



## **Data reduction of Rozhen echelle spectra with IRAF**

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**This is a brief instruction for reduction of echelle data with IRAF (Image Reduction and Analysis. Facility) for data obtained with the 2.0m Rozhen telescope and ESpeRo spectrograph.**

**Lecture notes in 01.04.02 “Astrophysics and Stellar astronomy”**

**This lecture is prepared as an aid to students and researchers involved in the project “Accretion flows in Binary Stars” dogovor KP-06-H98/8 фонд Научни изследвания**

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1. Подготовка. стартира се IRAF

```
cl> noao  
cl> imred  
cl> echelle
```

```
cl> copy ThAr_1_30s.fits th1.fits  
cl> files *.fits > li.1  
cl> hedit @li.1 dispaxis 1 add+  
cl> hedit @li.1 imagetyp object add+  
cl> copy HD138749_600s.fits a1.fits
```

a1.fits - трябва да е ярка добре експонирана звезда

2. стартираме apall върху спектъра на ярката звезда a1.fits:

```
cl> epar apall
```

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PACKAGE = echelle

TASK = apall

```
input = a1.fits List of input images  
(output = ) List of output spectra  
(apertur= ) Apertures  
(format = multispec) Extracted spectra format  
(referen= a1.fits) List of aperture reference images  
(profile= ) List of aperture profile images  
  
(interac= yes) Run task interactively?  
(find = yes) Find apertures?  
(recente= yes) Recenter apertures?  
(resize = yes) Resize apertures?  
(edit = yes) Edit apertures?  
(trace = yes) Trace apertures?  
(fittrac= yes) Fit the traced points interactively?  
(extract= yes) Extract spectra?  
(extras = no) Extract sky, sigma, etc.?  
(review = no) Review extractions?  
  
(line = 970) Dispersion line  
(nsum = 20) Number of dispersion lines to sum or median  
  
# DEFAULT APERTURE PARAMETERS  
(lower = -5.) Lower aperture limit relative to center  
(upper = 5.) Upper aperture limit relative to center  
(apidtab= ) Aperture ID table (optional)  
  
# DEFAULT BACKGROUND PARAMETERS  
(b_funct= chebyshev) Background function  
(b_order= 2) Background function order  
(b_sampl= -15:-5,5:15) Background sample regions  
(b_naver= 0) Background average or median  
(b_niter= 5) Background rejection iterations  
(b_low_r= 4.) Background lower rejection sigma
```

```

(b_high_ =      2.) Background upper rejection sigma
(b_grow =      0.) Background rejection growing radius

# APERTURE CENTERING PARAMETERS
(width =      5.) Profile centering width
(radius =     10.) Profile centering radius
(thresho=     0.) Detection threshold for profile centering

# AUTOMATIC FINDING AND ORDERING PARAMETERS
nfind =      60 Number of apertures to be found automatically
(minsep =     12.) Minimum separation between spectra
(maxsep =     55.) Maximum separation between spectra
(order =     increasing) Order of apertures

# RECENTERING PARAMETERS
(aprecen=     ) Apertures for recentering calculation
(npeaks =     INDEF) Select brightest peaks
(shift =     yes) Use average shift instead of recentering?

# RESIZING PARAMETERS
(llimit =     INDEF) Lower aperture limit relative to center
(ulimit =     INDEF) Upper aperture limit relative to center
(ylevel =     0.1) Fraction of peak or intensity for automatic width
(peak =     yes) Is ylevel a fraction of the peak?
(bkg =     yes) Subtract background in automatic width?
(r_grow =     1.) Grow limits by this factor
(avglimi=     no) Average limits over all apertures?

# TRACING PARAMETERS
(t_nsum =     10) Number of dispersion lines to sum
(t_step =     10) Tracing step
(t_nlost=     3) Number of consecutive times profile is lost before quitting
(t_func=     legendre) Trace fitting function
(t_order=     5) Trace fitting function order
(t_sampl=     *) Trace sample regions
(t_naver=     1) Trace average or median
(t_niter=     0) Trace rejection iterations
(t_low_r=     3.) Trace lower rejection sigma
(t_high_ =     3.) Trace upper rejection sigma
(t_grow =     0.) Trace rejection growing radius

# EXTRACTION PARAMETERS
(backgro=     fit) Background to subtract
(skybox =     1) Box car smoothing length for sky
(weights=     none) Extraction weights (none|variance)
(pfit =     fit1d) Profile fitting type (fit1d|fit2d)
(clean =     no) Detect and replace bad pixels?
(saturat=     INDEF) Saturation level
(readnoi=     1) Read out noise sigma (photons)
(gain =     1.) Photon gain (photons/data number)
(lsigma =     4.) Lower rejection threshold
(usigma =     4.) Upper rejection threshold
(nsubaps=     1) Number of subapertures per aperture
(mode =     ql)

```

3. правим apall на @li.1 като променяме параметрите, за да използваме a1.fits като референс имидж.

```
cl> erar apall
```

```
          I R A F  
Image Reduction and Analysis Facility
```

```
PACKAGE = echelle
```

```
TASK = apall
```

```
input =      @li.1 List of input images  
(output =   ) List of output spectra  
(apertur=   ) Apertures  
(format =   multispec) Extracted spectra format  
(referen=   a1.fits) List of aperture reference images  
(profile=   ) List of aperture profile images  
  
(interac=   yes) Run task interactively?  
(find =     no) Find apertures?  
(recente=   no) Recenter apertures?  
(resize =   no) Resize apertures?  
(edit =     no) Edit apertures?  
(trace =    no) Trace apertures?  
(fitrac=    no) Fit the traced points interactively?  
(extract=   yes) Extract spectra?  
(extras =   no) Extract sky, sigma, etc.?  
(review =   no) Review extractions?
```

..... другите параметри са същите като по-горе.

