Virtual Observatory as a Tool for Stellar Spectroscopy

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IAU GA SPS3 - VO in Action
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VO paradigma

- All curent work of an astronomer done in ONE GUI
- Transparent search, download, conversion
- Unified presentation - different relations
- Background computing on GRIDS
- Remote control - batch observation - robotic telescope
- ADASS quotation : The telescope is a database with very long time access

The reality in stellar spectroscopy

What stellar astronomers do most of time?

Inefficient, tedious, target oriented work

No revolutionary changes for 100 years ;-)

What poor astronomers are they
(those stellar ones)

The reality in stellar spectroscopy

- lookup in journals (catalogues) -> SIMBAD (Vizier)
- measurement of plates - scanning, (Aladin) (and NED as well)
- spectral plates -> FITS (ASCII) files (binary FITS tables - space missions)
- tables, nomograms -> online calculation (curve of growth)
- rulers, mm paper -> graphic tools, IRAF, MIDAS , STARLINK

The reality in stellar spectroscopy

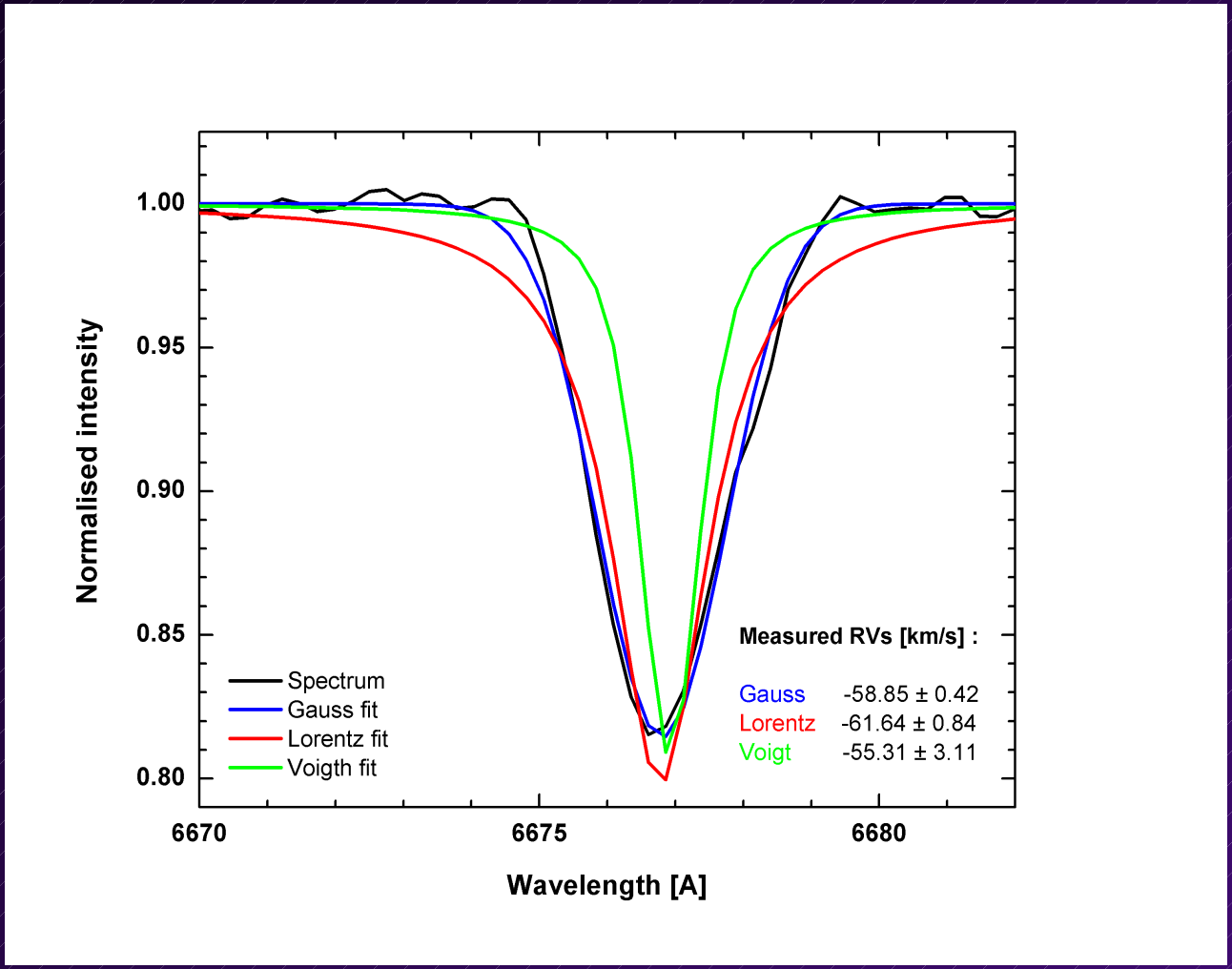
- Still switching different tools, packages, home-written custom scripts
- Conversion of formats, interpolation, axis transformation, tables of values from FITS headers ...
- Measurement - analysis - export publication
- Tables (LaTeX output), graphs - (PS)

