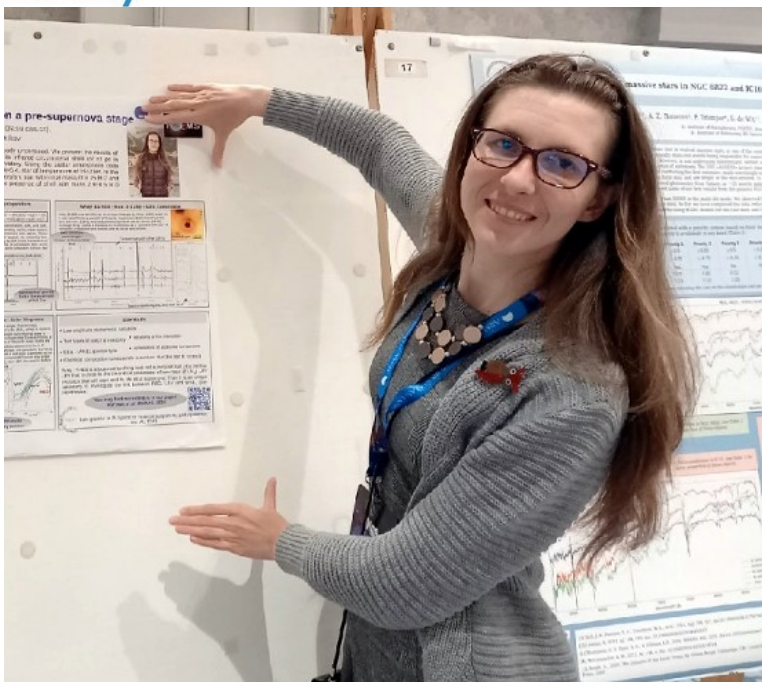
Olga Maryeva

Spectral data in public archives and reduction of them

Astronomický ústav AV ČR

Astronomický ústav AV ČR



Olga Maryeva – research scientist in the Astronomical Institute, Czech Republic

Interests: evolved massive stars, LBVs, WR stars, blue supergiants, massive star in M31 and M33, modeling of astmospheres (CMFGEN), stellar spectroscopy and data reduction pipelines

My expertise:

- modeling of stellar atmospheres using CMFGEN code
- working with spectra of hot stars in ultraviolet (UV), optical and infrared (IR) range; spectral classification of OB-type stars and Wolf-Rayet stars.
- spectral data reduction, for both echelle and long-slit regimes; writing custom pipelines.

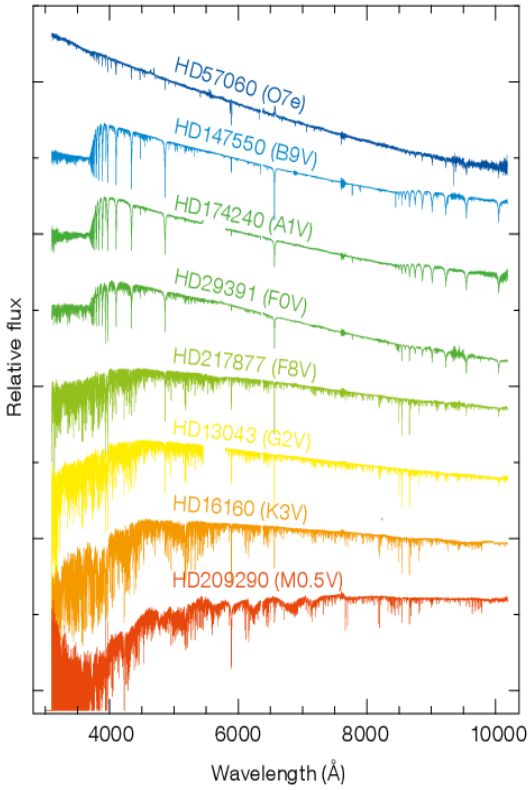
My biography - briefly:

- Faculty of Physics and Mathematics, Stavropol State University, Russia **Master thesis: *"Spectral Study of Romano's star in M33 galaxy"* (2008)**
- Special Astrophysical observatory, Russia ***PhD thesis "Spectroscopic manifestations of massive stars Evolution"* (2016)**
- **2017-2020** Postdoc in ASU
- Since **2020** Research Scientist in ASU

Open-access Spectral Data

Spectral Libraries

Science ready spectra



Elodie
Sophie
LAMOST
X-Shooter
IACOB

Telescope Archives

Raw data, calibrations, observational logs, ...

HST
ESO
GTC
SALT
SAO
etc ...

SOPHIE / ELODIE on-line database of high-resolution stellar spectra

http://atlas.obs-hp.fr/elodie/

Currently **87621** (SOPHIE) + **35535** (ELODIE) spectra are fully public

ELODIE was an echelle type spectro-graph installed at the Observatoire de Haute-Provence 1.93m reflector

The ELODIE archive

An on-line database
of high-resolution stellar spectra

Archive News | Publications using ELODIE Archive

Introduction | Help

Enter a designation or coordinates

Examples:
HIP117998, J04 14 57 15 32 10 , simbad:procyon, HD190007,HD190073, GJ%1

a. For identifiers
you can choose to query : only this object

b. For coordinate and around object queries, define a radius : [arcmin]

Get spectra | Get CCF | Reset

Query a sample of objects in a region of the sky

a. Define a region of the sky (B1950 or J2000):

Right ascension from to
examples: 14 00 00 to 18 00 00 (B1950)
J14 00 00 to J18 00 00 (J2000)
Declination from to
example: -02 00 00 to 02 00 00

Get spectra | Get CCF | Reset

Spectra: HD188209
We found 9 records ...

objname	RA (J2000) Dec	S	O	dataset	imanum	imatyp	exptime	sn	view_spec	view_head	get_spec	get_e2ds	cu
HD188209	J195159.0+470138	S	O	19970917	0012	OBJOd	1802.9	418	view_spec	view_head	get_spec	get_e2ds	cus
HD188209	J195159.0+470138	S	O	19970917	0016	OBJOd	900.6	197	view_spec	view_head	get_spec	get_e2ds	cus
HD188209	J195159.0+470138	S	O	19970918	0025	OBJOd	1002.1	276	view_spec	view_head	get_spec	get_e2ds	cus
HD188209	J195159.0+470138	S	O	19970919	0009	OBJOd	1200.7	348	view_spec	view_head	get_spec	get_e2ds	cus
HD188209	J195159.0+470138	S	O	19970919	0020	OBJOd	900.8	312	view_spec	view_head	get_spec	get_e2ds	cus
HD188209	J195159.0+470103	S	O	19980611	0044	OBJOd	1501.1	187	view_spec	view_head	get_spec	get_e2ds	cus
H										view_head	get_spec	get_e2ds	cus
H										view_head	get_spec	get_e2ds	cus
H										view_head	get_spec	get_e2ds	cus

Bright stars <10mag
High resolution

ectra Explanations
ectra Explanations

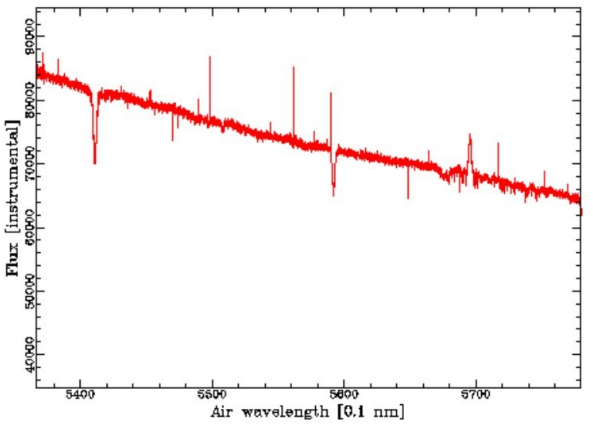
Sky search
Object name or list HD188209

Spectra: FITS Pipeline processing

Display the spectrum

File identification and executed pipeline: elodie:19980611/0045&z=s1d|vs

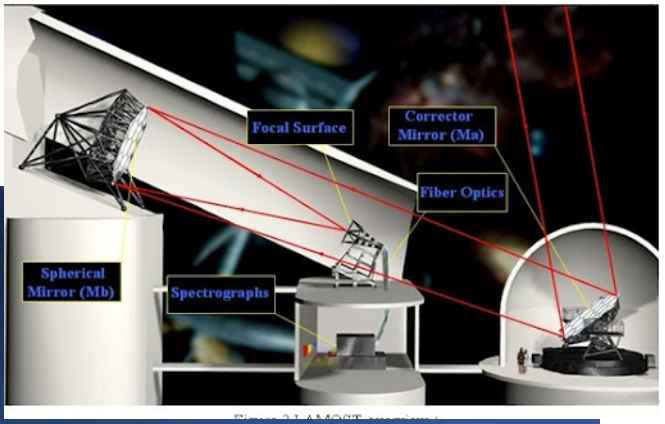
Coord=232845.7+520850900 Zoom out



Replot in wavelength range 5000 to 7000 [(
View Header | Download the 1D spectrum as FITS file

