The fiber-fed echelle spectrograph at the 1.2-meter telescope at Kourovskaya astronomical observatory

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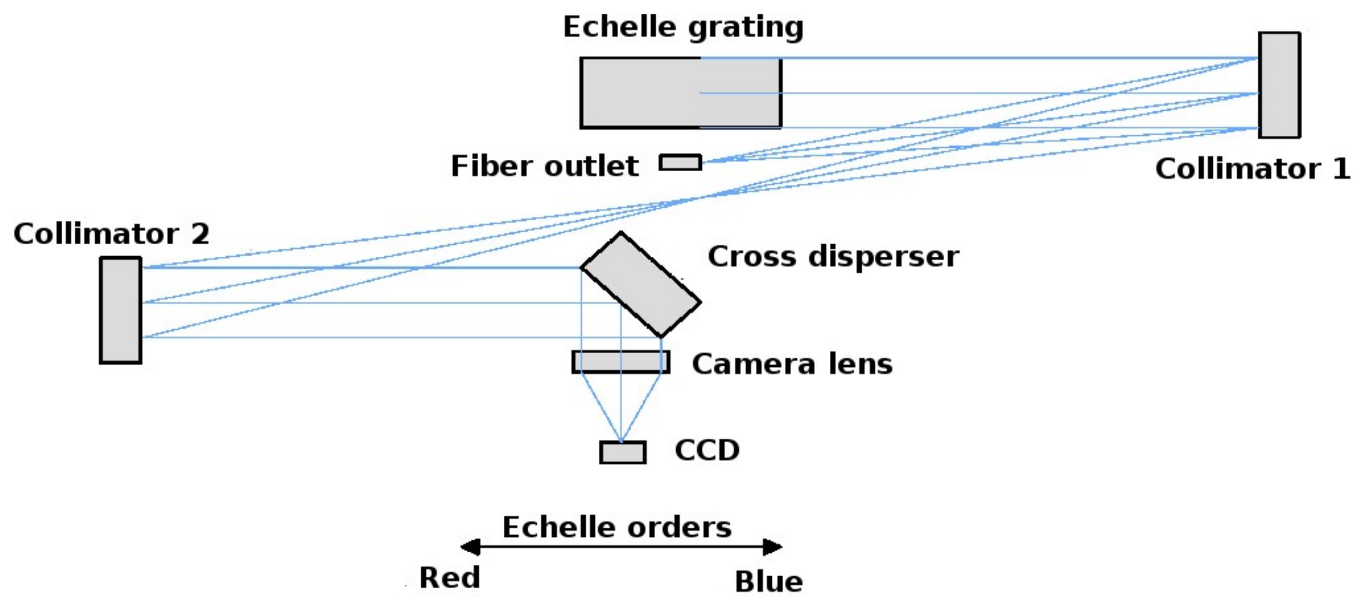
New fiber-linked echelle spectrograph made at the Astrospectroscopy laboratory SAO RAS [1] has been installed at the Nasmyth focus of the 1.2-meter telescope in the Kourovskaya astronomical observatory. The spectral range of the spectrograph is 3900 to 10500 Å with a resolution R=30000 and optical efficiency not less than 2%.

