X-rays from Magnetically Confined Wind Shocks: Effect of Cooling-Regulated Shock Retreat

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We use 2D MHD simulations to examine the effects of radiative cooling and inverse Compton (IC) cooling on X-ray emission from magnetically confined wind shocks (MCWS) in magnetic massive stars with radiatively driven stellar winds. For the standard dependence of mass loss rate on luminosity $Mdot sim L^{1.7}$, the scaling of IC cooling with L and radiative cooling with $Mdot$ means that IC cooling become formally more important for lower luminosity stars. However, because the sense of the trends is similar, we find the overall effect of including IC cooling is quite modest. More significantly, for stars with high enough mass loss to keep the shocks radiative, the MHD simulations indicate a linear scaling of X-ray luminosity with mass loss rate; but for lower luminosity stars with weak winds, X-ray emission is reduced and softened by a {em shock retreat} resulting from the larger post-shock cooling length, which within the fixed length of a closed magnetic loop forces the shock back to lower pre-shock wind speeds. A semi-analytic scaling analysis that accounts both for the wind magnetic confinement and this shock retreat yields X-ray luminosities that have a similar scaling trend, but a factor few higher values, compared to time-averages computed from the MHD simulations. The simulation and scaling results here thus provide a good basis for interpreting available X-ray observations from the growing list of massive stars with confirmed large-scale magnetic fields.

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