The ELODIE Archive © OHP / INSU-CNRS / OSU Pytheas
Contact: Database team

Large Sky Area Multi-Object Fibre Spectroscopic Telescope LAMOST

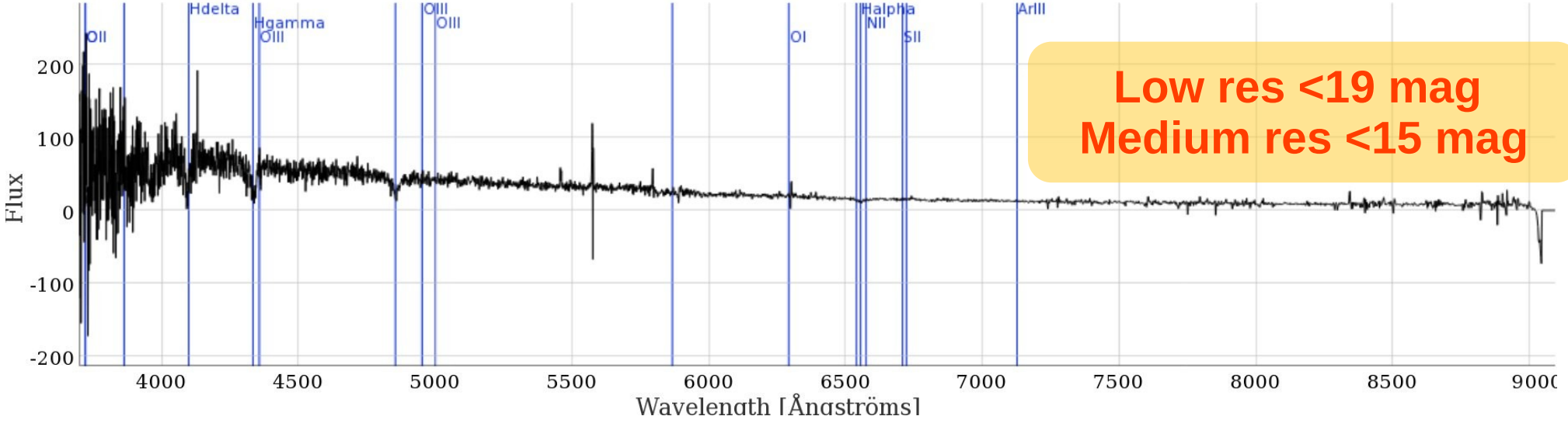


DATA RELEASE DR10 2011.10.24 - 2023.03.31

Star: >11 000 000
Low resolution spectra: 11 817 430
Medium resolution spectra: 10 486 216

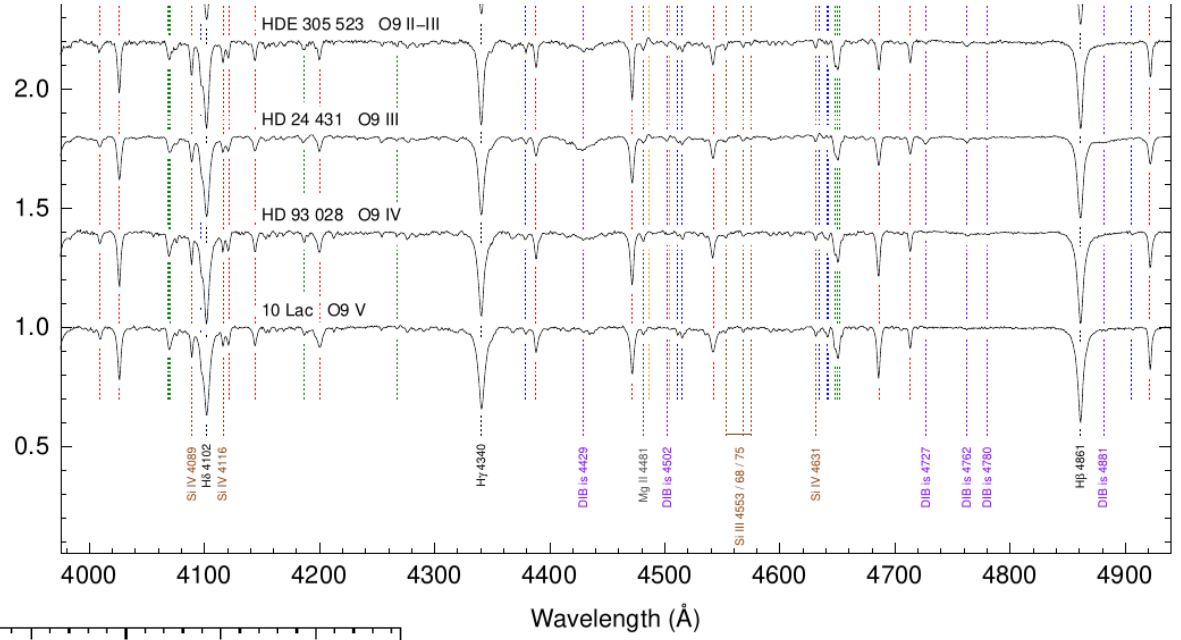
M Star Catalog : **876 134**
A Star Catalog: **680 989**
WD Star Catalog : **17 140**

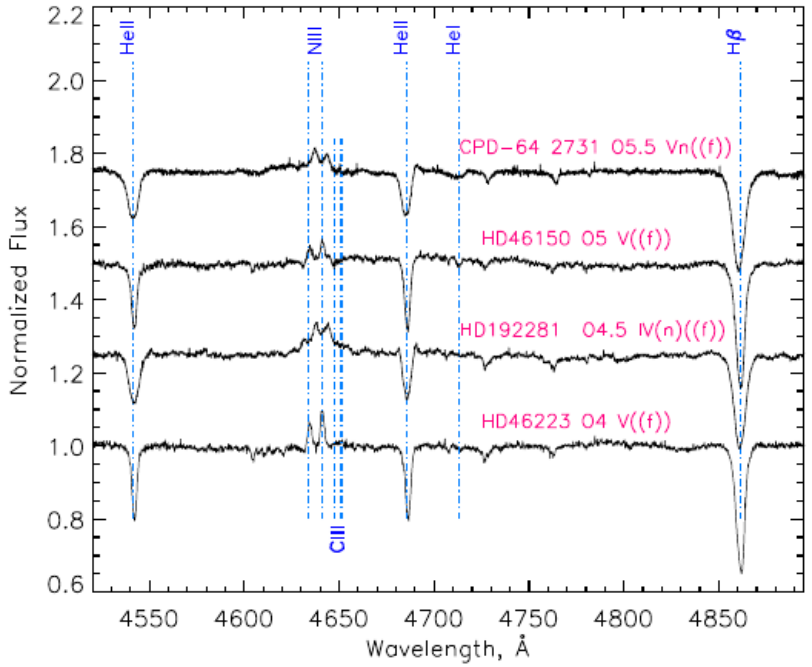
http://www.lamost.org/dr10/v1.0/

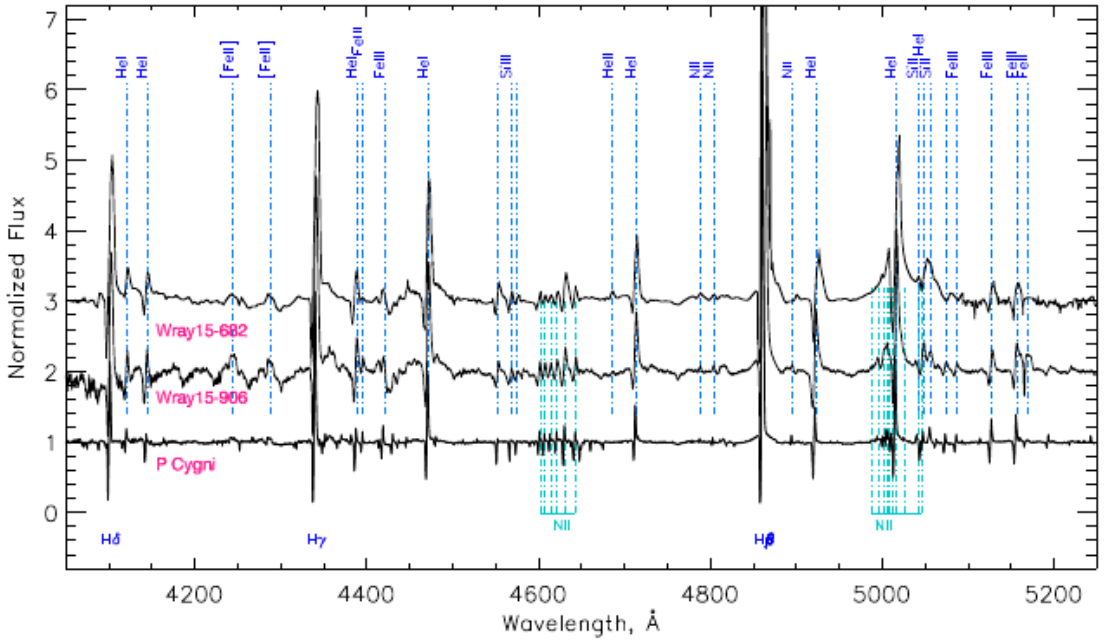


Low res <19 mag
Medium res <15 mag

Spectra of Standard stars & Spectral Classification







X-Shooter Spectral Library

http://xsl.u-strasbg.fr/index.html

DR3=683 stars

The X-Shooter Spectral Library is a stellar spectral library covering the wavelength range **3000–25000** Å, at a resolution **R~10 000**. The library was built using the medium-resolution spectrograph X-Shooter (ESO, VLT).