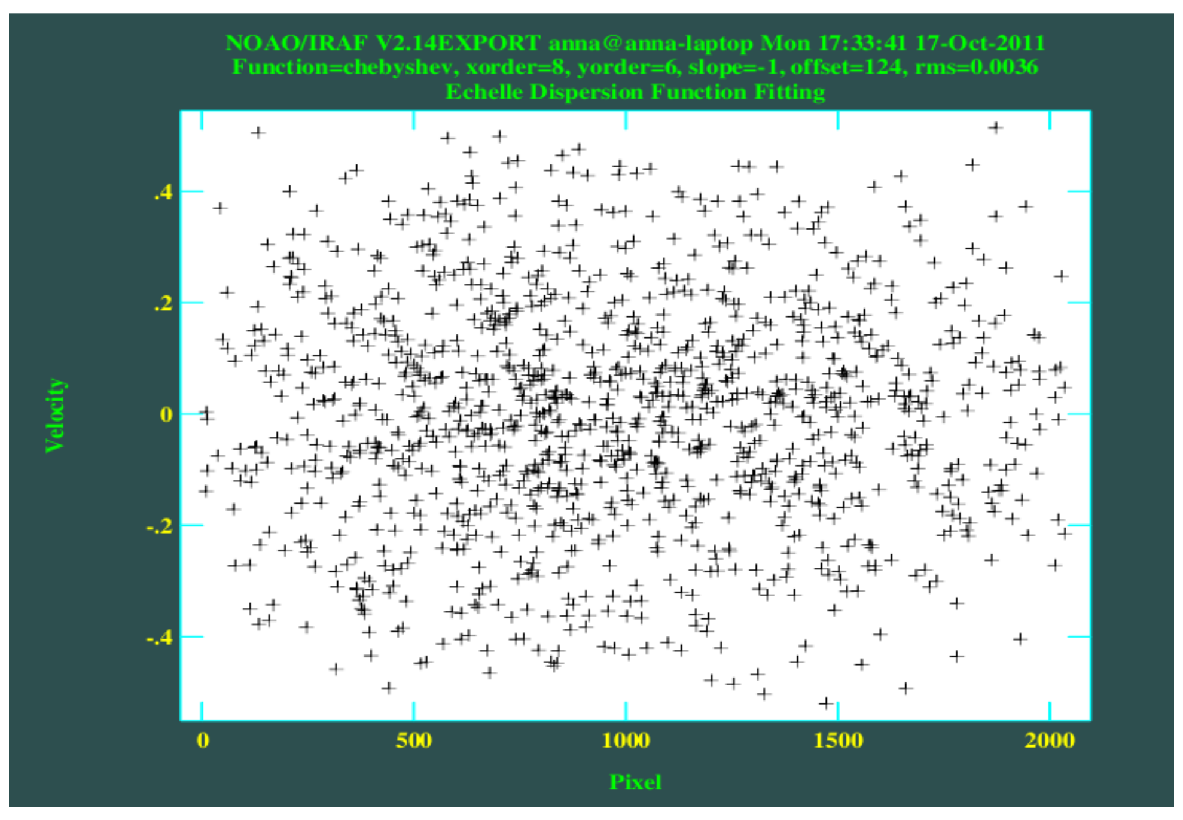
The system allow getting spectra in two wavelength ranges, 4100-7900 and 4800-10900 angstroms. Investigations for the "blue" range presented in the work include dispersion curve calibration, ThAr atlas (4100-7900 Å), tests on scattered light distribution (~2%), geometrical and temperature instability (average shift 1.8px/*C), signal-to-noise calculator, instrumental profile (FWHM = 4 – 6 px) and radial velocity accuracy (0.3 – 0.4 km/s) determination. The dispersion curve takes to account a light distribution along and across the dispersion and the objectives' distortion. All work was performed using IRAF software [2].

Also light losses such as atmosphere dispersion, errors of positioning an object on the fiber entrance are described, probable improvements are discussed.

