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Bidimensional Spectroscopy with the 6-meter Telescope in Time Resolving Mode

V. L. Afanasiev, S. N. Dodonov, S. V. Drabek and V. V. Vlasiouk

Special Astrophysical Observatory of Russian Academy of Sciences, Nyzhnij Arkhyz, Russia,357147

1. Introduction

Degradation of images of astronomical objects during observations with large optical telescope may be described as combination of atmosphere turbulence on a time scale shorter than some tenths of a second and random fluctuation of object's position due to telescope and observer's guiding errors, bending of construction under external factors (wind, etc.). Special investigations on the 6-meter telescope (Balega,1989) showed, that the peak frequency of such low-frequency fluctuations is located near 1 Hz.

The method of Time Resolving Image Mode, developed by J.-L.Nieto et al (1987) for post-detection improvement of angular resolution at CFHT, showed that, even in places with excellent quality of atmosphere, the resolution of large telescope may be increased by 20-30% only, although powerful methods of image recentering and frames selection were performed. Moreover, such method of data processing may be applied to relatively bright objects only. For 6-meter telescope, resolution improvement would be useless at all due to smaller Fried parameter and larger main mirror.

2. Application of Time Resolving Method to bidimensional spectroscopy

Taking into account the need of accurate telescope guiding during spectral observations and available detectors, we choose the following instrument configuration : the Multi-Pupil Field Spectrograph (Afanasiev et.al., 1990) with 9 by 11 lens raster, which forms a corresponding set of micro-pupils as multi-slits in the collimator's focal plane. As detector, we used a photon counting system based on a 4-stage image intensifier EMI with magnetic focusing and TV tube. Image processing complex of the 6-meter telescope (Afanasiev et al., 1986) performs scanning of a 512 × 512 pixels of 30 μ frame at a 25 Hz frequency. Detected photon events are written after accumulation in the auxiliary data storage memory unit (hard disk of PC AT) in blocks with 4K coordinates.

Spatial sampling is choosen by observer according to weather conditions (seeing at first) and may be varied from 0.3 ″/lens (when the enlarger 30^x is used for projection of object's image onto lens array) to 1.6 ″/lens (with the 8^x enlarger). The spectral resolution of the instrument depends on the size of micro-pupil monochromatic image and of the dispersion. The most popular grating has 1200 mm^{-1} and yields a dispersion of about 2 Å/pix. The corresponding resolution is between 5 and 6 Å.

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During processing of each detected event its "parent" lens on the input array and wavelength are computed, using data about the location of individual spectra on the frame and wavelength-channel dependence inside them. The knowledge of each photon origin allows to restore the brightness distribution of the observed object in integral light. Photons from several successive frames may be coadded to reach a reasonable number to run a centering procedure. Usually the amount of successive frames is choosen equal to 4 or 8 and depends on the object brightness.

After determination of the barycenter of the obtained "direct image" (taking into account correction for atmospheric dispersion) a value of the displacement is defined. Using this displacement, it is possible to realize spectral data sampling onto pixels associated with a fixed object position. The angular size of these "quasi-pixels" may be also 2 - 4 times smaller to reach better sampling. Known values of wavelength for each photon allow to perform its distribution into 3- D cube (re-sampled coordinates and wavelength).

2.1. Resampling and recentering efficiency

In case of non-random shifts of the object during exposure due to variable wind pressure, errors of guiding, etc., the proposed method allows to preserve resulting data from significant degradation. As our data show, deviation of barycenter from "ideal coordinate" may be compensated for up to a factor of two at least, using the proposed correction method.

2.2. Correction of detector's instabilities

One of the major drawbacks of a photon counting system based on image intensifiers is its instability due to different reasons : electromagnetic (like influence of magnetic field of Earth), and mechanical. The above described processing of coordinates of all detected photons allows to correct such undesirable effects, which may produce shifts in data, exceeding 2-3 detector pixels, especially in case of long-time exposures. To measure the value of coordinate shift a method based on cross-correlation of successive data fragments, was used.

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