Radio emission from the massive stars in the Galactic Super Star Cluster Westerlund 1

S.M. Dougherty(1,2), J.S. Clark(3), I.Negueruela(4), T. Johnson(1,5) and J.M. Chapman(6)

(1) NRC-HIA, (2) Univ. of Calgary, (3) The Open University, (4) Universidad de Alicante, (5) Univ. of Victoria, (6) ATNF

Aims: Current mass-loss rate estimates imply that main sequence line-driven winds are not sufficient to strip away the H-rich envelope to yield Wolf-Rayet (WR) stars. The rich transitional population of the young massive cluster Westerlund 1 (Wd 1) provides an ideal laboratory to observe and constrain mass-loss processes throughout the transitional phase of stellar evolution.
Methods: We present an analysis of deep radio continuum observations of Wd~1 obtained with the Australia Telescope Compact Array at four frequency bands that permit investigation of the intrinsic characteristics of the radio emission.
Results: We detect 18 cluster members, a sample dominated by the cool hypergiants, with additional detections amongst the hotter OB supergiants and WR stars. The radio properties of the sample are diverse, with thermal, non-thermal and composite thermal/non-thermal sources present. Mass-loss rates determined for stars with partially optically thick stellar winds are
$\sim10^{-5}\,M_{\odot}\,yr^{-1}$ across all spectral types, insufficient to enable the formation of WRs during a massive star lifetime, and the stars must undergo a period of greatly enhanced mass loss. The sgB[e] star W9, the brightest radio source in Wd 1, may provide an example, with a current mass-loss rate an order of magnitude higher than the other cluster members, and an extended nebula interpreted as a wind from an earlier epoch with a density $\sim3\times$ the current wind. Such an envelope structure in W9 is reminiscent of luminous blue variables, and one that shows evidence of two eras of high, possibly eruptive mass loss. Surprisingly, three of the OB supergiants are detected, implying unusually dense winds, though they are embedded in more extended emission regions that may influence the derived parameters. They also may have composite spectra, suggesting binarity, which can lead to a higher flux than expected from a stellar wind. Spatially resolved nebulae are associated with three of the four RSGs and three of the six YHGs in the cluster, which are due to quiescent mass loss rather than outbursts. The extended nebulae of W20 and W26 have a cometary morphology, implying significant interaction with either the intracluster medium or cluster wind. For some of the cool star winds, the ionizing source may be a companion star though the cluster radiation density is sufficiently high to provide the necessary ionizing radiation. Five WR stars are detected with composite spectra, interpreted as arising in colliding-wind binaries.

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Comments:

Email: sean.dougherty@nrc.ca