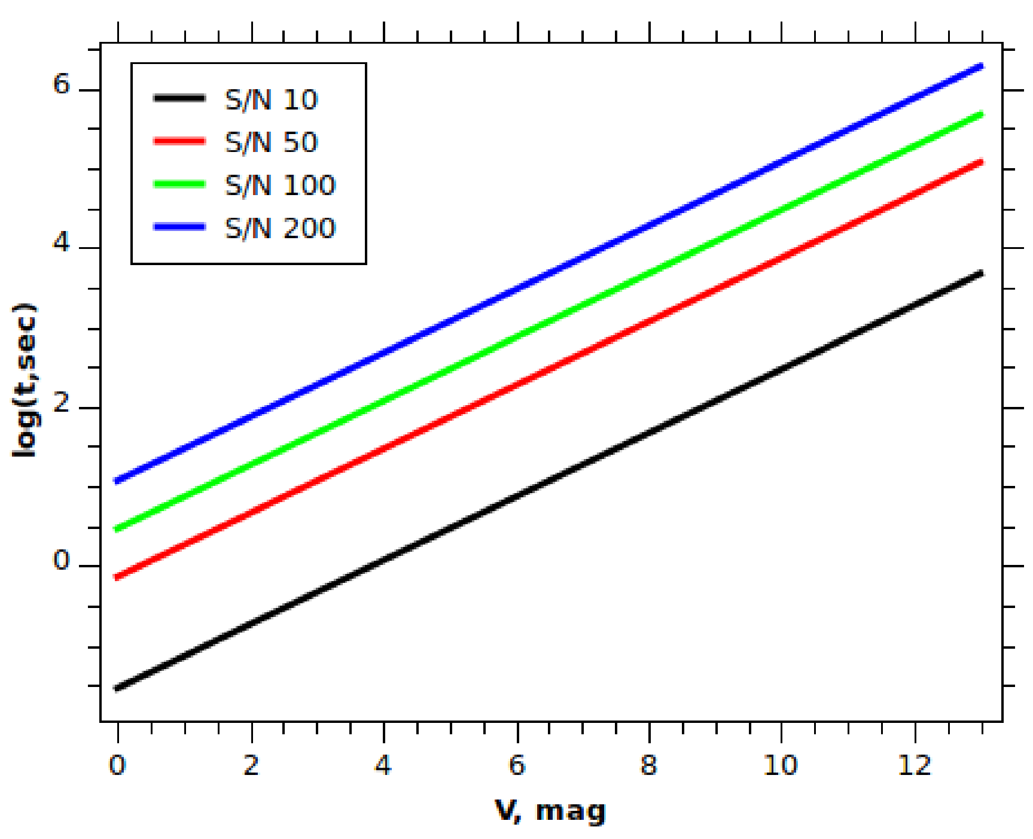
Optical design of the stationary part



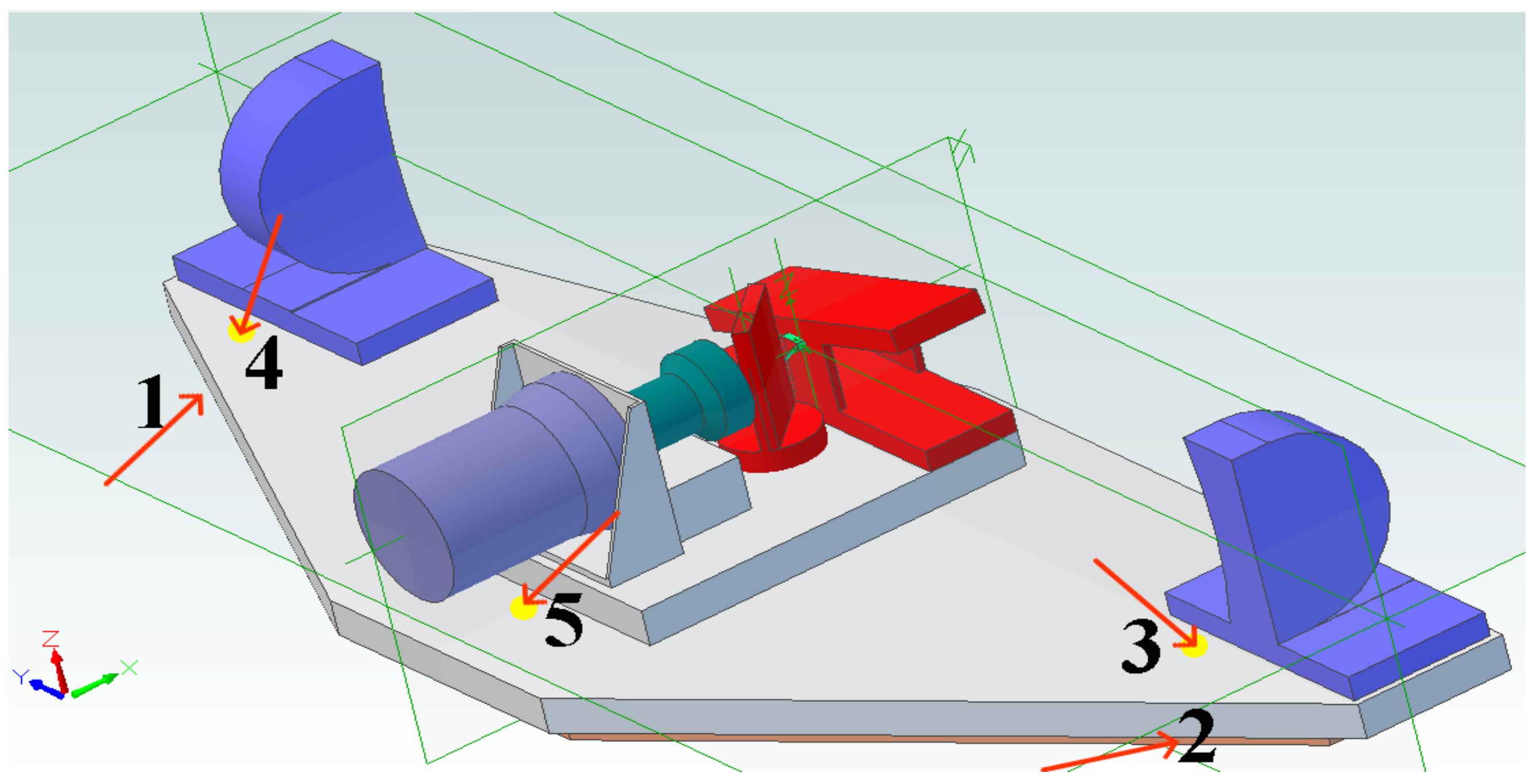
The residual of the fitting of ap. 1100 ThAr lines (velocity in km/s)



