

MWC 656: A Be+BH or a Be+sdO?

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Abstract. MWC 656 has been reported as classical Be star with a black hole companion. Revisited spectral variability properties render this unlikely, with a hot subdwarf more probable.

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1. Introduction

Casares et al. (2014) identified MWC 656 (HD 215227) as a binary consisting of a classical Be star and a black hole (BH). The interest in this star was triggered by a γ -ray detection with 0.6° error circle (Williams et al. 2010). The identification of a BH in MWC 656 hinges on radial velocities (RVs) from optical spectra, most critically on FeII $\lambda 4583$ emission from a circumstellar disk tracing the motion of the Be primary.

More recently, however, Be stars are being recognized in large numbers as Be+sdOB systems, i.e., with hot subdwarf companions (Wang et al. 2021), some showing striking similarities to MWC 656. For a conclusive distinction between a Be+BH and a Be+sdO system, we re-examined the original data together with new higher-resolution spectra from the past decade, namely the original 32 blue and 64 red spectra of Casares et al. (R=5500), four echelle spectra from amateur observers (R=9 000-12 000) from the BeSS database, three epochs of linear polarimetry, i.e., with very high S/N , from ESPaDOnS (R=48 000) at the CFHT, and twelve spectra from ARCES (R=31 500) at Apache Point Observatory.

2. Results

Re-determination of the orbital period: The combined spectroscopic database proved incompatible with the period of 60.37 ± 0.04 d found by Williams et al. (2010) in suboptimal photometric data and adopted by Casares et al. (2014). Fourier analysis of our new RV measurements from fitting a Gaussian to all the relatively narrow HeII $\lambda 4686$ emission profiles suggests a similar and highly significant period of 59.12 ± 0.05 d.

Radial velocity amplitudes: The semi-amplitude, K_2 , of HeII $\lambda 4686$ is virtually identical to that obtained by Casares et al. (2014) from the same line, i.e., about 80 km/s (Fig. 1, left). However, the optically thin double-peaked emission lines from the disk surrounding the Be star *do not* simply shift due to orbital motion, but also vary in peak

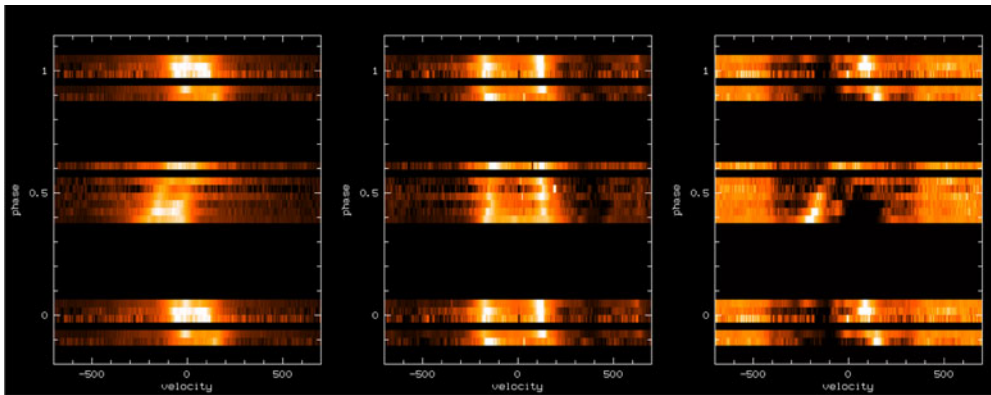


Figure 1. New spectra folded with revised period. $\pm 20\%$ phase extensions are shown for clarity. From left to right, the spectral lines are HeII $\lambda 4686$, FeII $\lambda 5317$, and HeI $\lambda 6678$. As phase zero, we adopt the periastron time given by Casares et al. (2014).

separation (Fig. 1, middle). This is due to the tidal distortion of the disk (Panoglou et al. 2016) and makes the line peaks unsuitable for measuring the RV amplitude of the Be star, K_1 . The effect is well illustrated also by the base of H α that changes in width with the orbital period. Since Casares et al. (2014) used such lines to measure K_1 , this invalidates their results and thus also the mass ratio which led to the suggestion of a BH.

In the new spectra, we detected photospheric lines from the Be star, in particular HeI $\lambda 6678$ (Fig. 1, right). The outer edges have peak-to-peak RV amplitudes of about 20 km/s (red side) and 30 km/s (blue side), respectively. The implied amplitude of K_1 of 10 to 15 km/s is at least a factor of 2 less than the value of 32 km/s derived by Casares et al. (2014). At $K_1 = 7$ km/s, the RV amplitude of H α (measured via the bisector of the lower wings) is even lower. This correction reduces the mass of the companion to the Be star by a similar factor and probably removes it from the BH domain.

3. Discussion

The HeII $\lambda 4686$ emission, from which the RV amplitude, K_2 , of the companion to the Be star was determined, is double-peaked and arises from an accretion disk around the companion. It is fed by spillover from the disk around the Be star. Such variable emission is also seen in the well-known Be+sdO binaries φ Per, 59 Cyg, and HD 55606 (Chojnowski et al. 2018). In addition, there are circumstellar gas streams, also similar to many sdO stars: Fig. 1 shows the new spectra phased with the orbital period: The HeI $\lambda 6678$ emission traces the orbit of the secondary, just as HeII $\lambda 4686$ does. But there is also an additional, phase locked *absorption* component. Around phase 0.4 it grows into a very deep shell absorption lasting for about 15% of the cycle. Owing to the lack/weakness of X-rays, Casares et al. (2014) posited that the BH is quiescent, i.e., non-accreting. The improved spectroscopic mapping of the gas in the system contradicts this.

Hence, MWC 656 is more likely to host a hot-subdwarf instead of a black-hole, and its proximity no longer serves to indicate a relatively large number of Be+BH binaries.

References

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