DR3 contains 830 stellar spectra. The spectra are arm-combined to the full wavelength range of the X-shooter spectrograph, and both original and galactic dust exinction corrected spectra are available. It also covers most of the HR diagram with **spectral types between O and M**, as well as AGB stars.

Spectra for sp. classification

ESO Library of Stellar Spectra

http://www.eso.org/sci/facilities/paranal/decommissioned/isaac/tools/lib.html

131 stellar spectra – all spectral types
spectral range is 1150-25000Å

IACOB spectroscopic database

IACOB Spectroscopic database

http://research.iac.es/proyecto/iacob/iacobcat/

Home | IACOB on the sky | Tecnical details | Acknowledgements | IACOB Publications | IACOB project website

Welcome to renewed interface of the IACOB spectroscopic database!

IACOB is an ambitious long-term observational project whose main scientific goal is to provide a complete and statistically significant empirical overview of the physical properties of **Galactic massive OB-type stars**. The ultimate objective of the project is that the compiled information can be used as a strong and long-lasting anchor point for our theories of stellar atmospheres, winds, interiors and evolution of massive stars.

This is the interface to have access to the spectra compiled during more than 12 years in the framework of the IACOB project: the so-called **IACOB spectroscopic database**. While not all the spectra are publicy available yet, we quote all the compiled observations for reference purposes. The different data releases (DRx) will be conveniently announced; in the meanwhile people interested in specific (samples of) spectra can contact the PI of the project by mail: simon [at] iac.es.

More details about the project can be found in the project webpage .

The IACOB spectroscopic database mainly comprise observations made with the FIES instrument attached to the 2.56-m Nordic Optical Telescope and the HERMES spectrograph attached to the 1.2-m Mercator Telescope . In future developments, we plan to also incorporate data of Southern Galactic OB stars as obtained with the FEROS instrument (gathered from the ESO public archive), as well as long-term medium and high cadence observations of a sample of about 40 Galactic O stars and B Supergiants, collected with the 1-m Hertzsprung-SONG and the 1.2-m STELLA telescopes.

Spectral variability, OB-type stars

NEWS (2020/06/21): The second data release -- which includes 552 FIES and HERMES spectra for more than 240 late- and mid-B stars with luminosity classes V, IV and III -- is now available!.

Search by name: Star name (Rigel, etc.)

Spectral type: e.g.: B1* or O* or *V*

Data Release: Any

Instrument: Any

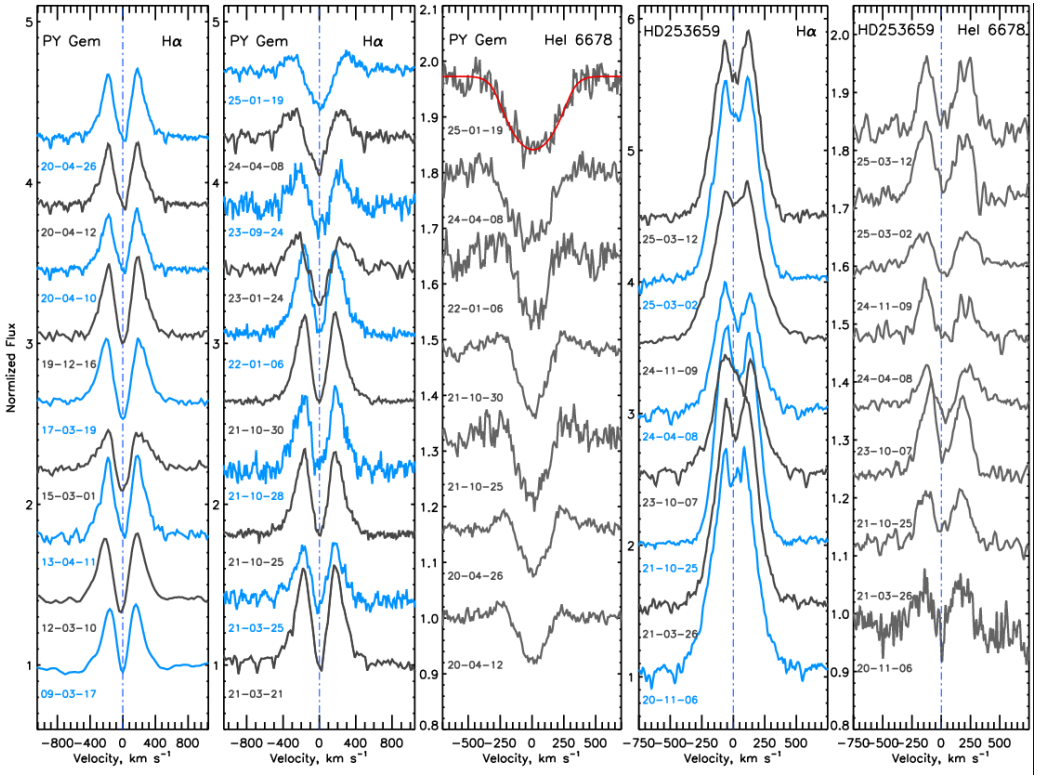
- [ ] Only spectra available to download
- [ ] Only the best spectrum per star

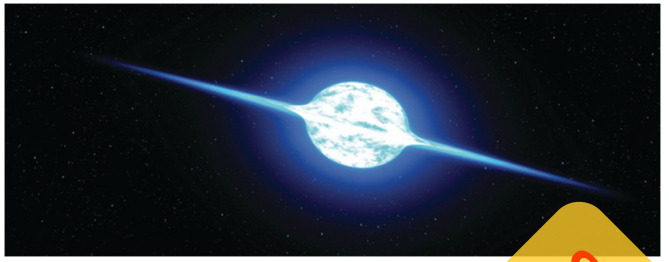
2566 stars 16986 spectra

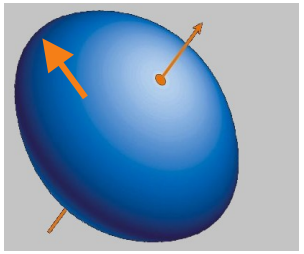
BeSS Data Base

The BeSS database contains the complete catalog of classical Be stars, Herbig Ae/Be stars, and B[e] supergiants. It assembles spectra obtained by professional and amateur astronomers of those stars. BeSS database is maintained at the LESIA laboratory of the Observatoire de Paris-Meudon.

There are currently 332943 Be star spectra in BeSS







Spectral variability, Be phenomenon

Be star				this star only / around this star
RA (α) J2000	h	m	s	
DEC (δ) J2000	d	'	"	
V magnitude between	and			
Spectral type between	and			
Vsini between	and	km/s		
Observations date between	and	AAAA-MM-JJ		
Resolution between	and			
Stellar type	All Be stars			
Source	PROS & AMATEURS			
Observer	All			
Instrument	All			
Wavelength domain between λ_1 =	and λ_2 =	Å		
Site	All			
				more criteria