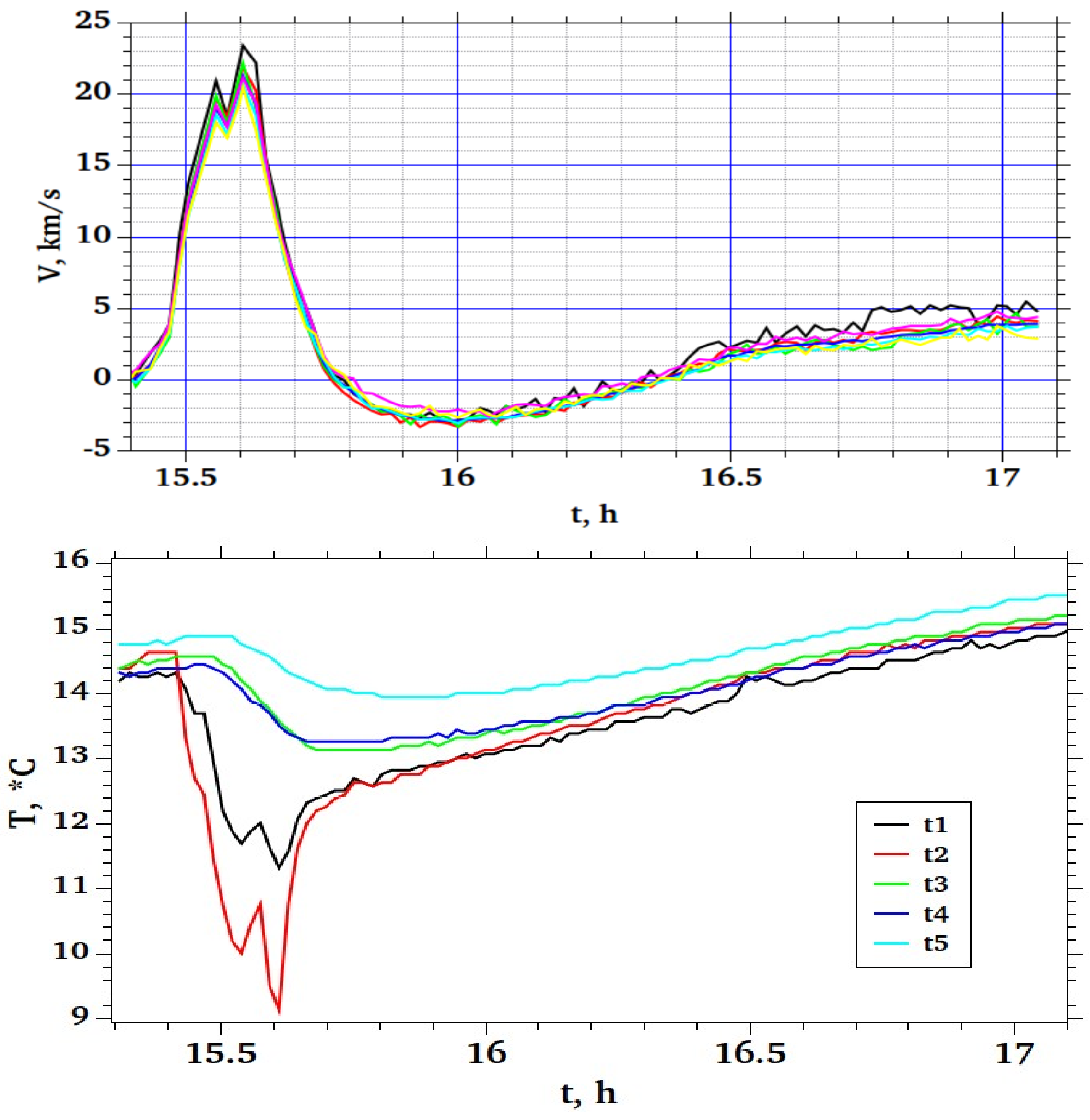
Estimated S/N for various magnitudes



