLX 4665	USNO 891
CSI+08 4236 1	IDS 19459+0836 A	PLX 4665.00	uvby98 100187642
2E 4294	IRAS 19483+0844	PMC 90-93 530	WDS J19508+0852A
2E 1948.3+0844	IRC +10441	PM 19484+0844	Zkh 297
1ES 1948+08.7	JP11 3142	PPM 168779	
FK5 745	LFT 1499	RAFGL 2463	
GAT 549	LHS 3490	ROT 2857	

What wavelength to choose?*

Gamma rays	> 10^6 K	Accretion disks around black holes, Pulsars and Neutron Stars, ...
X-rays	10^6-10^8 K	Stellar corona, Supernova remnants, regions of hot, shocked gas, ...
UV	10^4-10^6 K	hot stars, activity (stellar coronae), Supernova remnants, ...
Visible	10^3-10^4	Stars, stars, stars, ...
IR	10-10^3 K	cool stars, planets, dust (disks), ...
Radio	< 10 K	regions near WD, Supernova remnants, ...

*in this table I list only stellar related info

Julian Date and light time correction

Julian Date 1: January 1, 4713 BC, introduced by Joseph Scaliger in 1582

e.g. 26.09.2009 at midnight: JD 2455100.5

HJD = JD + Heliocentric correction

Heliocentric correction given by (max 8.3 min):

-T * R * (Cos L * Cos A * Cos D + (Sin L * Sin E * Sin D + Cos E * Cos D * Sin A))

T =Light travel time for one astronomical unit (499.0052 seconds or 0.005775523 days)

R = Earth - Sun distance in astronomical units for date of observation

L = Longitude of the sun

A = Star's Right Ascension (in decimal degrees)

E = Obliquity of the ecliptic = 23.43917 degrees

D = Star's declination (in decimal degrees)

R and L must be found from the AMERICAN EPHEMERIS AND NAUTICAL ALMANAC for each observing night. Online calculation: http://www.physics.sfasu.edu/astro/javascript/hjd.html

BEWARE! HJD ≠ BJD!

HJD: times at the centre of the Sun; BJD: times at the barycenter of the Sun

HJD-BJD = ± 4 sec

Some tools

Time-series of periodic variable stars are almost always analysed using Fourier transforms. The function (time series of whatever measurements) is approximated by a sum of sinusoids.

Frequency, amplitude and phase

interrupted data are a problem ...gaps due to day/night, bad weather, ...

several different algorithms

significant differences between coherent and non-coherent signal! (beware! diff. communities use diff. terms e.g. amplitude ≠ amplitude !

example Period04 (http://www.univie.ac.at/tops/Period04/)

ALWAYS have a look at the window function!

Time resolution: $1./\Delta T$ ($T_{end}-T_{begin}$)