Submit Erase

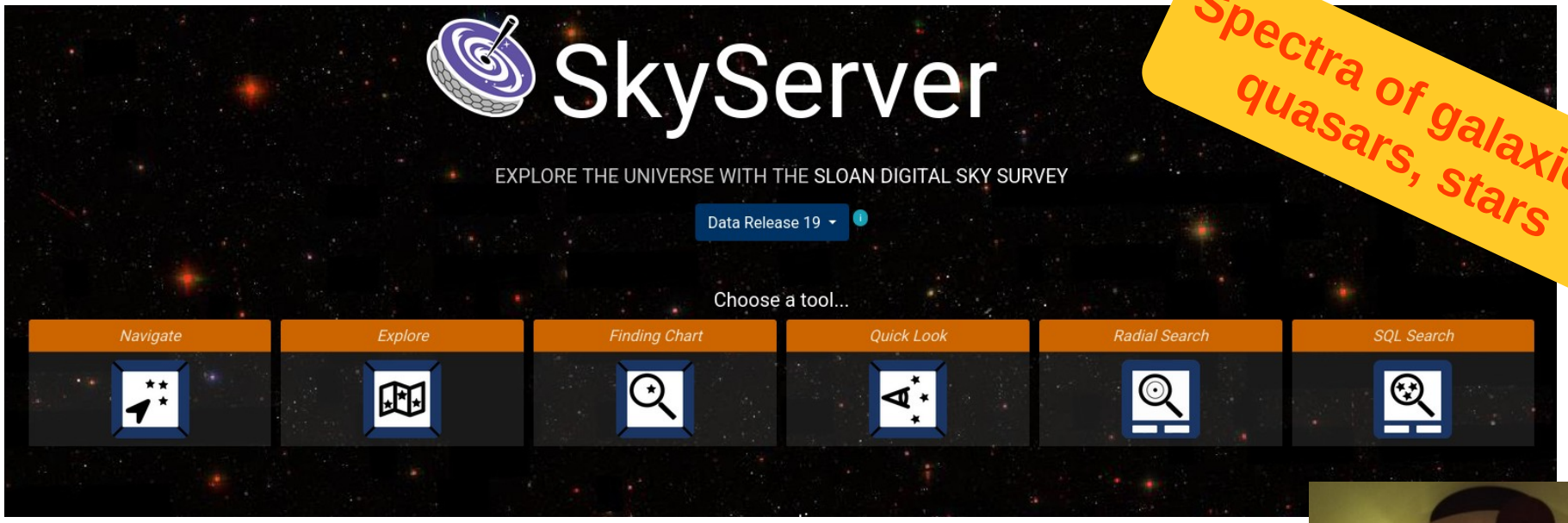
http://basebe.obspm.fr/basebe/

Sloan Digital Sky Survey (SDSS)

SDSS is a major multi-spectral imaging and spectroscopic redshift survey using a dedicated 2.5-m wide-angle telescope.

https://skyserver.sdss.org/dr19

Since begining of 2000-s



Spectra of galaxies, quasars, stars

The spectrograph operates by feeding an individual optical fibre for each target through a hole drilled in an aluminum plate.

Resolution R~2000

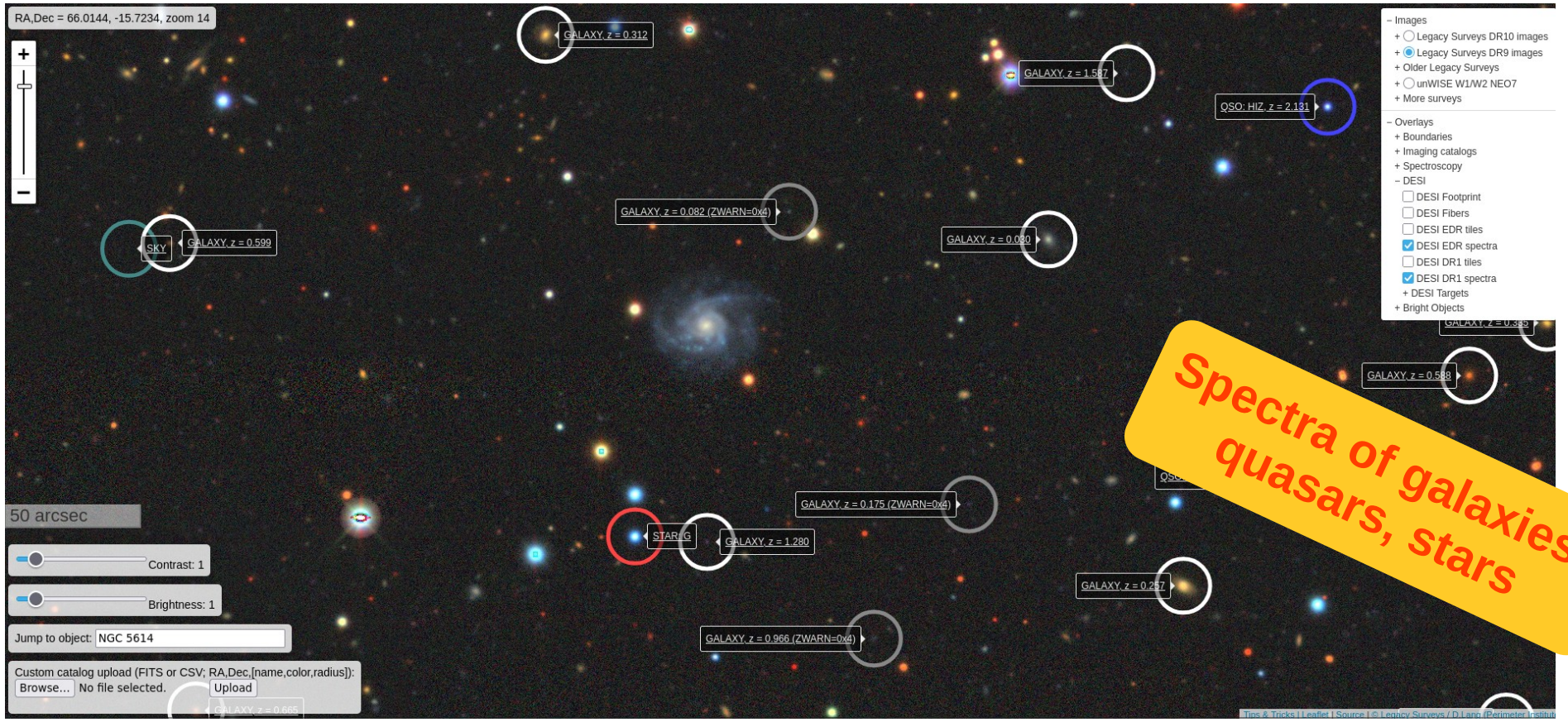
Dark Energy Spectroscopic Instrument (DESI)

NEW

DARK ENERGY SPECTROSCOPIC INSTRUMENT
U.S. Department of Energy Office of Science

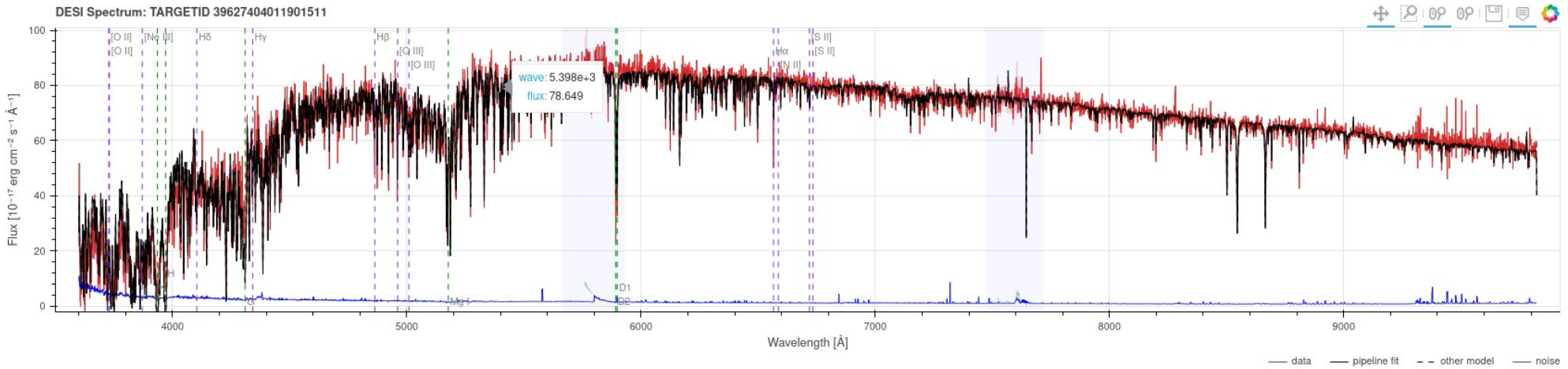
The DESI is a 5-year spectroscopic redshift survey observing millions of galaxies, quasars, and stars. The DESI is being conducted on the Mayall 4-meter telescope at Kitt Peak National Observatory.

https://www.legacysurvey.org/viewer/



Dark Energy Spectroscopic Instrument (DESI)

DARK ENERGY SPECTROSCOPIC INSTRUMENT
U.S. Department of Energy Office of Science



TARGETID	COADD_NUMEXP	COADD_EXPTIME
39627404011901511	2	2162.43

Reset X-Y range | OII-zoom | Undo OII-zoom

Spectrum number (0 to 0): **0**

Gaussian Sigma Smooth: **0**

Redshift rough tuning: **0**

Redshift value: 0.0001

Redshift fine-tuning: **0.0001**

Reset to z_pipe

Pipeline fit:

