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2-meter telescope devices: Coudé slit spectrograph and HEROS

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The Ondřejov 2-meter Telescope is used either in the Cassegrain or in the coudé focus; the primary focus is not used. The primary goal is the spectroscopy. Nowadays, the Cassegrain focus is equipped with the fiber-fed echelle spectrograph HEROS owned by the Landessternwarte Heidelberg-Königstuhl. The coudé focus is equipped with the slit spectrograph. Usually, the slit coudé spectrograph is being used in winter due to the lower sensitivity to the weather condition (seeing).

1 Introduction: Description of the telescope

The 2-meter telescope is in operation since 1967. After a major overhaul in 1982-1987, the telescope was mainly used for high-dispersion spectroscopy. The spectra were exposed on the 1D electronic detector Reticon in 1992-2000, nowadays we use either CCD chip installed in August 2000 in coudé spectrograph or echelle fiber-fed spectrograph HEROS installed in the Cassegrain focus.

The telescope is mainly used for the Be Stars spectroscopy, detection of secondary components in binary systems, search for relations between rapid and long-term variations in spectra, improving the knowledge of the basic parameters of stars, search for a possible causal relationship between non-radial pulsations of stars and their membership in the binaries with eccentric orbits (project SEFONO) etc.

The telescope is opened to the astronomical community from all over the world. The facility is mostly used by staff astronomers and by astronomers from other Czech institutions (the Dept. of Astronomy and Astrophysics of Charles University, Prague, Dept. of Theoretical Physics and Astrophysics of Masaryk University, Brno, Pedagogical Faculty of the University at Hradec Králové). An agreement signed after the division of Czechoslovakia (the facility was built as a Czechoslovak national instrument) guarantees access to Slovak astronomers.

The basic characteristics of the telescope are given in the Tab. I.

2 HEROS

HEROS[1] is the fiber-fed echelle spectrograph observing with two cameras in the blue and red part of spectra, respectively. The blue camera covers the range of 3650÷5650Å while the red camera shows 5840÷8350Å (in current configuration). Two CCD chips are put in the HEROS: 750×1180 pixels (22μm) thick chip in red camera and 800×2000 pixels (15μm)

[1] **H**eidelberg **E**xtended **R**ange **O**ptical **S**pectrograph

Table I: Characteristics of the 2-meter Telescope

Primary mirror:	
Full diameter:	208cm
Effective diameter:	200cm
Thick:	30cm
Weight:	2340kg
Focal length:	9m
Primar focus:	
Size of view field:	21'45"×21'45"
Equipment:	none (it is not used)
Secondary mirror:	
Effective diameter:	58cm
Weight:	100kg
Cassegrain focus:	
Effective focal length:	29.16m
Size of view field	6'44"×6'44"
Equipment:	HEROS
Coude focus:	
Effective focal length:	63.5m
Equipment:	Slit spectrograph

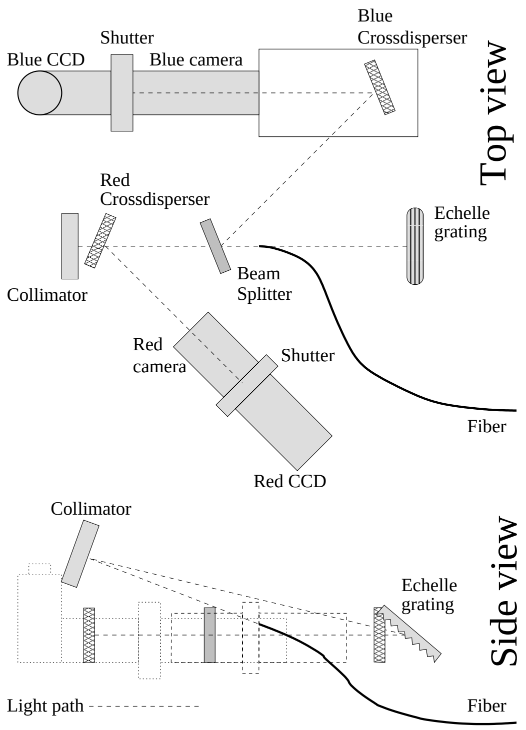

Fig. 1: Scheme of the HEROS. The light path is symbolized by a dashed line.

thinned back-illuminated chip in blue one. The scheme of the HEROS is shown on Fig. 1.

Remaining characteristics of the HEROS are summarized in the table Tab. II.

Each camera of the HEROS (red and blue) is controlled by one MS-DOS computer. The red control computer is, in principle, both controller of the CCD chip and camera and also the device interacting with the astronomer (saving data to the disk, sending them to the data server etc.). The blue computer interacts with the astronomer (independently on the red one) and drives the blue camera controller, which is a specialized device situated near to the blue camera.

