SPECTROSCOPIC SIGNATURES OF MAGNETOSPHERIC ACCRETION IN HERBIG AE/BE STARS

M. A. Pogodin [a*], ***N. A. Drake*** [b,c,d], ***N. G. Beskrovnaya*** [a], ***S. Hubrig*** [e], ***M. Schöller*** [f], ***S. P. Järvinen*** [e], ***A. Cahuasqui*** [g], ***O. V. Kozlova*** [h], ***I. Yu. Alekseev*** [h], ***S. E. Pavlovskiy*** [a]

[a] *Central (Pulkovo) Astronomical Observatory, St.Petersburg, Russia*

[b] *Laboratory of Observational Astrophysics, Si.Petersburg State University, Russia*

[c] *Laboratório Nacional de Astrofisica/MCTIC, MG, Brazil*

[d] *Laboratório Nacional/MCTIC, Rio de Janeiro, RJ, Brazil*

[e] *Leibniz-Institut für Astrophysik (AIP), Potsdam, Germany*

[f] *European Southern Observatory (ESO), Garching, Germany*

[g] *I.Physikalisches Institut, Köln, Germany*

[h] *Crimean Astrophysical Observarory, Nauchny, Crimean Republic, Russia*

Some Herbig Ae/Be stars show spectroscopic signatures indicating that accretion flows in these stars are guided from the circumstellar disk to the stellar surface by a magnetic field inside their magnetospheres. We consider three objects with such signatures. All of them can be divided into three groups: a) rotational modulation of spectral parameters originating near accretion region. These are the profiles of the infrared lines HeI 10830 and Paγ (the case of HD101412) and the lines HeI 5876 and Hβ in the visual spectral region (HD259431); b) cyclic variability of the HeI 5876 line profile when its red absorption component becomes strongly extended up to +400 km/s once during a rotation period (HD259431, HD37806); and c) fast variability of the red absorption component of the HeI 5876 line profile (during one night) in the form of standing intensity wavws. We can prove that all these phenomena can be observed only if the local accretion flows are rotating rigidly with the magnetic field of the star inside the magnetosphere.

Keywords: Herbig Ae/Be stars - Accretion disk - Magnetosphere.

* E-mail: mikhailpogodin@mail.ru

1. THE CASE OF HD 101412.

A1e – B9e, the surface magnetic field B∼3kG. the angle between the rotation axis and the line of sight i = 80° ± 7°, the angle between the magnetic and the rotation axis $\beta = 84° \pm 13°$ .The rotation period Prot = 42.076 ± 0.017 days [1].

30 spectra of HD 101412 were obtained in the near-IR region with the spectrographs CRIRES and X-shooter (ESO, Chile) from 2011 to 2013.

Using the method described in [2] we have found the variation period of several parameters of the lines forming in the region of the disk/star interaction (HeI 10830, Paγ) P = 21 days. Such syclic variability is a signature of two local accretion flows in the region of magnetic poles intersecting the line of sight twice during a rotation period. In more detail see [2].

2. THE CASE OF HD259431

Spectral type of the object is B5Ve, V sin i = 100 km/s.

More than 100 echelle spectra were obtained at 4 observatories (ESO, Crimean AO, OAN SPM and UFA AO). The Balmer emission lines show very variable profiles looking as either the PCyg-type or a double-peaked emission line with depression of the red wing (Fig.1, left). On these dates the red wing of the HeI 5876 line profile becomes very extended up to +400 km/s. It can be possible only in the case of the MA scenario.

We found the period of these variations P = 2.84 days. It corresponds to the expected rotation period of the star. The bisector velocity (Vbis) of Hβ at the 1.0 Fc level and the velocity of the red edge of the HeI 5876 (Vred) were used (Fig.1, right). We interpret this result as a signature of the rotating magnetosphere with the magnetic axis inclined to the rotating axis. At different phases of rotation the observer can see either the accretion flow at high magnetic latitudes or the wind zone at lower latitudes. We estimated the inclination of rotation axis i = 43° ± 3°. In more detail see [3].

3. THE CASE OF HD37806.

Spectral type of the object is A2e, V sin i = 120 km/s.

The profile of the HeI 5876 line forming in the region of the disk/star interaction shows a short-term variability looking like standing waves in the region of red absorption on the residual profiles constructed relative to the nightly mean (Fig.2, left top). According to the model calculations such variability can appear only if a rotating local stream intersects the line of sight which is orthogonal to the Surfaces of Equal Radial Velocities (SERVs) of the moving gas.

In the case of the Keplerian accretion disk (a) or such the disk with a radial motion (b), the SERVs are not orthogonal to the line of sight (Fig.2, left bottom) in the region between the star and the observer, and the short-term variations have to be looking as running waves on the residuals.

Only in the case of the MA scenario the SERVs intersecting the line of sight become orthogonal to it (Fig.2, right top). The figure is constructed for the simple geometric model (i = 90°, β = 90°). The model residuals are also shown in the figure (Fig.2, right bottom).

In the general case, for any geometry and orientation of the magnetic field configuration a character of SERVs stays similar. It is determined by a specific kinematics of the gas insude the magnetosphere: the radial velocity is minimal near the outer boundary of the magnetosphere and maximal near the stellar surface (free fall motion). Its rotation velocity is, on the contrary, maximal at the outer boundary of magnetosphere and minimum near the stellar surface (rigid rotation with the star).

We conclude that this type of short-term spectral variability can be considered as a signature of the MA scenario.

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