Z	SPECTYPE	SUBTYPE	ZERR	ZWARN	Δχ2(N+1/N)
0.0001	STAR	K	0.0000	0	130640.5

Other model (dashed curve):

Best fit

Targeting masks

MWS_ANY

mag_G	mag_R	mag_Z	mag_W1
17.09	16.28	15.92	16.93

mag_W2	MORPHTYPE	COADD_NUMNIGHT	COADD_NUMTILE
17.61	PSF	1	1

Emission lines | Absorption lines

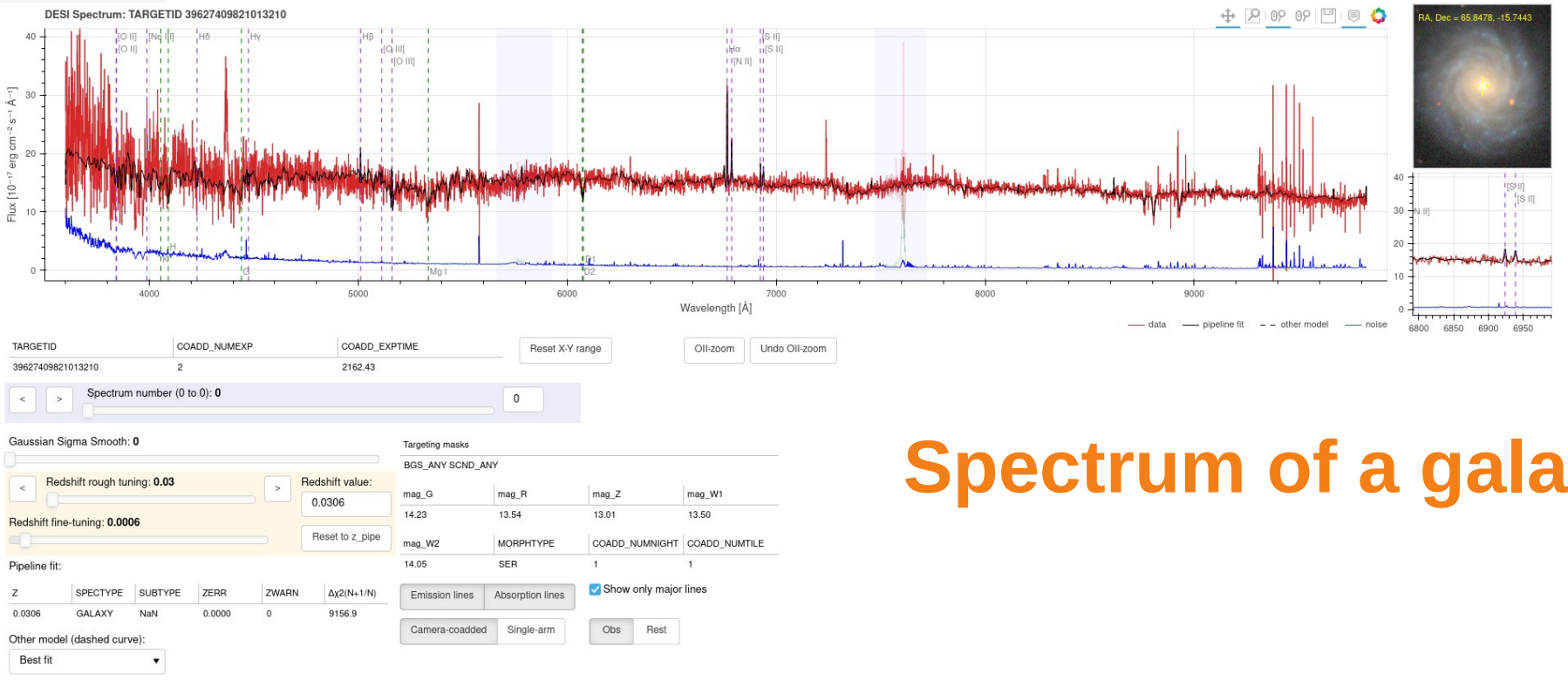
Show only major lines

Camera-coadded | Single-arm

Obs | Rest

Spectrum of a star

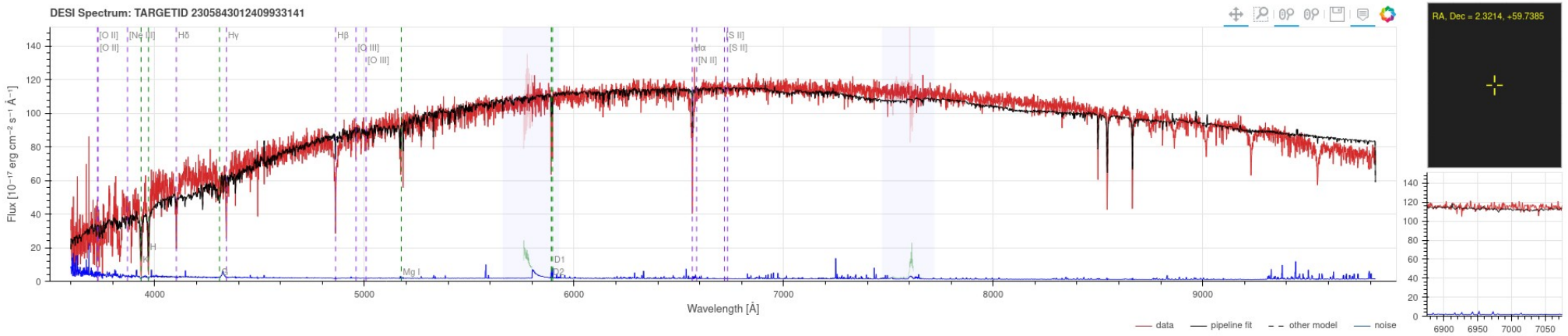
Dark Energy Spectroscopic Instrument (DESI)



Spectrum of a galaxy

Dark Energy Spectroscopic Instrument (DESI)

DARK ENERGY SPECTROSCOPIC INSTRUMENT
U.S. Department of Energy Office of Science



TARGETID	COADD_NUMEXP	COADD_EXPTIME
2305843012409933141	3	1800.11

Reset X-Y range | OII-zoom | Undo OII-zoom

< > Spectrum number (0 to 0): **0** 0

Gaussian Sigma Smooth: **0**

< Redshift rough tuning: **-0.01** > Redshift value: -0.0000

Redshift fine-tuning: **0.0100** Reset to z_pipe

Pipeline fit:

Z	SPECTYPE	SUBTYPE	ZERR	ZWARN	Δχ2(N+1/N)
-0.0000	STAR	K	0.0000	0	26171.8

Other model (dashed curve): Best fit

Targeting masks

MWS_ANY			
mag_G	mag_R	mag_Z	mag_W1
0.00	0.00	0.00	0.00
mag_W2	MORPHTYPE	COADD_NUMNIGHT	COADD_NUMTILE
0.00	GPSF	3	1

