Clumping in Hot Star Winds
W.-R. Hamann, A. Feldmeier & L.M. Oskinova, eds.
Potsdam: Univ.-Verl., 2008
URN: http://nbn-resolving.de/urn:nbn:de:kobv:517-opus-13981

Far-ultraviolet spectroscopy of O+O binaries in the Magellanic Clouds

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We report FUSE observations in 2005–2006 of three O-type, double-lined spectroscopic binaries in the Magellanic Clouds. The systems have very short periods (1.4–2.25 d), represent rare, young evolutionary stages of massive stars and binaries, and provide a unique glimpse at some of the most massive systems that form in dense clusters of massive stars. Improved orbit parameters, including revised masses, for LH54-425 are derived from new CTIO spectroscopy. The systems are: LH54-425 in the LMC (O3V + O5V, P=2.25 d, 62+37 $M_\odot$), J053441-693139 in the LMC (O2-3If + O6V, P=1.4 d, 41+27 $M_\odot$), and Hodge 53-47 in the SMC (O6V + O4-5IIIf, P=2.2 d, 24+14 $M_\odot$, where the O4 star appears to be less massive than the O6 star). Their short periods indicates that wind interaction and mass transfer are likely important factors in their evolution. The spectra provide quantitative and systematic studies of phase-dependent stellar wind properties, wind collision effects in O+O binaries at lower metallicities, improved radial velocity curves, and FUV spectro-photometric changes as a function of orbital phase.

LH54-425 (LMC). This binary, with P=2.2475 d, is one of the most massive known. Its binary nature was discovered by Ostrov (2002, MNRAS 336, 309), who derived masses of 100 $M_\odot$ for the primary and 50 $M_\odot$ for the companion. New optical spectroscopy obtained by one of us (SW) at the CTIO 1.5m provide a new radial velocity curve, slightly updated period, and significantly improved values of the orbital parameters. The revised stellar masses are 62 and 37 $M_\odot$ and spectral types are O3V and O5V. Ostrov found the primary to be O3 III (f*), but the new optical spectra (Hα profile) indicate $\log g$=4.0 and a main-sequence luminosity class. However, comparison of FUV spectra of LH54-425 with other early O stars in the LMC show the P-Cygni emission of S VI and O VI may be more consistent with O3 III. The v_∞ of the stellar wind of LH54-425 is 2800 km/sec. LH54-425 is the earliest type star, and one of the most luminous, in the LH54 OB association.

Hodge 53-47 (SMC). Classified as O6V+O4-5III(f) by Morrell et al. (2003, MNRAS 341, 583) who performed the first orbit analysis and found masses of 24 ± 3 $M_\odot$ for the O6 star and 14 ± 3 $M_\odot$ for the O4 star. The periodicity of 2.206 days was discovered in the OGLE survey. It is remarkable that the O4 star is the secondary (less massive) star, indicating that the mass ratio of the system has reversed due to mass transfer and/or loss. H53-47 has undergone significant mass transfer to arrive at the current situation of mass inversion. This may be a short-lived transition phase to a Wolf-Rayet stage. Since H53-47 has undergone significant mass transfer, the current secondary, formerly the more massive star, may show enhanced CNO abundances in its atmosphere. The O6 primary might also have increased CNO abundances as the result of mass accretion from its companion. FUSE observed H53-47 in Oct 2005 and in Nov 2006. Another star (H53-46) 3 arcsec from H53-47 required the use of a narrow slit, and this resulted in incomplete wavelength coverage of the FUV spectrum of H53-47.

J053441-693139 (LMC). Discovered by the MACHO project and catalogued as MACHO 81.8763.8. It is one of the brightest of 611 new eclipsing binaries discovered in their survey of the LMC (Alcock et al. 1997, AJ 114, 326). The system does not appear to have been previously cataloged as a binary or even as an O star. The spectral classification of O3If*+O6V was determined by Ostrov (2001, MNRAS 321, 250), who also performed the first orbit analysis and found stellar masses of 41 ± 1 $M_\odot$ and 27 ± 1 $M_\odot$. The spectral classification was revised by Walborn et al. (2002, AJ 123, 2754) to O2-3 If* + O6:V, making the primary one of the few stars in the new O2 spectral type. With P=1.4047 d, this is one of the shortest periods of any O+O binary, and the most massive of any O binary with $P < 2$ days. The orbital solution of Ostrov (2001) shows that the stars are in over-contact, as might be expected from the derived masses and very short period. This stage of evolution must be quite short, making this object unique. A single FUSE observation was obtained on Sep. 22, 2006 for 28 ksec spanning about half of a binary orbit. The P V 1118, 1128 and Si IV 1122 lines vary significantly with orbital phase for all three O-type, double-lined spectroscopic binaries.