Table II: Characteristics of the HEROS

Shared characteristics:	
Theor.available range	3450÷8650Å
Fiber:	100μm diameter
Collimator:	f/4.5
	f=360mm
Echelle grating:	31.6 grooves mm^{-1}
	63.4 deg gr. angle (tilt)
Red channel:	
Cross disperser:	300 groves mm^{-1}
	5000Å center of blaze
Camera:	f/2.8
	f=300mm
Blue camera:	
Cross disperser:	400 grooves mm^{-1}
	3500Å center of blaze
Camera:	f/2.8
	f=300mm

The CCD chip itself is, in both cameras, oriented horizontally. Spectral orders are shown on the monitor vertically.

Therefore it is necessary to transform the picture before reduction process to the standard echelle orientation: horizontal position of spectral orders, the dispersion runs from left to right and the order absolute number from top to bottom.

Detailed description of the HEROS, including photos, may be found on the HEROS web page[2].

3 Coudé slit spectrograph

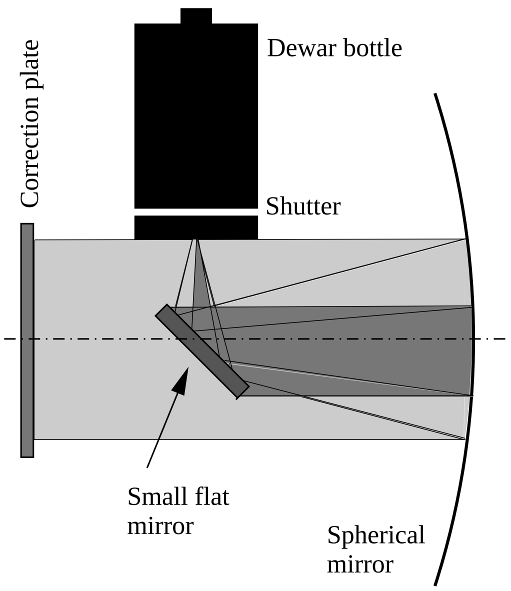

Fig. 2: Scheme of the Schmidt camera – side view. The shadow of the small flat mirror is shown in dark grey. In reality, the shadow of the mirror blocks about 15% of the incoming light. See also Fig. 3

The coudé spectrograph is a standard device equipped either with a slit or with an image slicer[3].

The scheme of the coudé spectrograph is presented on the Fig. 3

[2] `www.lsw.uni-heidelberg.de/projects/instrumentation/Heros/`

[3] The image slicer was used in the configuration with the 1872 RETICON in 1992-2000. In present, we use CCD SITe 2000×800 pixels (15μm) and 0.2mm slit width

3.1 Description of the spectrograph

The light beam runs along the hour axis of the telescope to the coudé room on the ground floor. It is just the light beam incoming to the slit head (see Fig. 3). Then it passes the turning mirror which may either release the light beam to the spectrograph (in the first position) or screen it (and release the light beam of the flat-field lamp – the second position). Next, the beam passes the turning prism which may either route the light beam to the ocular or to the spectrograph. The ocular is used to optical guide the telescope (as the light is fixed to the center of the field of view, the prism is turned to the opposite position and the light passes to the spectrograph; the guiding through "guiding camera" follows – see next).

Light then runs through the slit head and enters the spectrograph. First of all it is re-parallelized (since the spectrograph is behind the coudé focus of the telescope) on out-of-axis collimator (f = 4606mm, f/31.75). Then it is decomposed into the spectrum on a grating (154×206mm, 833.77mm^{-1}) Bausch & Lomb. Finally, the spectrum is focused by a Schmidt camera to the CCD chip (Fig. 2). We can use two Schmidt cameras (with respect to grating position) with f = 700mm or f = 1400mm. In present, we use the first one. The characteristics of these cameras is summarized in the table Tab. III.

3.2 Description of the slit head

The slit head is quite complicated system because it is equipped with many devices for the observation with CCD, Reticon and even with photographic plates (although we do not use photographic plates any longer). Nonetheless, we have simplified presented scheme (see Fig. 3) and show devices being used in current configuration with CCD only.

First of all, the light beam reflects on dichroic mirrors in order to eliminate the overlapping of spectral orders – only one selected spectral range (covering one spectral order) is reflected. Then the light beam passes through the turning prism which may either release the stellar light beam to the slit (in the first position) or reflects the ThAr calibration light to the slit (in the second position). Next, the beam falls on a semi-transparent mirror which 5% of the light redirects to the exposuremeter. 95% of the light runs to the collimator. We should point out that one can use grey filters in front of the ThAr lamp in order to optimize intensity of comparison spectrum.

Characteristics of slit head devices (grey filters, dichr. mirrors and color filters) are summarized in the table Tab. IV. The more detailed description of the telescope and instruments may be found on the web pages of the stellar department (see References).