Simple Spectral Analysis

- (Over) Ploting spectra
- Different objects
- Different ranges (UV over IR)
- Different time (RV, profile changes)
- All heritage packages (bplot, splot, specplot, spectool, DIPSO, XALICE) can do this
- And VO-enabled as well !

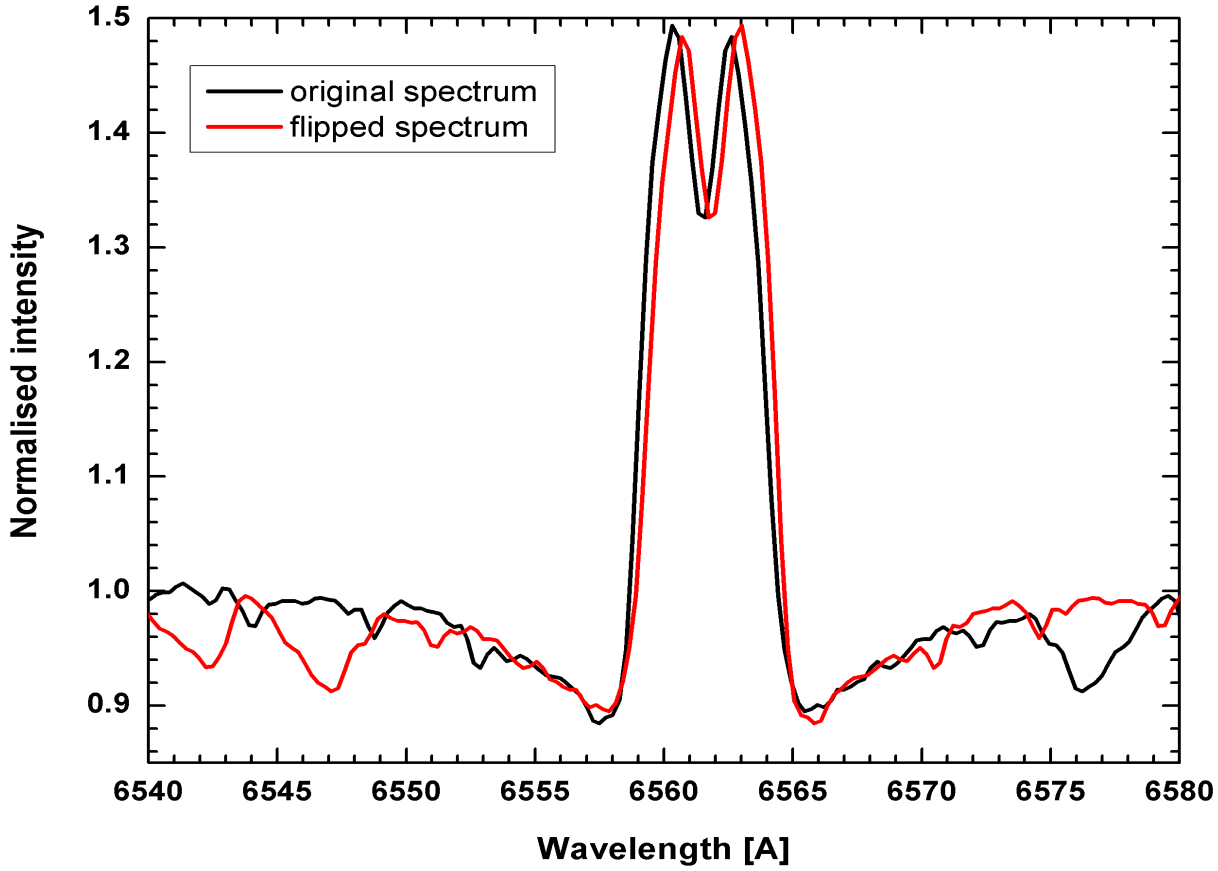
Measurement of RV, z

- Individual spectra
- Normalization
- Fits of Gauss, Maxwell, Voigt
- Cross correlation
  - Good template