Emission lines | Absorption lines — Show only major lines

Camera-coadded | Single-arm — Obs | Rest

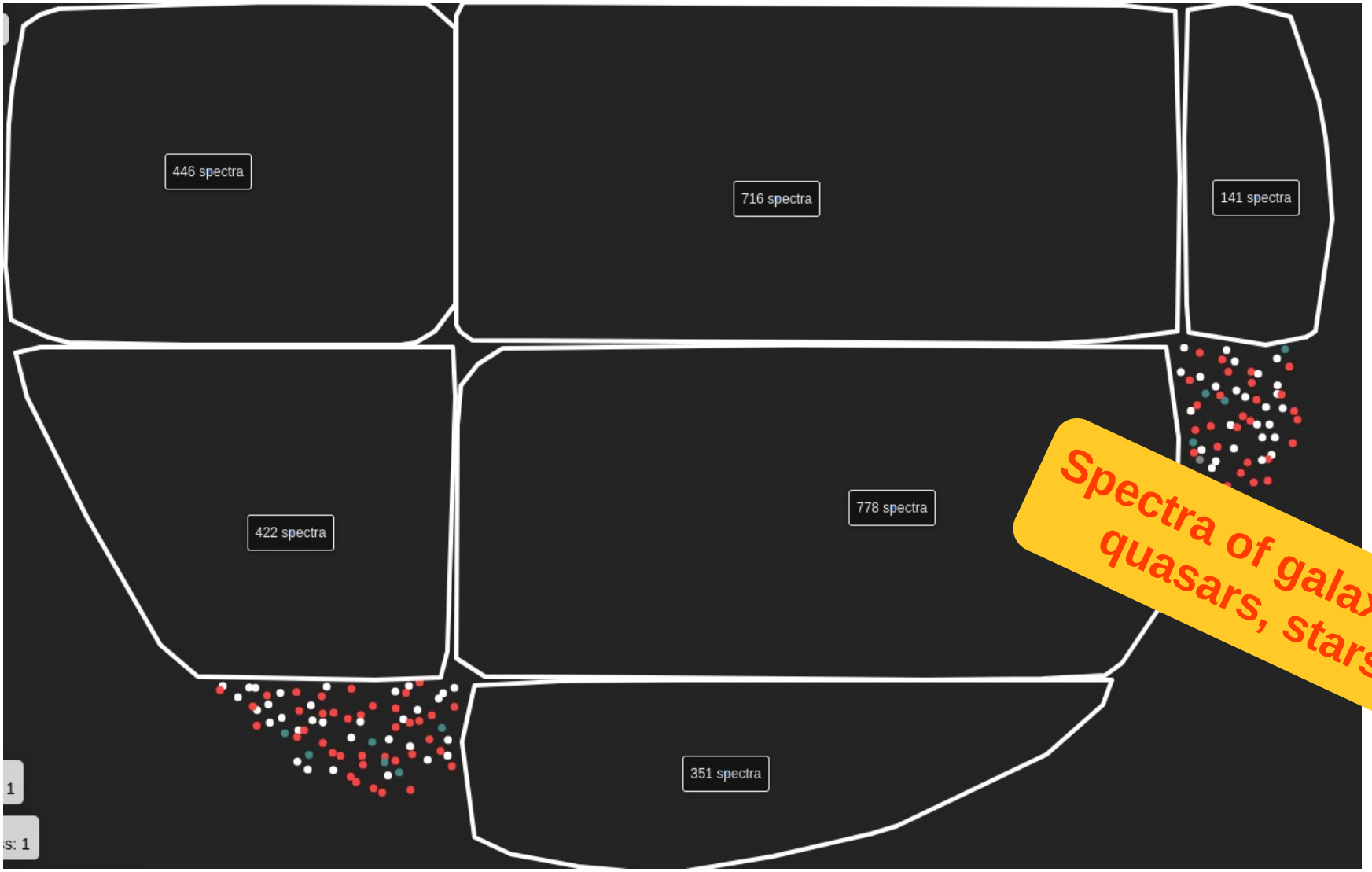
Spectrum of a star

Dark Energy Spectroscopic Instrument (DESI)

NEW

DARK ENERGY SPECTROSCOPIC INSTRUMENT
U.S. Department of Energy Office of Science

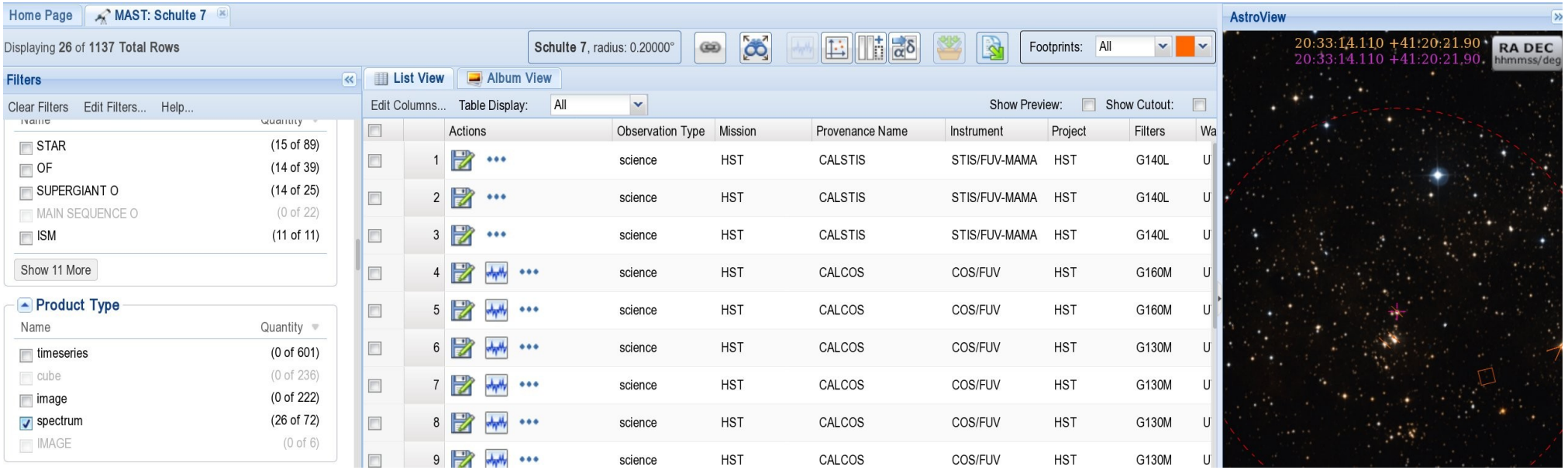
Data Access https://data.desi.lbl.gov/doc/access/



Mikulski Archive for Space Telescopes – MAST

The Mikulski Archive for Space Telescopes is an astronomical data archive focused on the optical, ultraviolet, and near-infrared. MAST hosts data from over a dozen missions like IUE, Hubble, Kepler, TESS, and soon JWST.

https://archive.stsci.edu/index.html



Gran Telescopio CANARIAS – GTC

http://gtc.sdc.cab.inta-csic.es/gtc/index.jsp

Search by Target:

Object List:

Examples (coordinates in J2000):
64.99061 52.98401
4 19 57.75 +52 59 02.436
4:19:57.75 +52:59:02.436
ULAS J135058.86+081506.8

Browse... **No file selected.**

Search radius: 5 arcmin

GTC is a 10.4m telescope

Search by Date:

Between: 16 March 2009

And: 26 August 2021

End Time	Exptime (s)	Airmass	Pub	Reduced Data									Raw Data									
				User Reduced Data ?			GTC Reduced Data ?			QLA Reduced Data ?			Raw Data			Cal. Files			Acq. Images			QC Files	
2018-09-09 02:53:36.8	600	1.02	2	ADS	View	Fetch							Header	Preview	Fetch	View	Fetch	View	Fetch	View	Fetch	
2018-09-09 02:42:56.7	900	1.03	2	ADS	View	Fetch							Header	Preview	Fetch	View	Fetch	View	Fetch	View	Fetch	
2018-09-09 02:11:17.8	600	1.07	2	ADS	View	Fetch							Header	Preview	Fetch	View	Fetch	View	Fetch	View	Fetch	
2018-09-09 02:00:37.6	900	1.09	2	ADS	View	Fetch							Header	Preview	Fetch	View	Fetch	View	Fetch	View	Fetch	
2018-09-09 01:22:34.8	600	1.17	2	ADS	View	Fetch							Header	Preview	Fetch	View	Fetch	View	Fetch	View	Fetch	
2018-09-09 01:11:53.3	900	1.21	2	ADS	View	Fetch							Header	Preview	Fetch	View	Fetch	View	Fetch	View	Fetch	
2016-08-27 02:31:12.2	600	1.11	1	ADS	View	Fetch							Header	Preview	Fetch	View	Fetch	View	Fetch	View	Fetch	
2016-08-27 02:20:31.7	900	1.14	1	ADS	View	Fetch							Header	Preview	Fetch	View	Fetch	View	Fetch	View	Fetch	
2016-08-27 02:04:58.8	1200	1.18	1	ADS	View	Fetch							Header	Preview	Fetch	View	Fetch	View	Fetch	View	Fetch	
2016-07-30 04:31:36.9	600	1.09	1	ADS	View	Fetch							Header	Preview	Fetch	View	Fetch	View	Fetch	View	Fetch	

SALT South African Telescope

since July 10, 2020 there is open access to SALT data

https://ssda.saao.ac.za/

Target name ?

Resolver ?

Simbad resolve

Right ascension ?

Declination ?

Search radius ?

Radius units

Arcseconds

Target type

Galaxy ISM Solar System Body Star

Proposal code ?

Principal investigator ?

Proposal title ?

Observation night ?

