Multi-object spectroscopy in the observational complex of the RTT150

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The multi-object spectroscopy technique was implemented on the Russian-Turkish 1.5m optical telescope (aka. RTT150) by modifying the slit wheel of its main instrument TFOSC (TÜBİTAK Faint Object Spectrograph and Camera). Remotely controlled rotating holders of the multi object masks were installed in the two nests of the slit wheel. The accuracy of the mask unit's rotation is the order of 1 arcmin, in which the image plane for 2 sources located at a separation of 5 arcmin corresponds to a positional accuracy of 0.1 arcsec. To investigate the quality of the MOS technique in RTT150, the well-known merging galaxy cluster Abell 1914 was observed spectroscopically. The dispersion of the differences between known and RTT150 redshift estimations is 0.0006, which is good enough for cosmological studies.

Keywords: Multi-object spectroscopy, galaxy clusters: individual: Abell 1914, optical observations, astrophysics: instrumentation

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1. Necessity of MOS at RTT150

The main scientific goal of the Russian-Turkish 1.5m optical telescope, RTT150, is ground based follow-up observations of the X-ray sources of the joint Russian-German astrophysical space observatory Spektr-RG (SRG). For that purpose, one important task is the optical identification of high-energy sources discovered by the all-sky surveys of the Pavlinsky ART-XC X-ray telescope. The mean positional uncertainty of the ART-XC X-ray sources is about 50 arcsec, it means that in a region at low galactic latitude the number of optical sources to be observed spectroscopically with RTT150 can reach up to several dozens. In addition, nearly 20 thousand of galaxy clusters have been detected recently from the SRG eRosita telescope all-sky survey [1]. Only less than 50% of these clusters were previously known. At the end of the SRG mission it is expected to be discovered ∼100000 galaxy clusters. A significant number of eRosita galaxy clusters can be observed at the RTT150. It is well-known that the projected distribution of most of the brightest members around the clusters is within a few arcmin. Thus, to increase the efficiency of the observing time in spectroscopy for the moderately crowded fields of sizes up to several arcmin, we developed and implemented the facility for multi-object spectroscopy (MOS) at the RTT150.

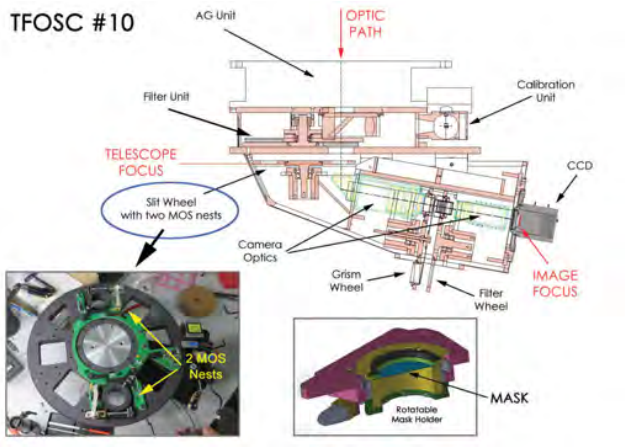


Figure 1: The schematic drawing of the TFOSC shown with the modified aperture wheel with the mask holder.

2. Modification of the multifunctional detector of RTT150

2.1. TFOSC

Available instrumentation at the RTT150 telescope makes it possible to perform comprehensive studies of the astrophysical objects including high-precision positional, photometric, and spectroscopic measurements, as well as polarimetric measurements of the linear polarization. The main instrument of the telescope, which implements all these observational methods, is an instrument from the FOSC series (#10) — TFOSC (TÜBİTAK Faint Object Spectrograph and Camera) produced by the Copenhagen University. The schematic drawing of TFOSC is shown in Fig. 1. The TFOSC system consists of two filter wheels before the telescope focal plane (Filter Unit), a wheel with a set of different slits and masks located in the focal plane (Slit Wheel), and a set of calibration lamps (Calibration Unit). Two additional filter wheels consisting of broad and narrow-band filters and other dispersion elements are located in the collimated part of the instrument (Grism and Filter wheels).

