OPTICAL SPECTROSCOPY OF MT DRA IN 2006 AND 2009

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ABSTRACT. We present low-resolution phase-resolved spectra of the polar MT Dra during its high states in 2006 and 2009. Balmer series, He I and He II 4686 Å emission lines have complex shapes and show similar profile variations over an orbital cycle. The radial velocities vary with orbital period and display motions of the gas falling close to the magnetic poles of the white dwarf.

1 INTRODUCTION

AM Her type variables or polars are cataclysmic binaries which contain a magnetic white dwarf with fields from $10^7$ to $10^8$ G. The behaviour of the material flow from the red dwarf secondary is totally controlled by the magnetic field. The stream attached to the field lines is funneled to the white dwarf’s magnetic pole where an accretion column is formed. In the case of two magnetic poles active, two accretion columns exist. The location and shape of the accretion column will depend on the orientation of the magnetic dipole and on the location of the coupling region (see Warner 1995 for a review).

MT Dra (RX J1846.9+5538) is one of several polars with accretion onto two poles (Schwarz et al. 2002). During our sets of observations, the system was in a high brightness state. Here we present preliminary results of the analysis of our spectroscopic data.
2 OBSERVATIONS

Our spectroscopy of MT Dra was performed in the Special Astrophysical Observatory of the Russian Academy of Sciences (Nizhny Arkhyz, Russia) in two observing runs, on March 21–22, 2006 and October 21–22, 2009. Time-resolved spectra were obtained with the 6-m telescope using the SCORPIO focal reducer (Afanasiev and Moiseev 2005) in a long-slit mode, with a slit width of 1″, providing a spectral resolution of 5 Å. The EEV-42-40 2048 × 2048-pixel CCD camera and a grating with 1200 grooves per mm together yield the dispersion of 0.88 Å/pixel. On the two occasions, we obtained 34 spectra over almost three orbital cycles. The acquired spectra cover a wavelength range from 3900 Å to 5700 Å. Individual target exposure times were 300 s for 16 spectra in 2006; 900 s for 2 spectra and 600 s for 16 spectra in 2009.

We performed data reductions using the standard MIDAS packages. The procedure included standard bias, flat-field correction, and cosmic particles removal procedures, and optimal extraction of spectra, followed by wavelength calibration using He-Ne-Ar lamp frames. Typical continuum signal-to-noise ratio of an individual spectrum for the data of 2006 is \( \sim 30 \) and for the data of 2009, \( \sim 40 \). An example of the spectrum is given in Fig. 1.

3 RESULTS

During our observing runs, MT Dra was in a high brightness state. The spectra contain only emission lines and show no signs of the secondary. They are typical of polars in a high brightness state. Balmer series lines with a flat decrement, He I and strong He II lines are present. The N III+C III complex (Bowen blend) at 4640–4650 Å is also seen. Parts of the normalised spectra containing H\( \beta \) and HeII 4686 Å lines for both 2006 and 2009 are shown in Fig. 2. We use the ephemeris \( \text{HJD}_{\text{min}} = 2454676.446 + 0.0893869 \times E \) from Zubareva et al. (2011).

The line profiles have a very complex structure. They are asymmetric and show two or more peaks at some phases. Unfortunately, the resolution of the spectra is insufficient to distinguish between individual line components.
The radial velocities of H\(\beta\) and HeII 4686 Å lines were measured taking into account weights of every component of a line. Semi-amplitudes of the curves for both runs are close to 600 km s\(^{-1}\) (Figs. 3 and 4). Also given in the figures are the line widths (FWHM). The fact that radial velocities show almost sinusoidal changes is quite unusual. Since MT Dra was in its high-mass-transfer state during both observing runs, one would expect both accretion columns to contribute to the emission of the system. We suppose that the separation between the lines corresponding to different accretion columns is quite small, so the centroid velocities follow a sine wave.

The exact inclination of the system and the orientation of the magnetic dipole are still unknown. However, in some aspects MT Dra is similar to the well-studied polar ST LMi (Robertson et al. 2008) except that only one magnetic pole is active in ST LMi most of the time. The phase shift of \(\sim 0.2\) between the phased radial velocity curves for 2006 and 2009 runs could be explained using geometric considerations. Due to precession of the magnetic dipole axis around the rotation axis, we can see an accretion column (not necessarily cylindrical) in different positions at different phases (Ferrario and Wickramasinghe 1990).

Our observations were carried out under different conditions during the two runs and thus do not allow us to draw a more detailed picture. In order to get more information about MT Dra on the base of solely the optical region of the spectrum, simultaneous spectroscopy and photometry are necessary.

Acknowledgements. AMZ would like to thank E.A. Barsukova (Special Astrophysical Observatory) and Yu.V. Pakhomov (Institute of Astronomy) for their help in processing the spectra.

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Figure 1: A spectrum from the 2006 data set. The orbital phase is given.
Figure 2: Trailed spectra for He II 4686 Å line (a, c) and H\(\beta\) line (b, d) for both 2006 and 2009 data runs. The orbital phases for 2006 data are indicated on panel a, for 2009 data – on panel d.

Figure 3: MT Dra radial velocities and line widths (FWHM) from the 2006 data set. Open squares are for H\(\beta\), filled squares are for He II 4686 Å.
Figure 4: MT Dra radial velocities and line widths (FWHM) from the 2009 data set. Open squares are for H$\beta$, filled squares are for He II 4686 Å.