Table III: Characteristics of the coudé spectrograph Schmidt cameras

No. 1:	
Corr. plate diameter:	268.9mm
Spher. mirror diameter:	550mm
Focal length:	700mm
No. 2:	
Corr. plate diameter:	226mm
Spher. mirror diameter:	800mm
Focal length:	1400mm

Acknowledgement

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References

http://stelweb.asu.cas.cz/2m/2mtel/telescope.html

http://stelweb.asu.cas.cz/instruments/instrum.html

Table IV: Characteristics of (selected) slit head devices

Dichroic mirrors

Notation	Type
A	blue
B	infrared
C	aluminium
D	red

Colour filters

Number	Notation	Type	Operation (Å)
1	hole		
2	red	RG2	6350÷7910
3	red	OG4	4800÷9000
4	dethermal	C997	<6000
5	blue	BG39	3500÷5500

Grey filters

Number	Type	Reduction of light
HK6	hole	1x
HK5	neutral	4x
HK4	neutral	16x
HK3	neutral	64x
HK2	neutral	256x
HK1	neutral	1024x

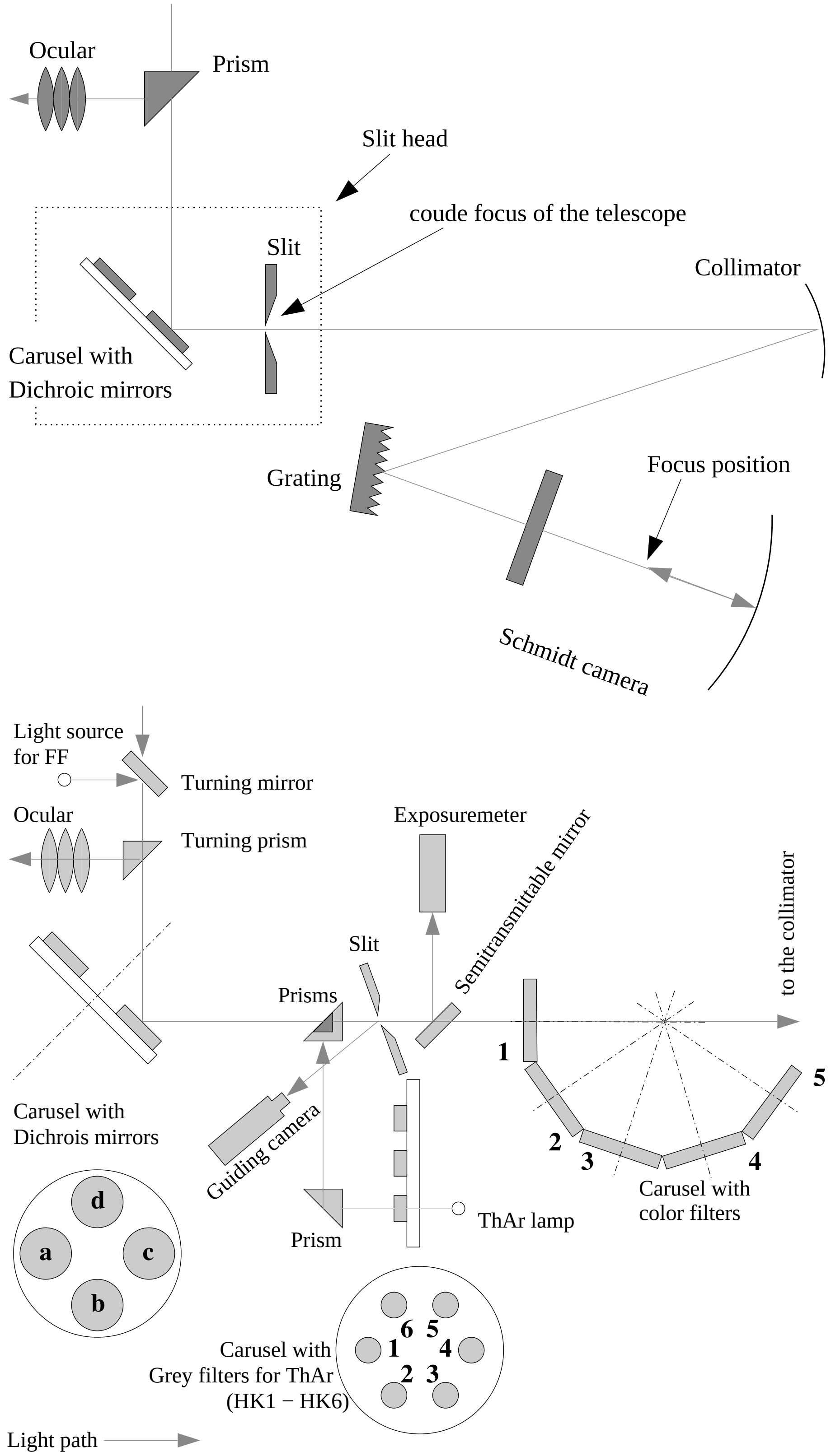

Fig. 3: Top: scheme of the coudé slit spectrograph. Bottom: detailed scheme of the slit head of the spectrograph. We present current configuration (i.e. the equipment for CCD observation). The light path is depicted by grey lines and arrows.