From Interacting Binaries to Exoplanets: Essential Modeling Tools
Proceedings IAU Symposium No. 282, 2011
Mercedes T. Richards & Ivan Hubeny, eds.

doi:10.1017/S1743921311027608

Search for Tidally Driven Anomalies in the Atmospheres of Am Stars

Ivanka Stateva[1], Ilian Iliev[1] and Ján Budaj[2]

[1]Institute of Astronomy with NAO, Bulgarian Academy of Sciences,
Sofia 1784, Bulgaria
email: stateva@astro.bas.bg
[2]Astronomical Institute, Slovak Academy of Sciences,
059 60 Tatranska Lomnica, The Slovak Republic

Abstract. We present here the systematic study of the chemical abundances of Am stars in order to search for possible abundance anomalies driven by tidal interaction in these binary systems. These stars were put into the context of Am binaries with $10 < P_{\rm orb} < 180d$ and their abundance anomalies discussed in the context of possible tidal effects. There is clear anti-correlation of the Am peculiarities with $v \sin i$. However, there seems to be also a correlation with eccentricity and orbital period.

Keywords. diffusion, stars: abundances, stars: chemically peculiar, stars: binaries: close

1. Introduction

The Am stars is a subgroup of Chemically Peculiar stars on the upper MS. The spectra are characterized by unusually weak spectral lines of light elements like C, Mg, Ca and Sc and contrary, abnormally strong lines of the iron peak and heavier elements. The obtained peculiarities appear to be due to microscopic selective diffusion driven mainly by the radiation pressure and the gravity. Rotation was found to play a key role in this process as it induces a large scale mixing which could disturb the slow diffusion process. The Am peculiarity seems to depend on the orbital elements in a binary system as well. Iliev *et al.* (1998) studied the dependencies between the rotational velocity, orbital period, eccentricity and the abundances in the Am stars. They concluded that there are a number of subtle effects that are difficult to understand if the rotation, stellar age, and mass are the only agents determining the Am peculiarity. The Am phenomenon seems more pronounced in binaries with eccentric orbits and longer orbital periods provided that the binary components are still within the reach of tidal effects.

We started a systematic study (Budaj & Iliev 2003, hereafter Paper I); and Iliev *et al.* 2006, hereafter Paper II) of the Am peculiarity in binary stars in order to search for abundance anomalies driven by the tidal interaction in these systems.

2. Observations, atmospheric parameters and spectral synthesis

Observations were carried out with the 2m RCC telescope of NAO-Rozhen. The Photometric AT200 camera with a SITE SI003AB 1024x1024pxs CCD chip was used to obtain spectra in the spectral region around 6439 Å. The typical S/N ratio was about 300, the resolving power R=30 000. Standard IRAF procedures were used for bias subtraction, flat-fielding, and wavelength calibration.

The atmospheric parameters were derived from both *uvbyβ* and Geneva photometry. In the case of *uvbyβ* photometry, we used the TEFFLOGG code of Moon & Dworetsky (1985); and for Geneva photometry, we used the calibration of Künzli *et al.* (1997).

A detailed spectrum synthesis of the spectral regions was accomplished using the code SYNSPEC (Hubeny, Lanz & Jeffery 1994; Krtička 1998). Model atmospheres were interpolated from Kurucz (1993). The VALD atomic line database (Kupka *et al.* 1999) was used to create a line list for the spectrum synthesis.

3. Results

We studied the dependences between the chemical abundances and the orbital elements of the binary systems, $v \sin i$ and $T_{\rm eff}$. The main advantage of our analysis is the homogeneity of the observational material we used - all data were obtained at one telescope with the same spectrograph and detector. The Am peculiarities are mainly manifested by a Ca deficit and Fe overabundances and they could be represented through the values of [Ca/Fe]. This ratio would multiply the effect of Am peculiarities because these two elements have displayed opposite behavior.

Up to now, 15 stars from our sample have been fully processed. Two of the stars were found not to be Am stars.

First, we investigated the dependences of [Ca/Fe] on the eccentricity. Despite some scatter in the data, there seems to be a trend: the correlation coefficient is -0.55±0.05. One star, HD 198391, is distinguished from the common trend. This star is the hottest star amongst the sample and it is not a typical Am star. Namely, the Am peculiarities increase ([Ca/Fe] decreases) with increasing eccentricity.

The dependence of [Ca/Fe] on the orbital period is not as clear, but still there is a tendency for the metalicity to increase towards the longer periods. The eccentricity and the orbital period, are not fully independent because of the synchronization and circularization of the orbits. That was the reason for analysing only stars with $10 < P_{\rm orb} < 180d$.

We studied also the dependence of the Am peculiarities on the projected rotational velocity of the Am stars. In general, there is a clear trend of increasing the peculiarity (decreasing of [Ca/Fe]) towards small values of $v \sin i$; the correlation coefficient is +0.85±0.04. Besides the hottest star already mentioned, two other stars, both marginal Am stars, do not follow the common trend. The departure of these two stars from the clear smooth correlation of metallicity and $v \sin i$ that the rotation is not the only agent responsible for this peculiarity.

The dependence of the Am peculiarity on the effective temperature was also checked. There are might be a trend of decreasing the peculiarity with the temperature.

Acknowledgments

This work is partially supported by grant DO 02-85 from the Bulgarian NSF and by VEGA grants 2/0074/09, 2/0078/10, 2/0094/11 from the Slovak Academy of Sciences.

References

Budaj J. & Iliev I. K.h., 2003, *MNRAS*, 346, 27 (Paper I)

Hubeny I., Lanz T., & Jeffery C. S. 1994, *in Jeffery C.S., ed, Newsletter on Analysis of Astronomical spectra, No.20, CCP7. St. Andrews Univ.*, St.Andrews, p. 30

Iliev I. K.h., Budaj J., Zverko J., & Barzova I. S., Žižňovský J. 1998, *A&AS*, 128, 497

Iliev I. K.h., Budaj J., Feňovčik M., Stateva I., & Richards M. T., 2006, *MNRAS*, 370,819 (Paper II)

Krtička J. 1998, *in Dušek J., Zejda M., eds, Proc. 20-th Stellar Conf. Nicholaus Copernicus Observatory and Planetarium*, Brno, p. 73

Kupka F., Piskunov N. E., Ryabchikova T. A., Stempels H. C., & Weiss W. W. 1999, *A&AS*, 138,119

Künzli M., North P., Kurucz R. L., & Nicolet B. 1997, *A&AS*, 122, 51

Kurucz R. 1993, *ATLAS9 Stellar Atmosphere Programs and 2km/s Grid (Kurucz CD-ROM 13)*

Moon T. T. & Dworetsky M. M. 1985, *MNRAS*, 217, 305