2.2 Aperture wheel modification

It is obvious that to observe all selected sources in moderately crowded and relatively small fields with less masks, it is necessary to distribute the slits with non-overlapping dispersion and to include as many sources as possible per mask. This condition implies that slit shape has to be pinhole. We have developed a remotely controlled rotating mask holder in the wheel nest with a replaceable head including a twist lock fixing. On the Fig.1 (lower left corner) the MOS mask holders are shown. All TFOSC wheels including the aperture wheel have the ability to rotate 360 degrees. Since there is only one part is moving in the MOS mask holder the other is not, transmission of power and control signals is a challenge. We solved this problem by installing concentric grooves isolated from each other on the aperture wheel itself in an unused area close to the rotation axis and fixed runners on a special mast in the aperture wheel adapter. The rotation of the mask holder is carried out by a worm gear coupled with a tiny stepper motor. Control system are based on a Teensy USB Development Board. The system has a mask rotation accuracy of 1 arcmin, which corresponds to a positional accuracy on 0.1 arcsec for simultaneous spectroscopy of the two sources in the TFOSC image plane located at a separation of 5 arcmin.

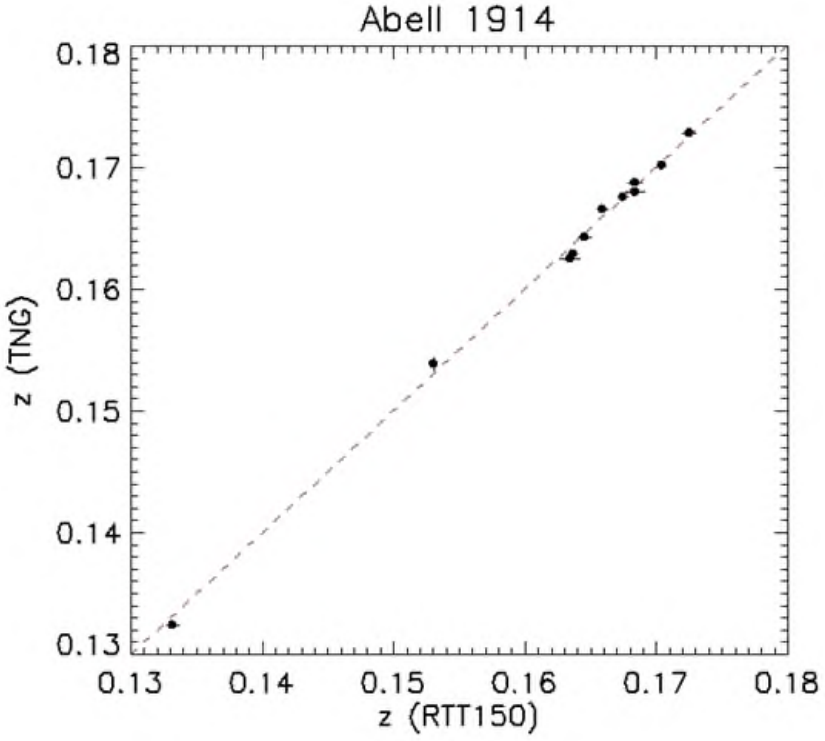


Figure 2: The correlation between TNG and RTT150 redshift measurements of the sources in the field of Abell 1914.

3. Test observation

To investigate the quality of the MOS technique that we implemented at the RTT150, we observed the well-known merging galaxy cluster Abell 1914. We used multi-objects mask with pinhole apertures. Since there is a sky background in the aperture besides the light from the source, additional holes for the blank sky were added to the mask. The details of the mask and the extraction of individual spectra are described in detail in [2]. The low resolution ($R \sim 600$) spectra from 40 pinholes covering spectral range from 4000 to 8500 were obtained using TFOSC-MOS in 11 Mart 2018 with an exposure of 1800s.

Redshifts of the galaxies were estimated by cross-correlating the target spectrum with a template spectrum of an elliptical galaxy. The redshifts of some galaxies were spectroscopically measured previously from the MOS spectra obtained at the 3.58m TNG telescope with 3600s exposure [3]. The correlation of the two sets of redshift measurements of the member galaxies of the Abell 1914 galaxy cluster and background galaxies in this field with brightness from 16^m up to 19^m is shown on Fig.2 (the dotted line shows the line of equality, $y = x$). The dispersion of differences between the TNG and the RTT150 redshift estimations is 0.0006, which is good enough for cosmological studies like identification and confirmation of galaxy clusters.

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References

1. R. Sunyaev, V. Arefiev, V. Babyshkin, A. Bogomolov, et al., *arXiv e-prints*, arXiv:2104.13267, 2021.
2. I. M. Khamitov, I. F. Bikmaev, R. A. Burenin, M. V. Glushkov, S. S. Melnikov, and A. R. Lyapin, *Astronomy Letters*, **46**, 1, 2020.
3. R. Barrena, M. Girardi, and W. Boschin, *MNRAS*, **430**, 3453, 2013.