Data category

Science Arcs Biases Flats Standard

Rejected observations

Include rejected observations

Archive of Russian 6-m telescpe (BTA)

https://www.sao.ru/oasis/cgi-bin/fetch?lang=en

The General Observation Archive

Archive regulation *Acknowledgments* *Current status*

6m telescope	
CCD	1996-02-13 - 2000-04-30
IFP	1997-05-14 - 2000-03-02
LYNX	1996-02-28 - 2002-05-28
MOFS	1997-03-07 - 2001-08-18
MPFS	1996-08-18 - 2009-10-27
MSS	1996-05-26 - 2017-09-11
NES	1998-03-10 - 2019-10-19
PFES	1996-08-06 - 2001-01-07
SCORPIO	
SP124	1996-02-18 - 2000-12-09
UAGS	1994-11-08 - 2005-10-20
Small telescopes	
CEGS	1997-03-24 - 2010-10-26
MAGIC	2020-01-25 - 2020-07-23
MMPP	
MNGL	2017-09-05 - 2018-12-22
Z600	1996-01-12 - 2001-06-06
ZMCCD	
ZMUAGS	
Radio telescope *(request only by date)*	
REF1	1982-01-12 - 2021-01-06
REF2	2011-10-19 - 2021-05-19
REF3	2013-02-12 - 2017-12-30
REF4	2011-07-17 - 2017-06-21
REF5	2008-09-04 - 2008-10-27
REF6	1988-02-03 - 1988-04-21

First date: 1982 01 01 1982

or

select dates by the BTA observation program key

R.A.(J2000) Decl.(J2000)

(ra=hh mm ss.s; dec=[-]dd mm ss.s or in degrees)

or object name:

Radius: 5 (arcmin)

Data type: obs Observation mode: any

Filter: any

Program author:

Info

Search Clear

SCORPIO-1 is a multi-mode focal reducer of the BTA

Zoo of Raw Data

We have a huge variety of raw data from different instruments
To properly handle them, you need to:

- Know how to work with various data formats
- Know main steps of data preparation and processing
- Know what calibration data you may need

Main steps of data processing

- Bias / dark correction
- Cosmic rays removal
- Flat-fielding

- Mask of orders (eschelle)
- Extraction of spectra
- Linearization

- Flux calibration using spectrophotometric standard stars

Calibration frames

Sometimes, calibration frames are not acquired every night, and you have to specifically look for them in data archives.

Sometimes they are part of standard observations and are distributed together with object data

FITS format

De facto standard for astronomical data exchange.

Primary elements — images or binary tables

Multi-extension FITS as a way to store heterogeneous data in a single file

- Primary header with generic information
- Set of extensions with individual headers + content (image / table)
- Every extension may have human-readable name to help identifying what's inside it

Standard tools for inspection / quick look of FITS files:

FV — supports any FITS file with any structure, shows tables / images, plots XY graphs, etc etc

SAOImage DS9 — primarily FITS image viewer, plus rudimentary image analysis

TopCat — generic tool for working with data tables in various formats, including FITS tables. Supports inspection, visualization, analysis, etc

Representation of reduced spectral data in FITS

- Binary table with separate columns for wavelength and flux
- 1d/2d image + WCS standard for wavelength data
- 2d image + IRAF multispec standard for separate wavelength info for different orders

Keywords in FITS Header (for 1D spectral data)

Representation of reduced spectral data in FITS

- Binary table with separate columns for wavelength and flux
- 1d/2d image + WCS standard for wavelength data
- 2d image + IRAF multispec standard for separate wavelength info for different orders

They all differ by FITS keywords

1d spectra in FITS images + WCS for linearization

Lambda = **CRVAL1** + **CDELT1***(x-**CRPIX1**)
Or
Lambda = **CRVAL1** + **CD1_1***(x-**CRPIX1**)

X = 1..N (FITS standard is 1-based, not 0-based!)

FITS standard for integer data scaling

Value = **BZERO** + data***BSCALE**
e.g. 0..65535 → -32767..32767

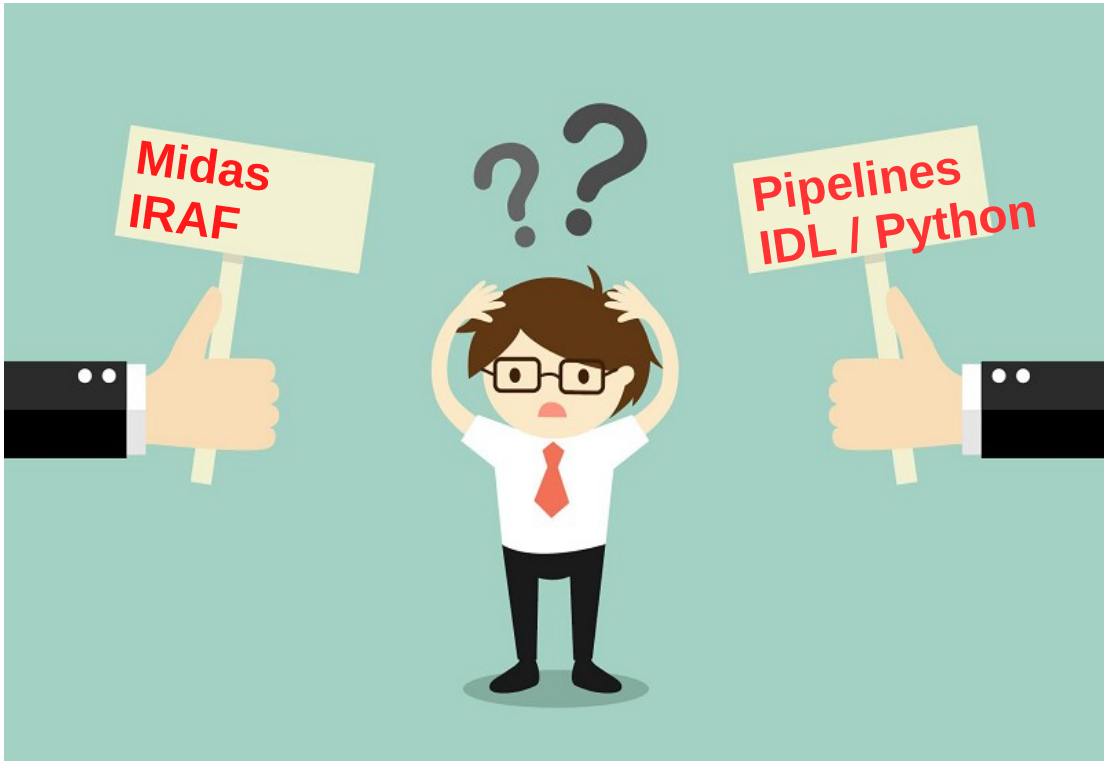
This conversion is often handled automatically by FITS reading routine, but sometimes the keywords are left in the headers — do not forget to check/remove them before saving your modified (e.g. floating-point) file!

HISTORY is for storing human-readable notes on the data provenance — e.g. history of data processing. Do not forget to use it in your scripts, it really helps to track various problems with the data later!

COMMENT is for generic comments in the header

Data Reduction

Midas, IRAF, Pipelines (for example ESO-reflex), IDL / Python



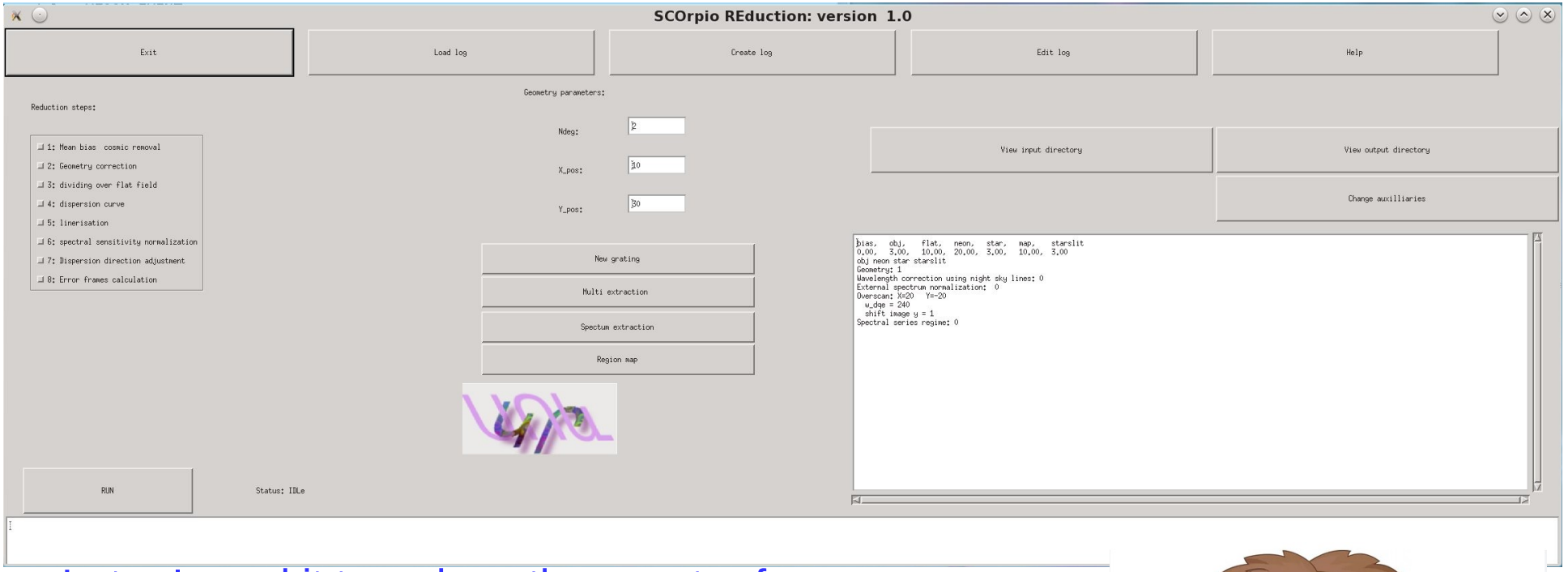
The choice is usually defined by your habits and existence of ready to use pipelines for specific data