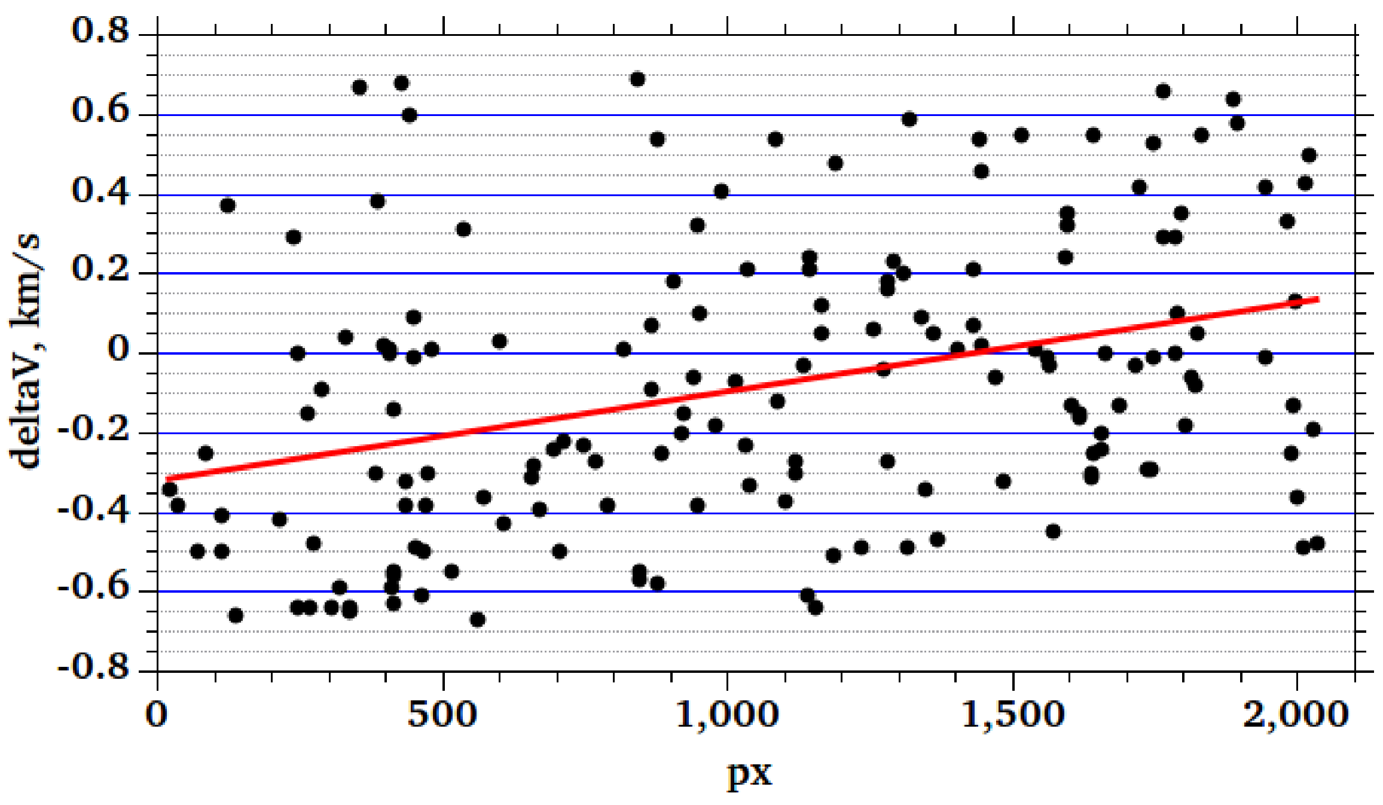
Thermal elements in the base of the stationary part of the spectrograph



