Radio emission models of Colliding-Wind Binary Systems - Inclusion of IC cooling

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Radio emission models of colliding wind binaries (CWBs) have been discussed by Dougherty et al. (2003). We extend these models by considering the temporal and spatial evolution of the energy distribution of relativistic electrons as they advect downstream from their shock acceleration site. The energy spectrum evolves significantly due to the strength of inverse-Compton (IC) cooling in these systems, and a full numerical evaluation of the synchrotron emission and absorption coefficients is made. We have demonstrated
that the geometry of the WCR and the streamlines of the flow within it lead to a spatially dependent break frequency in the synchrotron emission. We therefore do not observe a single, sharp break in the synchrotron spectrum integrated over the WCR, but rather a steepening of the synchrotron spectrum towards higher frequencies. We also observe that emission from the wind-collision region (WCR) may appear brightest near the shocks, since the impact of IC cooling on the non-thermal electron distribution is greatest near the contact discontinuity (CD), and demonstrate that the impact of IC cooling on the observed radio emission increases significantly with decreasing binary separation. We study how the synchrotron emission changes in response to departures from equipartition, and investigate how the thermal flux from the WCR varies with binary separation. Since the emission from the WCR is optically thin, we see a substantial fraction of this emission at certain viewing angles, and we show that the thermal emission from a CWB can mimic a thermal plus non-thermal composite spectrum if the thermal emission from the WCR becomes comparable to that from the unshocked winds. We demonstrate that the observed synchrotron emission depends upon the viewing angle and the wind-momentum ratio, and find that the observed synchrotron emission decreases as the viewing angle moves through the WCR from the WR shock to the O shock. We obtain a number of insights relevant to models of closer systems such as WR140. Finally, we apply our new models to the very wide system WR147. The acceleration of non-thermal electrons appears to be very efficient in our models of WR147, and we suggest that the shock structure may be modified by feedback from the accelerated particles.

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