Measurement of RV, z

- Mirroring method



Mirroring method

- Shift until best match of direct and flipped profile
- From old oscilloscopic comparator
- Complicated profiles (Be)
- Adjustable region of interest (wing/core)
- Interactive
- Needs reference line position
- Only SPEFO and SPLAT

Bisector Analysis

- Quantitative study of LPV
- Searching exoplanets
- High resolution - echelle
- Rectified (normalized) spectra
- Various smoothing
- Cuts in relative depth of line - half of span
- Zoom of bisectors position
- Results in 3D cube (time, line, depth)

Advanced Tools for Spectral Analysis

Require several variables from FITS headers

JD, time, epoch and derived variables

RV, line position, period – phase

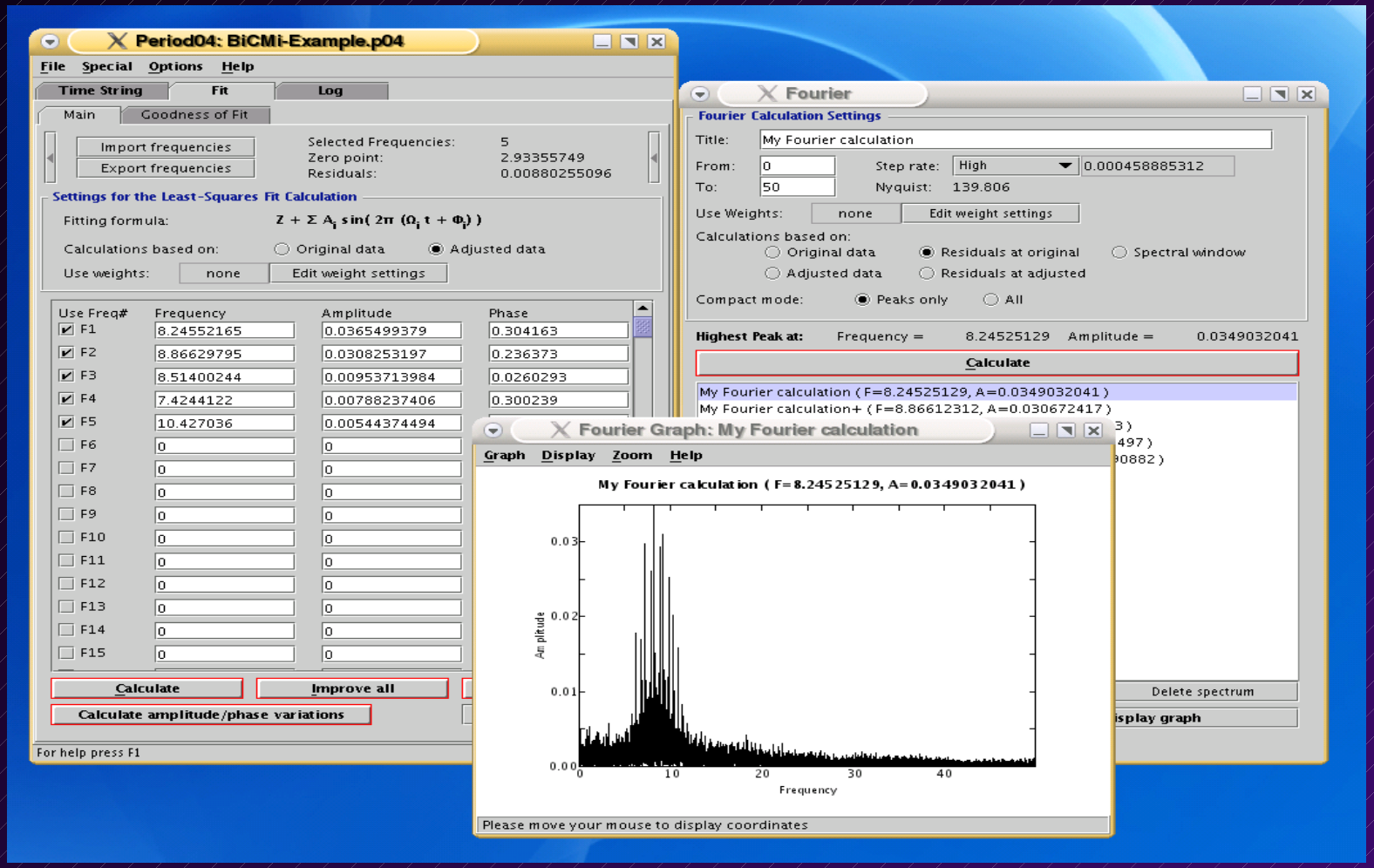
and PROCESSED spectrum
(normalization, log lambda)

