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L.N. Kondratyeva, F.K. Rspaev, E.K. Denissyuk, M.A. Krugov

Fesenkov Astrophysical Institute, Almaty, Kazakhstan
lu_kondr@mail.ru, eddenis@mail.ru, mkrugov@astroclub.kz

NEW RESULTS OF STUDY OF THE PLANETARY NEBULA M1-77

Abstract. The object M1-77 is known as the young low excitation planetary nebula. The variability of the brightness and the radial velocities of the metal lines lead some authors to the idea of the binary nature of the central star in the object. In this paper, the new photometric and spectral results obtained for the object M1-77 in 2009 – 2017, are discussed. Irregular variations of brightness in B, V, and R filters with an amplitude of ~ $0^m.4$ were detected. During our observations, the absolute fluxes in the emission lines Hα, [NII] and [SII] increased approximately as a factor 20. Significant changes of the fluxes began in 2011. Simultaneously, an increase of the electron density of the gas in the nebula was recorded. It can be assumed that the reason of the observed events is the reset of an additional mass of gas that has entered the nebula.

Key words: planetary nebulae, emission lines; individual: M1-77.

Introduction. The young planetary nebula M1-77 with the coordinates α(2000.0) = 21^h 19^m, δ(2000.0) = + 46° 19' was discovered in 1946 [1]. Different estimations for the distance were obtained: 2.4, 2.5 and 2.83 kpc [2, 3, 4]. It is assumed that the central star has the low effective temperature ~ 20000K. The diameter of the nebula is ~ 7" [2, 5]. Photometric observations [6] revealed rapid changes in the brightness of the object within the range $0^m.1$ - $0^m.2$.

In the spectrum, the emission lines HI, [NII] [SII] are observed on the background of a strong continuum. The relative intensities of the emission lines are presented in [5]. Absolute fluxes are given in [7]. According to [5], the radial velocity, measured from the emission lines Hα and [NII], equals to -84 ± 3 km/s. Rapid, within a few hours, changes in radial velocity were detected by De Marko [8]. One possible explanation is the binary nature of the central star in the object M1-77 [9].

Observations and processing In Fesenkov Astrophysical Institute the spectral observations of the M1-77 object are mainly performed on the telescope AZT-8 (70cm). CCD camera SBIG STT-3200 (2184x1472, 6.8μ) is used as radiation receiver at the output of the spectrograph. The available spectral range for observations is ~ 3500 Å (4000 - 7500 Å Å).

Additional spectral observations were made on a 1-meter telescope installed at the Tien-Shan Observatory. The telescope is equipped with a new diffraction spectrograph. At the output of the spectrograph there is a CCD camera SBIG Atik-16200 (4500x3600, 6μ). It has an increased sensitivity in the ultraviolet and, in principle, makes it possible to obtain spectrograms in the range from 3600 Å to 7500 Å. During observations, the spectrograms of the studied object are obtained with a narrow (2 "- 3") and with a wide (7 "- 10") entrance slit. Observations of a standard star with a known energy distribution are performed with a wide slit, which ensures the passage and recording of the full entire radiation flux. Standard processing of the files consists of subtracting the dark background, taking into account the flat field and the atmospheric absorption. The spectral sensitivity of the apparatus is determined by comparing the observed energy distribution in the spectrum of the standard with the data of the Catalog. After taking into account all the corrections, the values of the radiation fluxes in absolute energy units are determined. Spectrograms obtained with a narrow slit and with a resolution of 0.25 - 0.5 Å are used to study the structure of emission lines.