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#### 4. Идентифицираме Th-Ar линии в th1.ms.fits

ec> epar eidentify

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PACKAGE = echelle  
TASK = eidentify

images = th1.ms.fits Images containing features to be identified  
(databas= database) Database in which to record feature data  
(coordli= linelists.dat) User coordinate list  
(units = ) Coordinate units  
(match = 0.085) Coordinate list matching limit in user units  
(maxfeat= 5550) Maximum number of features for automatic identification  
(zwidth = 10.) Zoom graph width in user units  
(ftype = emission) Feature type  
(fwidth = 4.) Feature width in pixels  
(cradius= 5.) Centering radius in pixels  
(thresho= 100.) Feature threshold for centering  
(minsep = 2.) Minimum pixel separation  
(functio= chebyshev) Coordinate function  
(xorder = 3) Order of coordinate function along dispersion  
(yorder = 3) Order of coordinate function across dispersion  
(niterat= 0) Rejection iterations  
(lowreje= 2.5) Lower rejection sigma  
(highrej= 2.5) Upper rejection sigma  
(autowri= no) Automatically write to database?  
(graphic= stdgraph) Graphics output device  
(cursor = ) Graphics cursor input  
(mode = ql)

---

за фитиренето аз използвам порядъци H $\alpha$ , H $\alpha$ -1, H $\alpha$ +4, H $\alpha$ +36 (виж фигурите)  
[ H-beta = H-alpha +25 ], [ NaD = H $\alpha$  + ? ]  
маркирам по 3-4 линии, а в порядък H $\alpha$ +4 - 5-6 линии.

след като е направено първоначалното фитиране трябва да се сменят

(xorder = 6) Order of coordinate function along dispersion  
(yorder = 6) Order of coordinate function across dispersion

---

#### 5. refspectra

cl> epar refspectra

---

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PACKAGE = onedspec  
TASK = refspectra

input = @li.2 List of input spectra  
(referen= th1.ms.fits) List of reference spectra  
(apertur= ) Input aperture selection list

(refaps = ) Reference aperture selection list  
(ignorea= yes) Ignore input and reference apertures?  
(select = nearest) Selection method for reference spectra  
(sort = ) Sort key  
(group = ) Group key  
(time = no) Is sort key a time?  
(timewra= 17.) Time wrap point for time sorting  
(overrid= no) Override previous assignments?  
(confirm= yes) Confirm reference spectrum assignments?  
(assign = yes) Assign the reference spectra to the input spectrum?  
(logfile= STDOUT,logfile) List of logfiles  
(verbose= no) Verbose log output?  
answer = yes Accept assignment?  
(mode = ql)

---

cl > refspectra

th1.ms.fits е референс спектър за всички спектри получени през нощта.

cl> epar dispcor

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PACKAGE = echelle

TASK = dispcor

input = @li.2 List of input spectra  
output = @li.3 List of output spectra  
(lineari= yes) Linearize (interpolate) spectra?  
(databas= database) Dispersion solution database  
(table = ) Wavelength table for apertures  
(w1 = INDEF) Starting wavelength  
(w2 = INDEF) Ending wavelength  
(dw = INDEF) Wavelength interval per pixel  
(nw = INDEF) Number of output pixels  
(log = no) Logarithmic wavelength scale?  
(flux = yes) Conserve total flux?  
(blank = 0.) Output value of points not in input  
(samedis= no) Same dispersion in all apertures?  
(global = no) Apply global defaults?  
(ignorea= no) Ignore apertures?  
(confirm= no) Confirm dispersion coordinates?  
(listonl= no) List the dispersion coordinates only?  
(verbose= yes) Print linear dispersion assignments?  
(logfile= ) Log file  
(mode = ql)

create rv.obs in the format (внимание формата е важен)

```
1987 10 21 11:00:24 3:36:15 0:22:04
1987 10 21 11:08:00 8:19:35 -0:51:35
1987 10 21 11:15:47 8:35:12 6:40:29
1987 10 21 12:12:10 9:13:20 61:28:49
1987 10 21 12:16:03 9:27:48 9:07:08
1987 10 21 12:20:43 9:50:45 -6:06:58
1979 3 25 11:22:59 16:07:28 -23:37:49
```

```
cl> rvcorrect f=rv.obs > rv.dat
```

```
cl> cl < li.4
```

```
hedit CICam.wl.20210916.fits VHELIO 24.18 add+ ver- show+
```

```
cl> cl < li.5
```

```
dopcor oldfile.fits newfile.fits -vhelio isvel+
```