Period Analysis

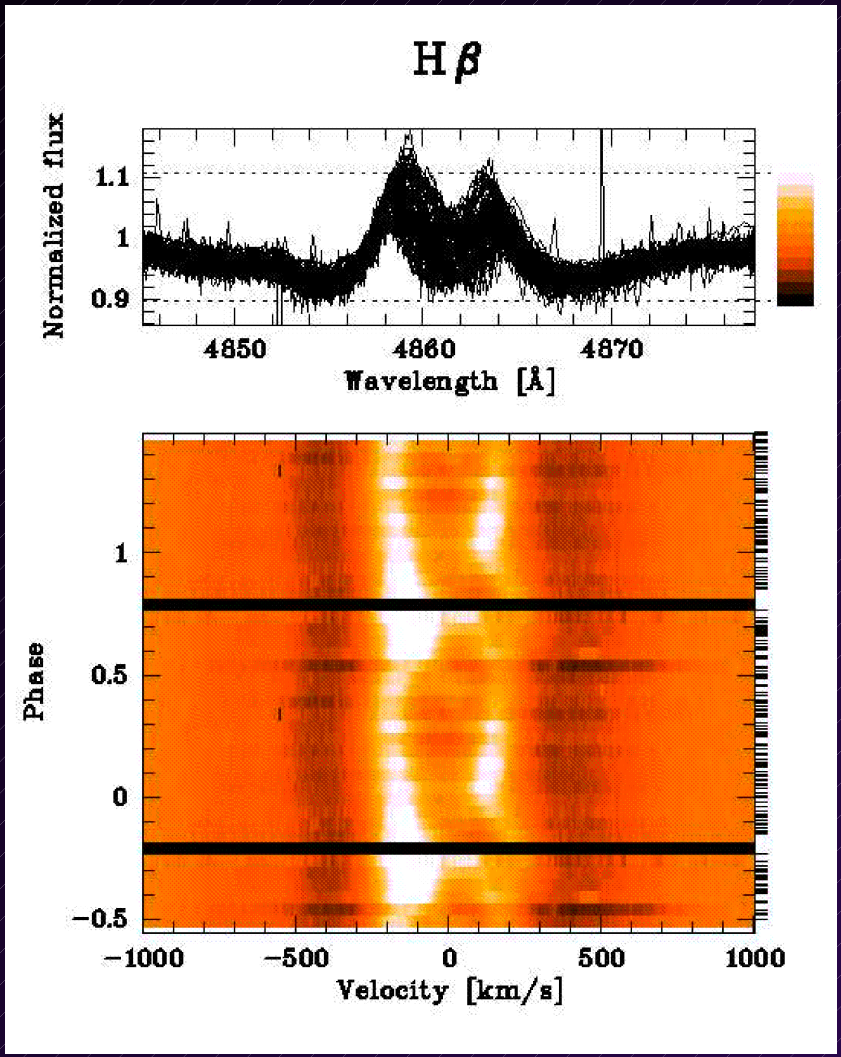
- Time series
- Various variables
  - EW
  - Moments (asteroseismology)
- PDM, Fourier (CLEAN), many others
- Requires
  - Rectified spectrum
  - Time
  - Ranges
  - Initial estimate of period

Period Analysis

- Period98, Period04 (java), FROG ?



