X-Ray Emission from OB Stars with Weak Magnetic Fields

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DOI:10.26119/978-5-6045062-0-2_2020_293

We test the hypothesis that X-rays from OB stars weakly depends on their magnetic fields. We suppose that X-rays originate mainly from the thermal emission of hot gas heated by shocks formed in the radiative stellar wind due to the line driving instability (LDI, Lucy & White 1980). Blobs in the wind ploughing through less radiatively accelerated an ambient gas form the forward shocks heating gas and enhancing X-rays as it pointed out by Lucy (2012); Guo (2010).

At the same time the X-rays from OB stars can be partly nonthermal. Chen & White (1991) proposed that X-rays with energy higher than 2 keV can have non-thermal contribution and be generated as a result of inverse Compton scattering of UV-photons by relativistic electrons. Authors predict a weak (a few Gauss) magnetic field of O stars. Ryspaeva & Kholtygin (2020a) estimated the power component contribution in X-ray spectra of OB stars describing possible non-thermal X-ray emission. They revealed the correlations of fraction of power component in full X-rays vs. plasma temperature and spectral hardness vs. spectral index.

We reanalized archival X-ray observations of 39 O stars and 43 B stars obtained by "XMM-Newton" satellite in 2001-2017. Their spectra were approximated by different models using the "XSPEC 12.10.0" package.

We fitted stellar X-ray spectra using the model of shocked plasma PSHOCK[3] by Borkowski et al. (2001) and a model APEC[4] of emission from collisionally-ionized gas by Smith et al. (2001). The following model combinations were tested.

APEC+PSHOCK, APEC+APEC+PSHOCK

PSHOCK+PSHOCK

PSHOCK+PL, 2PSHOCK+PL

Here the model PL (power law) describes possible non-thermal X-ray emission. Our analysis shows that X-ray spectra of OB stars indeed can be described by these models. We compared in Fig. 1 the reduced χ^2 values for our models with those for purely thermal models by Ryspaeva & Kholtygin (2020a).

[3] https://heasarc.gsfc.nasa.gov/docs/xanadu/xspec/manual/node214.html

[4] https://heasarc.gsfc.nasa.gov/docs/xanadu/xspec/manual/node135.html

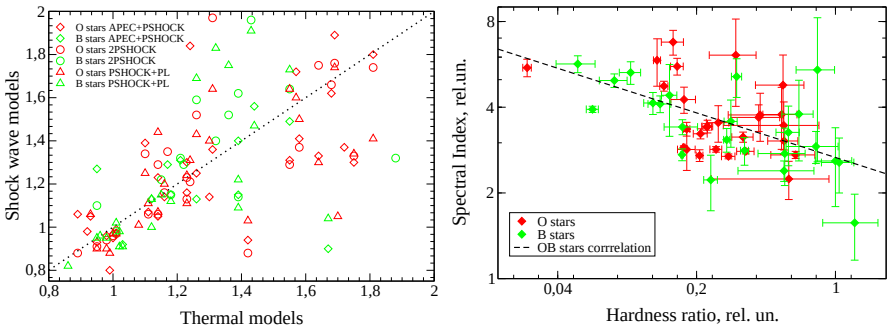

Fig. 1. *Left panel:* A comparison of χ^2 values for thermal models APEC and those with PSHOCK model. *Right panel:* The dependence between spectral index and hardness ratio for PSHOCK+PL models.

We trace possible correlations between parameters of spectral fitting by PSHOCK+PL, PSHOCK+PSHOCK+PL models. The power dependence between spectral index and hardness ratio with the correlation coefficient $R = 0.54$ and false alarm probability FAP-0.006 was revealed. The similar correlation is valid for fitting by model APEC with additional power component accordingly by Ryspaeva & Kholtygin (2020b). In contrast to modeling by APEC+PL, there is no dependence between fraction of power component and plasma temperature. This fact can be explained, that spectral indexes from two above approaches are very similar, but fraction of power components differs. Our modeling confirms that the magnetic field of OB stars weakly affect their X-ray spectra.

Acknowledgements. AK is grateful for support from the Russian Science Foundation grant 18-12-00423.

Bibliography

Borkowski, K. J., Lyerly, W. J., & Reynolds, S. P. 2001, ApJ, 548, 820
Chen, W. & White, R. L. 1991, ApJ, 366, 512
Guo, J. H. 2010, A&A, 512, A50
Lucy, L. B. 2012, A&A, 544, A120
Lucy, L. B. & White, R. L. 1980, ApJ, 241, 300
Ryspaeva, E. & Kholtygin, A. 2020a, Research in A&A, 20, 108
Ryspaeva, E. B. & Kholtygin, A. F. 2020b, Astrophysical Bulletin, 75, 127
Smith, R. K., Brickhouse, N. S., Liedahl, D. A., & Raymond, J. C. 2001, ApJ, 556, L91