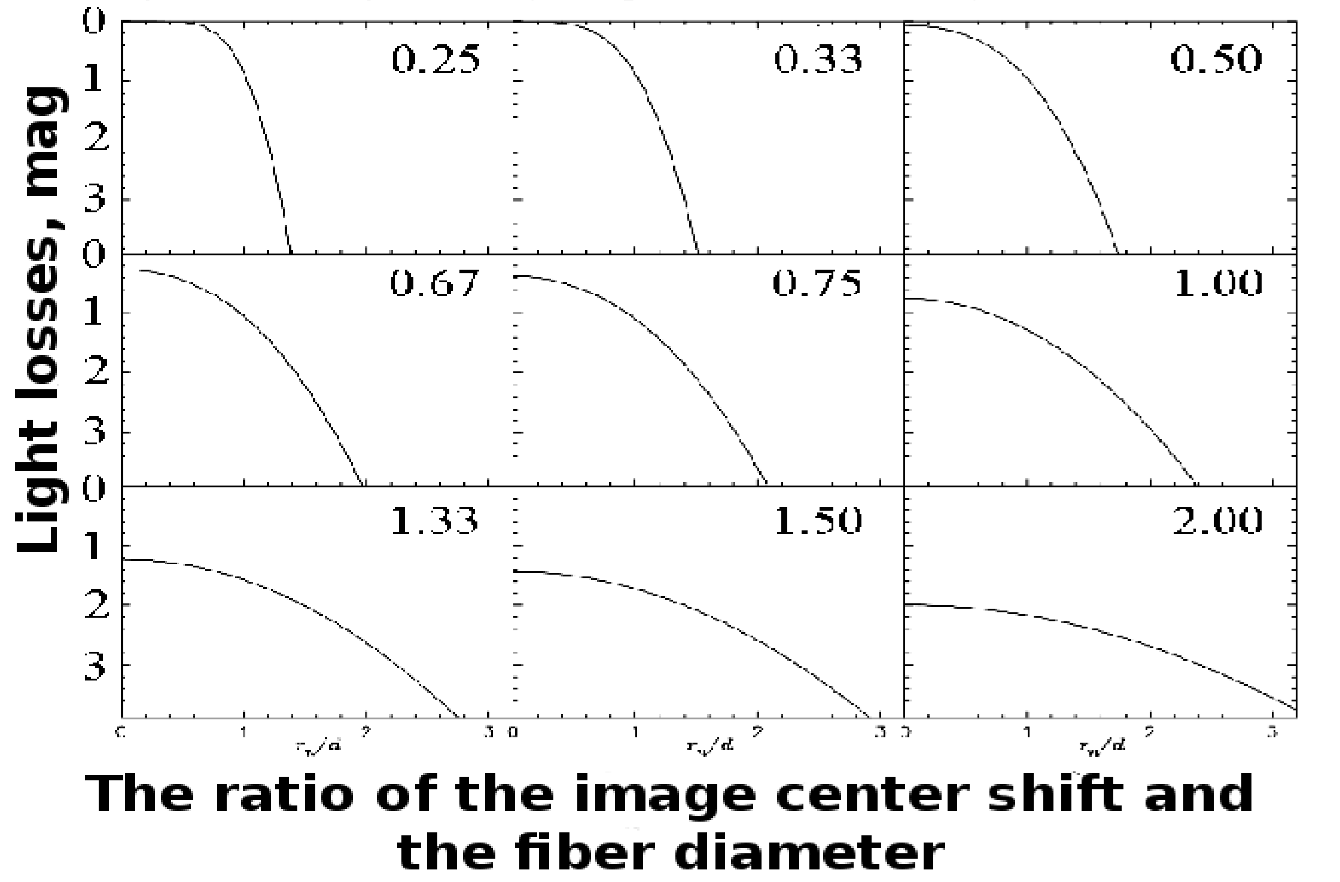
Wavelength shift of 7 ThAr lines in variuos parts of the 109 order and corresponding temperature changes according to 5 thermal elements



The radial velocity of Aldebaran mesured by 167 lines in various orders compared with Massarotti (2008). Within an orders the wavelength increases from left to right.



Efficiency for point sources expressed as an aperture correction in magnitudes for the same fiber-image displacements and image sizes [4]