Dynamic Spectra



- Quotient, Difference template (average)
- For study of LPV (asteroseismology, winds)
- Requires
  - time (JD) - winds
  - period (see Period analysis) - phase (LPV)
  - change of template (average, median)
  - removing bad data (interactive overplotting)

Dynamic Spectra

- Interactive features, color cuts, LUT
- GRID (many stars)
- Custom packages
  - D. Massa – IDL
  - MIDAS TSA - (Stahl, Rivinius)
- Multiple lines at the same time

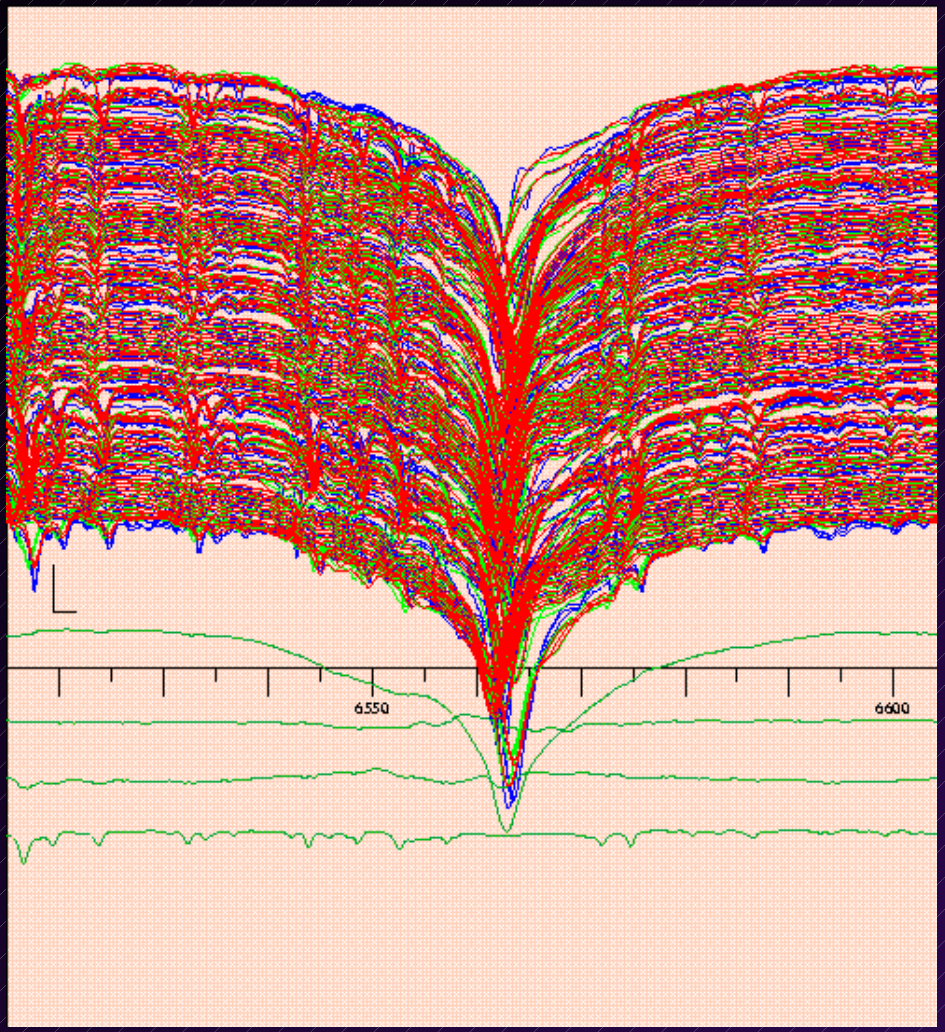
Spectral Disentangling

- For blended spectra of binary (multiple) stars
- Very powerful
- Requires good orbital coverage, estimate of orbital parameters (SIMBAD)
- Wavelength space disentangling - computing power, space
- Fourier disentangling - perfect continuum, cut regions, log lambda

Spectra Disentangling

- Show all spectra overploted
- Remove bad - same cut, regions
- KOREL (P. Hadrava), FDBinary (S. Ilijic)
- Batch processing on GRID, interactive control of iteration, plug-in optimization methods (agents - genetic, insects cloud, NN)
- Iterative – Interactive – refeed results (orbit) as parameters

