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Echellé Spectrograph with a Fabry-Perot Interferometer in the Inner Mounting

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Abstract. We discuss a design of the echellé spectrograph with Fabry-Perot interferometer on the inner mounting as an instrument for the Russian 6-m telescope BTA. Its potential spectral resolution is about $R \approx 360\,000$.

As it is well known (Jacquinot 1954) that the parameter of multiplication of the spectral instrument luminosity L by the spectral resolution R of a Fabry-Perot interferometer is larger than that of a diffraction grating by the order of magnitude for the same system pupil square A. We discussed the prospects of using of a Fabry-Perot interferometer (FPI) for high resolution spectroscopy on BTA in a paper by Panchuk (2000), where we described an interferometer on the external mounting (related to the NES spectrograph (Panchuk et al. 2009)). If FPI is the main disperse element, parameters of a spectrograph which is using for spectral order separation should not be very challenging for collimated beam diameter d_{coll}. In the case when the parameter d_{coll} is small there is a possibility to install FPI on the inner mounting for the interferometer to be operated in a collimated beam of the spectrograph.

We designed a mock-up of the echellé spectrograph with FPI on the inner mounting (see Fig.2 in the paper by Panchuk et al. (2015)). We used: lens collimator of a focus of $F_{coll} = 130$ mm and diameter of $D_{coll} = 34$ mm; the IT51-30 interferometer with splitting ring of $t = 3$ mm; echellé grating with a blaze angle of $\theta_b = 63\overset{\circ}{.}5$ and of 75 groves per mm and grooved area of 60×30 mm^2; lens camera of a focus of $F_{cam} = 200$ mm and diameter of $D_{cam} = 50$ mm. For a spectral order separation we use diffraction grating of 300 groves per mm of 40×40 mm grooved area that is operated in the first order instead of a prism, which we proposed to use in the previous version of the instrument. Because of this the structure of the instrument became more compact and it can be capsulated in a low pressure capsule if required. If we will use fiber of 0.05 mm diameter and FPI of Q-factor equal to 10 we will get a spectral resolution of about $R \approx 360\,000$; in the case of use of 100-mm diameter fiber the spectral resolution will be twice less. This is very useful for studies of chemically peculiar stars (Sachkov 2014). We use the mock-up described to improve the method software as well as the instrument control system. The design of the Nesmith-2 focus of the BTA telescope provides for the installation of a relatively small echellé spectrograph with FPI on the continuation of Z-axis of the telescope. We propose to use lens collimator of a focus of F_{coll} = 922 mm. FPI is installed into the collimated beam of a diameter of d_{coll} = 30 mm. An input diaphragm dimension corresponds to a working condition in the central part of the beam, a wavelength scanning is arranged by precise inclination of plates to the Z-axis. In the current version of the instrument we use the same echellé grating as in the previous mock-up, grooved area is of 120×60 mm^2. An grating of 300 groves per mm is used for spectral order separation. Lens objective parameters are: focus F_{cam} = 500 mm, diameter D_{cam} = 100 mm.

A calibration procedure will be performed simultaneously with interferograms registration by sending a laser beam through a central part of FPI's plates. A BTA primary focus cabin shadow is projected onto this central part. A light loss absence on the optics (in the case of external mounting, Panchuk (2000)) and the instrument dimension decreasing by two times are among of the main method advantages. A parasitic light caused by external inclined FPI plate planes is the main disadvantage of the design, but it is negligible in the case of stellar spectroscopic observations.

The proposed instrument will also be used during ground support observations of the World Space Observatory - Ultraviolet mission (Boyarchuk et al. 2013; Shustov et al. 2014; Panchuk et al. 2014; Malkov et al. 2011). We refer the interested readers to articles (Sachkov et al. 2014a,b,c) to track the instrumentation evolution of the project.

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