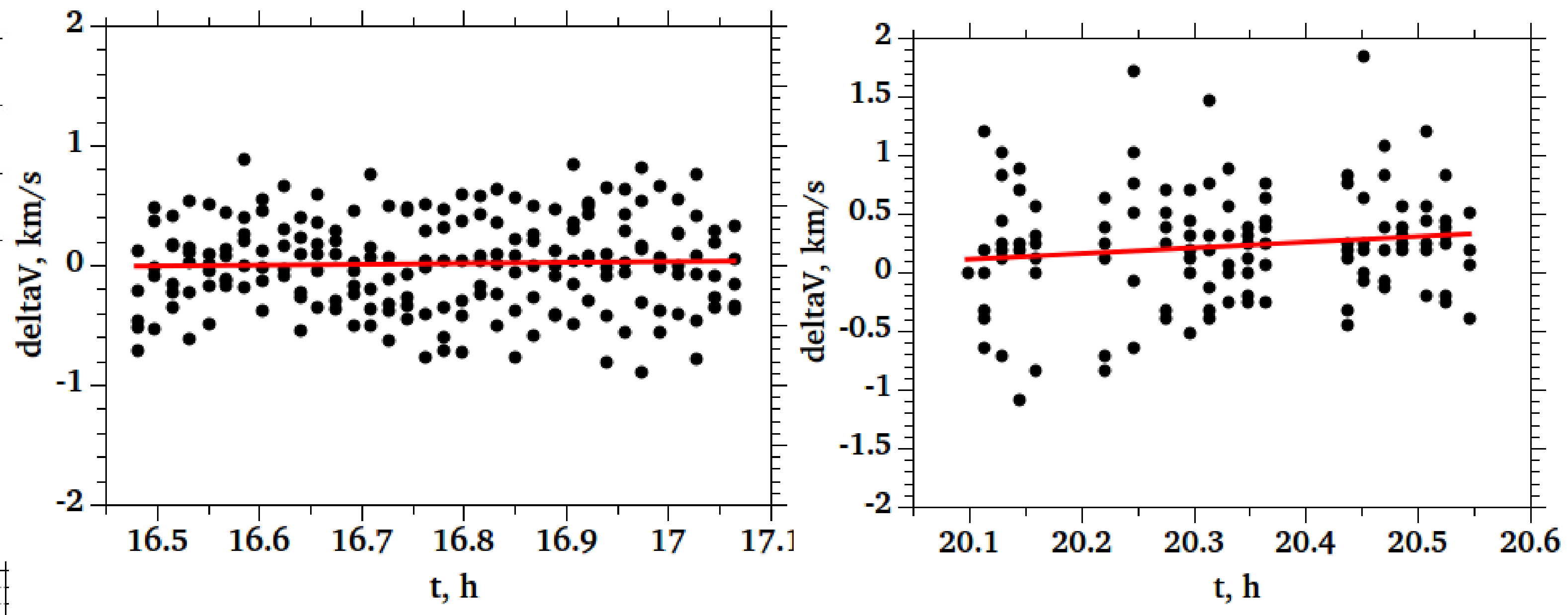
During the test observations we found a wave-scale shift correlated with temperature changes.

To investigate the temperature instability five thermal elements (DS18b20) were installed in the base of the stationary part of the spectrograph, three inside and two outside. An obvious correlation between the spectrum shift and base temperature changes was observed.

Temperature decreasing causes the spectrum redshift, increasing – the blueshift. It is related to the temperature deformations of the base of the stationary part of the spectrograph. The temperature inertia of the system is seen. As it is shown in the figure slow temperature increasing after the steep drop still shifts the spectrum to the red side due to the fact that the inner parts of the spectrograph base are still cool down. The shift dependence is not linear and changes with temperature gradient between inner and outer side of base. We suspect that such a significant shifts caused by bimetallic (Al+steel) construction of the base. An average shift is about 1.8px per degree, an average shift on the linear piece (temperature increase is 1.7*C/hour) is 1.64px/*C. The random error of the line location in case of stable temperature (+-0.06*C) is 0.1px which is a theoretical limit of the line centering error.

The only solution of the problem is thermo stabilization of the stationary part of the spectrograph. We plan to implement this work in nearest time.

The random error of radial velocity mesurement for ThAr lines. The left panel — motionless telescope, the right panel — moving telescope (azimuth 0, 90, 180, 270, 360 deg, altitude 20, 40, 60, 80 deg).



We tried to detect the correlation between wavelength shift and position of the telescope using ThAr lamp spectra got in short-time period (0.5 h) without steep temperature changes of the spectrograph base. Smooth temperature increase was taken into account by subtracting a linear trend. The results show that motions of telescope increase the random RMS error of the wavelength scale shift by 2 times, it equals 0.2px.

This effect is related to poor scrambling of light in a fiber.