- You may spend some time learning the pipeline someone else wrote
- Or spend some time writing your own processing scripts
- Or combine some existing tools you already know

No universal recipe exists, but think about re-usability of what you learned

My experience

Together with colleagues I wrote in IDL language a package for reduction of long-slit spectra from SCORPIO spectrograph (Russian 6-m telescope)



Later I used it to reduce the spectra from OSIRIS (GTC), FOCAS (Subaru), ISIS (WHT)

Don’t ask me why IDL, I’m just too old

SPECTRUM REDUCTION

Load logfile | Edit logfile | Create logfile

MAIN REDUCTION STEPS:

- [ ] 1: Mean Bias
- [ ] 2: Cosmic
- [ ] 3: Flat Field
- [ ] 4: Geometry Correction
- [ ] 5: Create Disperse
- [ ] 6: Linearization

RUN

Data Reduction Parameters:

- [ ] Star standart
- [ ] ThAr for star standart

Overscan values:

X1: 0.00 X2: 0.00 Y1: 154.00 Y2: -172.00

Cosmic:

OBJ	FLAT	THAR	STAR	THARSTAR
10.00	10.00	30.00	10.00	30.00

Grating:

Create New Grating

Add New Grating

View input directory

View output directory

View RGB

Logfile:

Description

SPECTRUM EXTRACTION:

Extraction of spectrum of object

Extraction of spectrum of star-standart

ADDITIONAL FUNCTIONS:

Normalisation

Barycent

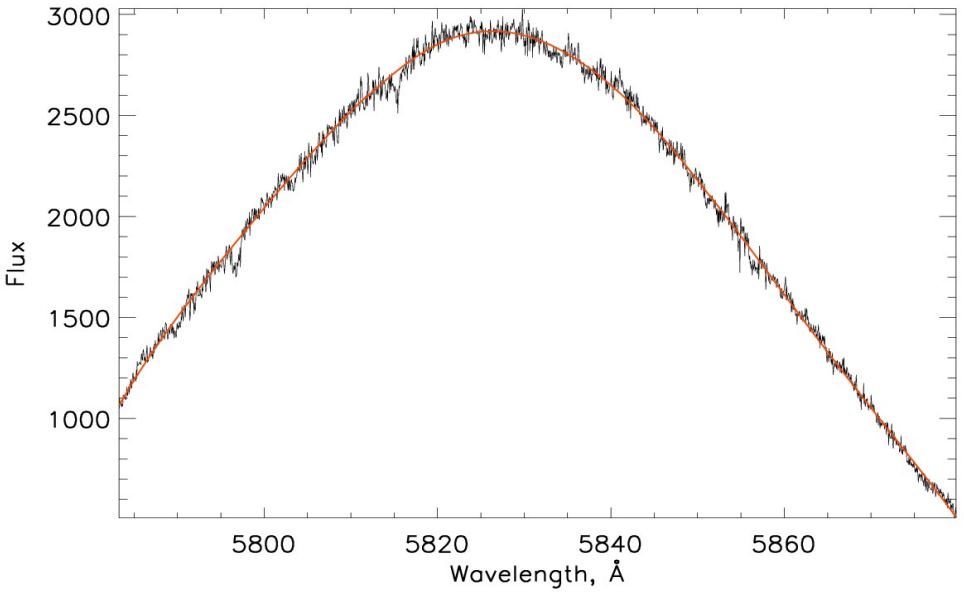
Status: IDLe

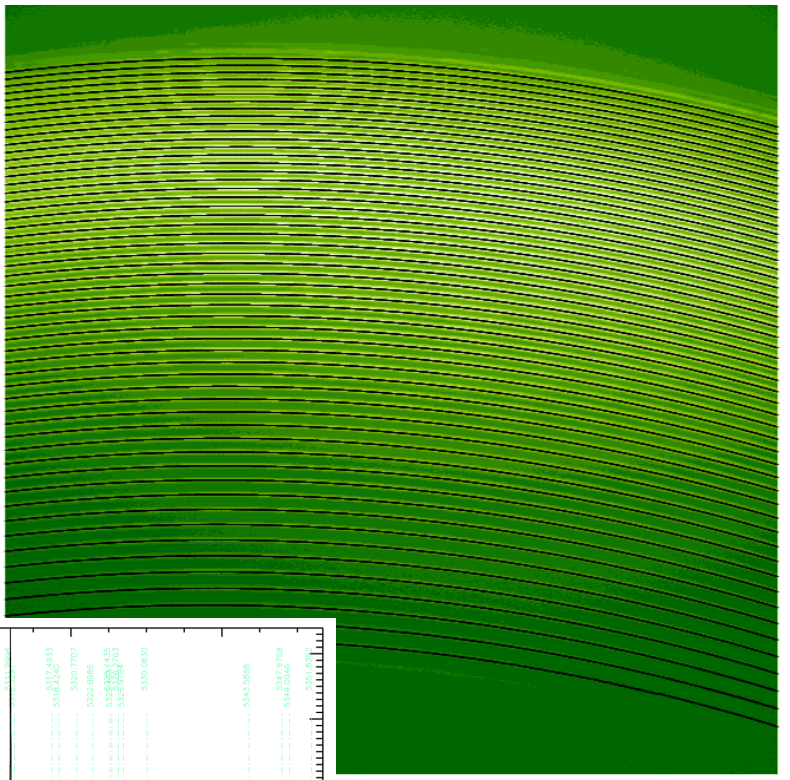
EXIT

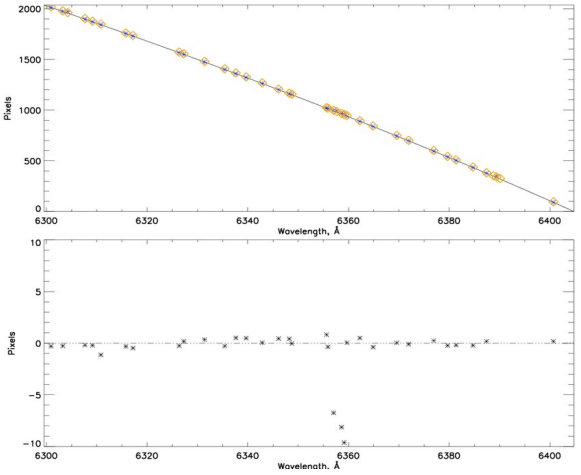
Takeaway message

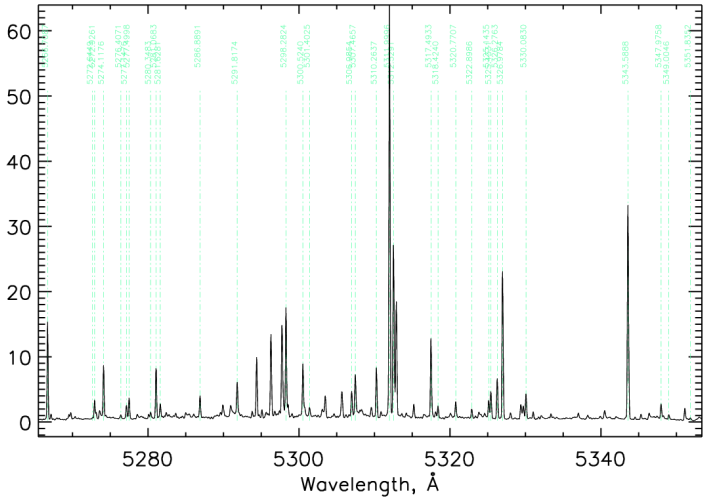
- Do not be afraid of writing your own pipelines sometimes it is faster and easier than learning the code made by others (but sometimes not)
- Write for yourself, not for everyone else! It should help you, so make it as you see it fit best
- Automatize boring and repeating things
- Do not try to make too universal tools, smaller and simpler tools will be easier to adapt to some new data
- Do not be afraid to express yourself in your code!

Plot more figures for control quality of data reduction









Topics for Bachelor/ Master thesis

Studies of Luminous Blue Variables (LBVs) and LBV candidates

Spectral + photometric variability, modeling

Studies of blue supergiants based on DESI archive spectra

Estimation of luminosity, independent test for Gaia distance measurements

olga.maryeva@asu.cas.cz

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Thank you for your attention!

I hope it will be useful for you

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