Spectra Disentangling



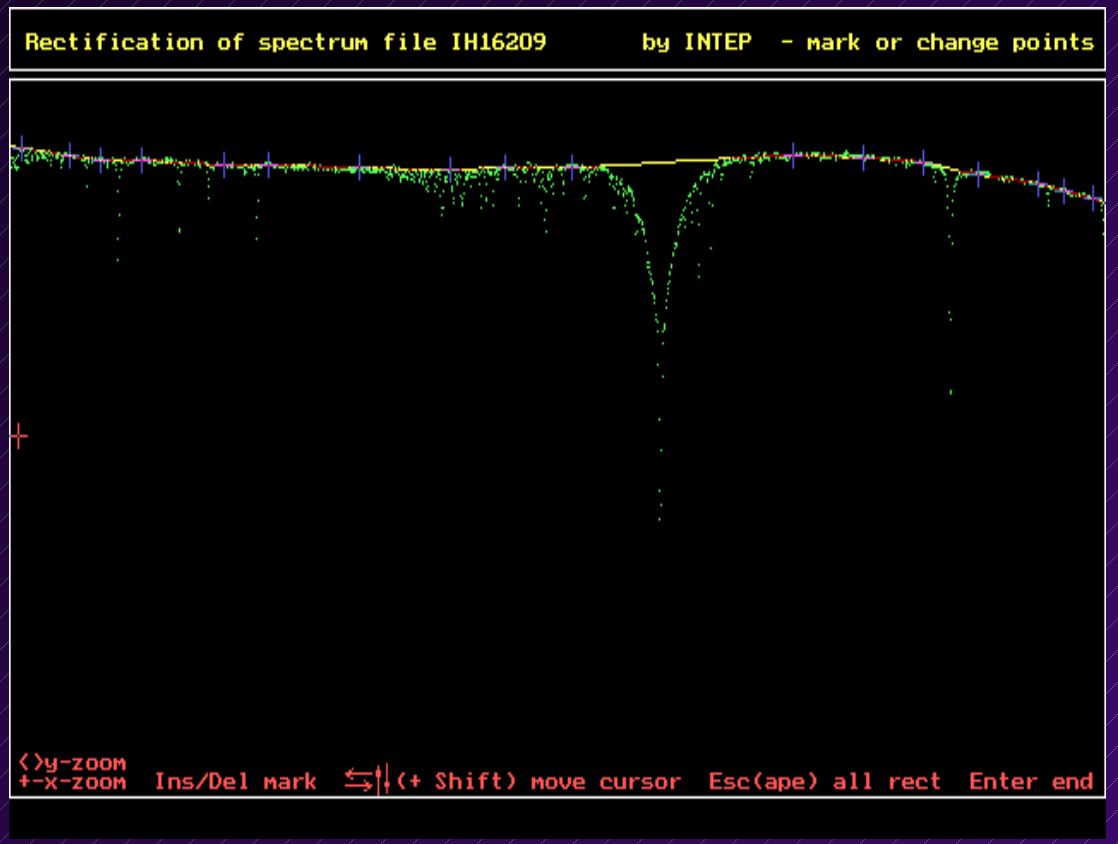
- Example of triple star – P. Hadrava
- Poster S240-121 next week
- Telluric line removal

