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SC3-63371 and SC4-67145: two wind-interacting A+B binaries

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Abstract. We report on two SMC objects with remarkable light curves and spectra. Both are in fact A I + B III binaries that exhibit interacting winds. We show a sketch of the geometry.

Keywords. stars: emission-line, Be, stars: winds, outflows, stars: variables: other

1. Introduction

SC3-63371 ("SC3") and SC4-67145 ("SC4") are 2 of 8 Small Magellanic Cloud "Type 3" variables (Mennickent *et al.* 2002: Be candidates defined by nearly periodic I-band light curves) brighter than $M_v = -4.2$. Previous low-dispersion spectra exhibited strong H/K and D lines and Hα emissions. These features indicated conflicting A and Be type classifications. These unusual properties motivated us to obtain 3 high dispersion spectra of both objects in 2004, 2007, and 2009 and a far-UV (*FUSE* satellite) observation. These results are published fully by Mennickent & Smith (2010a). We also undertook a several year photometric campaign to characterize flux variability. The photometry has been published by Mennickent *et al.* (2010b). Light curves of both objectss show short periods, possibly due to nonradial pulsations. SC3's light curve also exhibits a regular 238.1 day period, complicated by an ellipsoidal variation and a reflection effect that suggests the star is in a highly eccentric binary. SC4 exhibits a periodic 184.26 day eclipse, the duration of which is much too long to arise from the transit of a stellar companion, suggesting the presence of a long column density of circumstellar matter. Our radial velocity measures (Fig. 1, inset) are consistent with the binary interpretation for SC4.

2. Spectroscopic Analysis

We have used SYNSPEC code to model the Ca II K line and derived spectral types of A6 I and A5 II with the optical spectrum. These types and classes agree well with matchings of comparison stars in the UVES Paranal Spectral Atlas as well as a comparison of optical magnitudes and the SMC's distance modulus of 19.0. Modeling strengths of several Fe III lines and the C III λ1176 complex likewise suggests spectral types of B3 III for both UV spectra. These comparisons indicate that both objects are A + B binaries. The v*sin i* values of all components are moderate (20-75 km s^{-1}). Remarkably, the 2 objects out of the 8 brightest Mennickent Type 3 stars are evolutionarily very similar.

The far blue spectra of SC3 and SC4 disclose sharp Balmer cores up to ∼H30. In the optical metallic lines of both SC3 and SC4 exhibit components of the photosphere and a circumbinary (CB) disk. However, red He I lines present in spectra of (only) SC3 suggest a hot medium with a relative blueshift of some 74 km s^{-1}. This indicates that the hot region responsible for them is not cospatial with the metallic line forming regions.

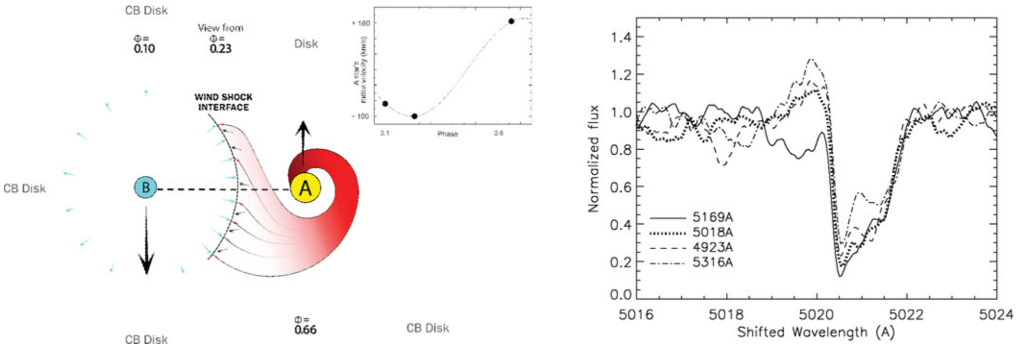

Figure 1. Left: Cartoon of wind-wind interaction and gas streaming into the ≈A5 II star of SMC4. Right: Difference in the blue and red wings of common-multiplet Fe II lines in a single spectrum of SC4 in 2009 (photometric phase 0.66). The weakest lines (e.g. λ5316) exhibit blue wing emissions and the strongest line of the series, λ5169, shows absorption.

The optical line profiles of SC4 at all times show stationary "Blue Absorption Components, a phenomenon reported to date apparently for only one other star, N8 (putatively sgB[e], Heydari-Malayeri 1990). In addition, weak emissions are present in medium-excitation that can mask the visibility of the stellar/CB components. In some phase, secondary blue absorptions or emissions can be observed, even for example in optically thin lines of a common Fe II multiplet. Fig. 2 shows overplotting of such Fe II lines from a single spectrum, showing changes from absorption (weak multiplet member) to emission (strong member). Such variations among multiplet members speak to formation in a inhomogeneous medium. We suggest that these optically thin components form across a narrow wind-wind shocking zone, where physical conditions can change over relatively small scale lengths. We believe also that in the SC3 system the He I line emissions arise in a i more energetic wind-wind shock, distinct from other line formation regions.

The strong Hα emission in the spectra of both objects suggests an extended equatorial disk. However, the small velocity separations of the V and R emission peaks, when assessed against the long periods of these systems, strongly suggests the disks are circumbinary and not circumstellar. The radial velocity variations of SC4 suggest the characteristic disk size is three times the binary separation. However, the He II emissions and the qualitatively different blue components - absorption to emission such as in Fig. 2 - suggest that the formations of these features in shocks. Fig. 1 is a sketch of the geometry we envision, as seen from the pole of the binary. Here observers see the effects of wind-wind shocks between the star in which wind detritus spirals into a column toward the A supergiant. At phase $\phi \sim 0.0$ the observer looks through this column, which is thick enough to exhibit the 184 day light eclipses in the photometry.

Post-ZAMS Ae stars have been known to exist mainly among supergiants, and their spectra exhibit weak ephemeral Hα emission components. But we now see that "Be-like" Balmer emissions also occur in spectra of a new class of wind-interacting A I + B binaries.

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The core of the LOC. From left to right and top to bottom: Evelyne Alecian; Michèle Floquet; Olga Martions, Annick Oger, Evelyne Alecian, and Bertrand de Batz; Bertrand de Batz, Michèle Floquet and Bernard Leroy; Coralie Neiner; Evelyne Alecian; Michèle Floquet; Coralie Neiner.

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