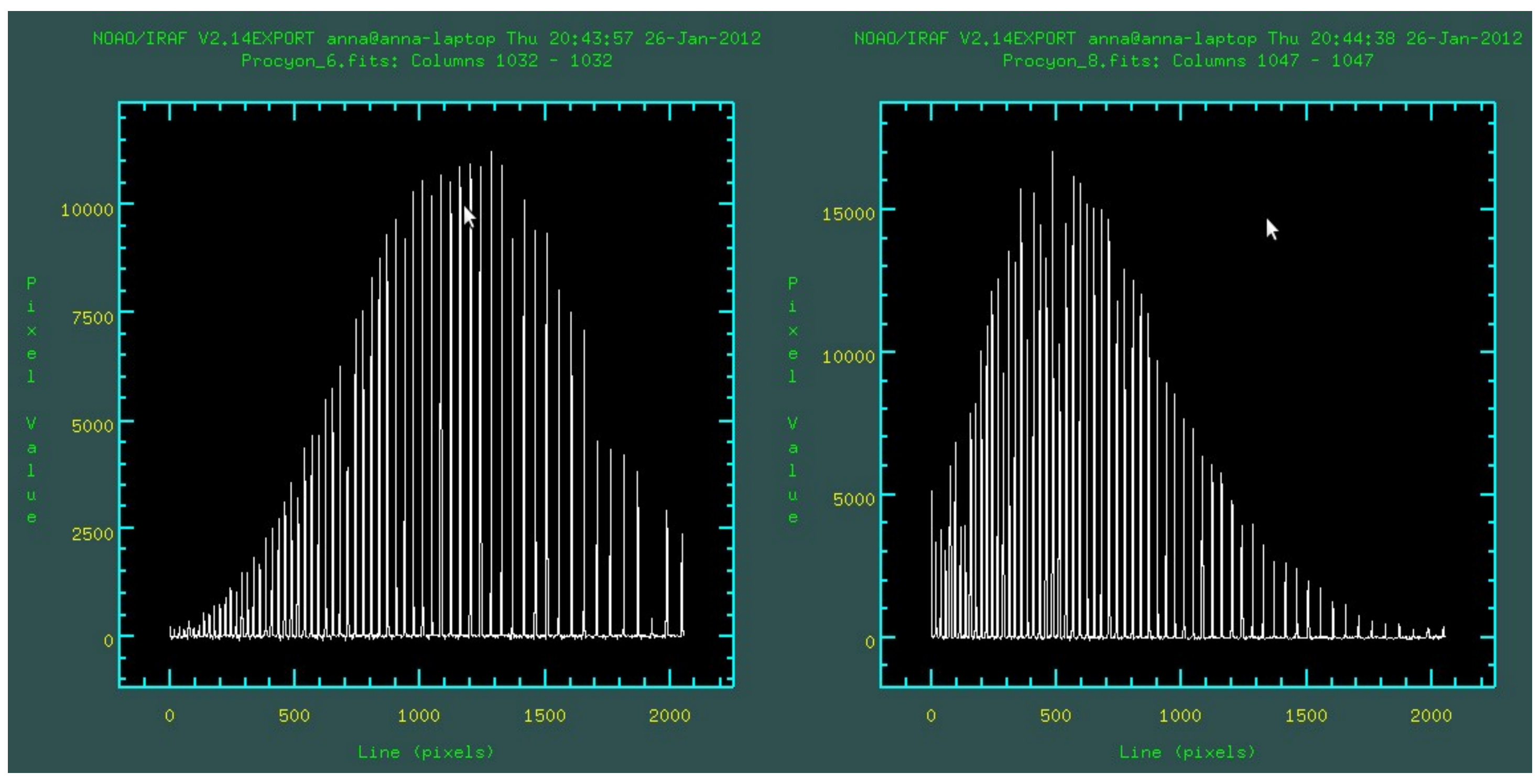
There is no any correlations between the shifts and position of the telescope.

We used the spectrum of the bright star Aldebaran to determine a radial velocity accuracy. Short exposure allowed to exclude the influence of temperature instability. The radial velocity measured by 167 lines in several orders differs from data by Massarotti [3] by -0.08 km/s, RMS=0.34 km/s.

During the test observations of Procyon on relatively high altitude (35 deg) we found out a significant influence of the atmospheric dispersion. The effect is clearly seen on the cross-dispersion profile of the echelle frame. The position of the flux maximum differs for various positions of the star on the fiber entrance.

An existing autoguiding system of the spectrograph don't work properly. We developed a project of a new on-telescope unit. 8R/92T beam-splitter and fast CCD camera will be used for guiding system. The new device allows using two fibers with different apertures (5 and 10 arcsec). This two configurations will provide spectral resolution 30 000 and 15 000 respectively. The new device will be available next year.

Cross-dispersion profile of the echelle frame for different position of star on the fiber entrance.



Acknowledgements

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