Benefits of implementing as VO services

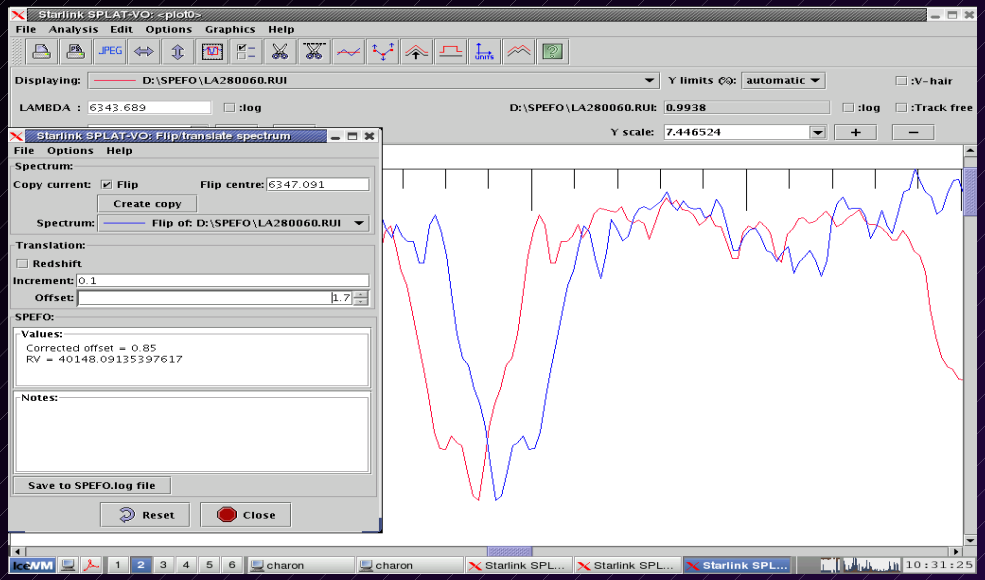
- Unified data format (VO-Table, semantics of variables)
- Transparent data conversion, homogenization, rescaling
- Powerful presentation with remote data (URI)
- Large spectral survey feasible
- Serendipitious research - click on star in the image of cluster to see its dynamic spectra (many observation)

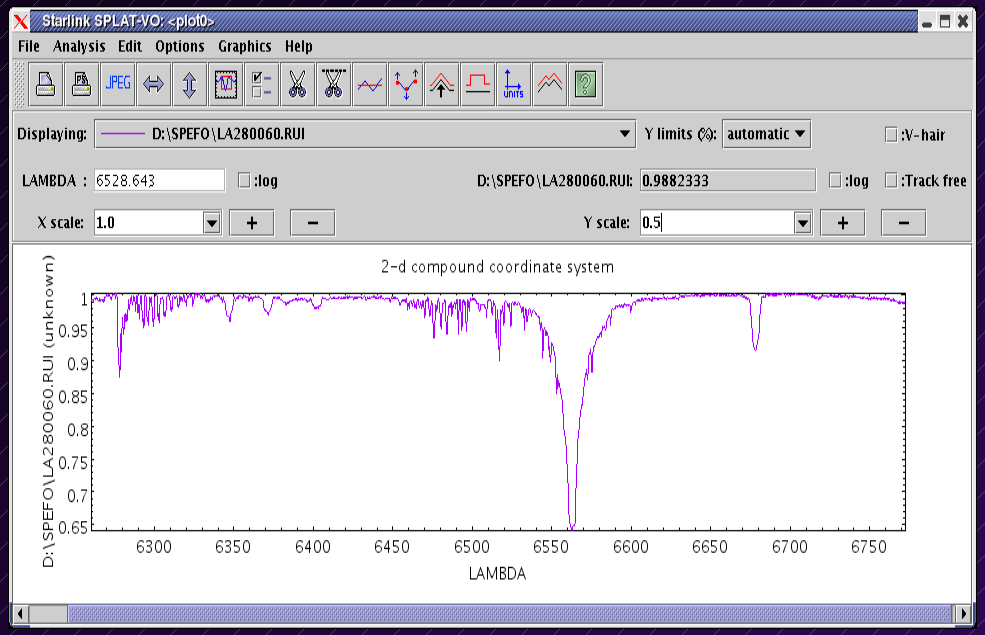
Present VO - enabled spectral analysis tools

- Complicated stars – Be, Symbiotic, Novae ...
- Flexible Fitting of Continua (INTEP, Akima)
- RV measurement (mirroring, fitting)



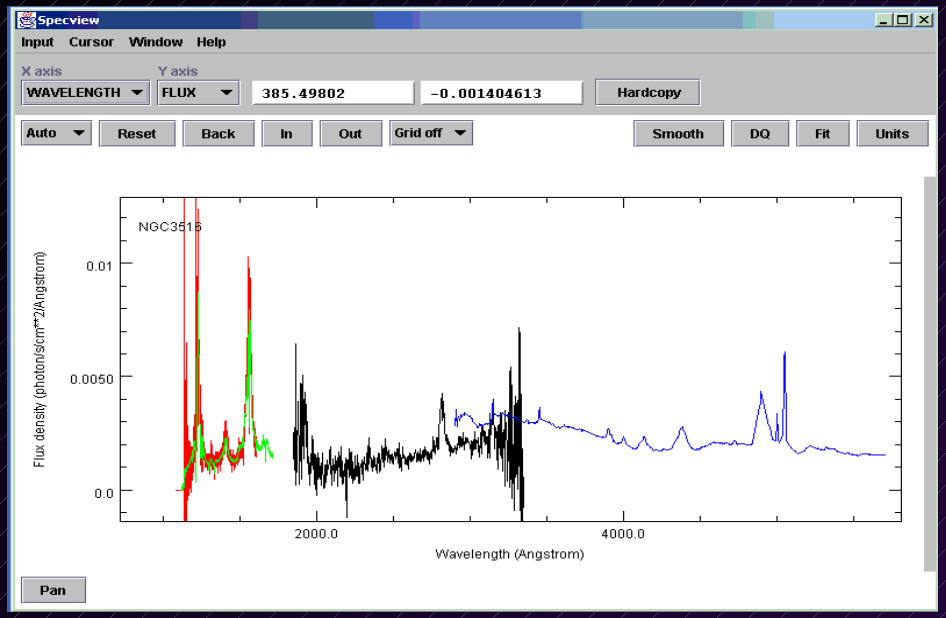
SPLAT

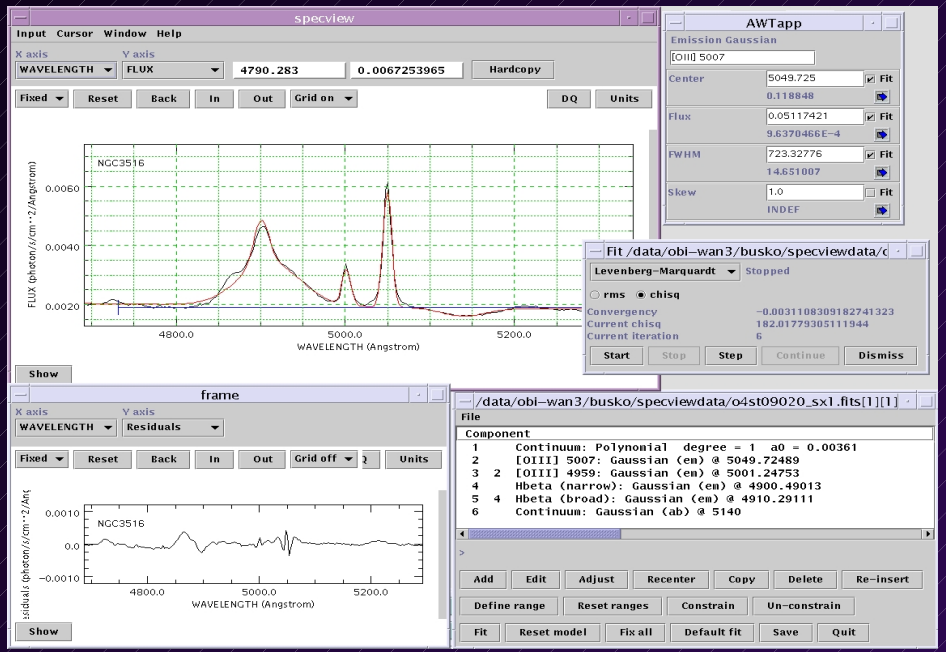




- Has all features
- VO – registry hardcoded
- Custom line list
- Development not justified
- Most advanced
- P. Draper (JCMT)

SpecView (STScI)





- Fitting profiles from models
- Simple polynomials
- Analysis strong (deredening, CLOUDY)
- Supported !!
- Not good for IRAF WCS (1D FITS)

VOSpec

- Very simple
- Polynomial fits
- No RV measurement
- No complex operations
- In VizieR now
- Can work with SLAP!
- Theoretical VO supported

Conclusions

Present state:

- VO – enabled tools lacks features necessary to replace local analysis tools
- Simple rectification
- RV only fit of Gauss...
- Only few spectral archives of optical stellar spectra (Elodie)

- What to do ?
- More stellar spectra to VO archives
- VO portal using local private spectral server
- Write analysis tools with VO interface
- VO services for common tasks
- Ask astronomers !