Modelling the radio emission from Cyg OB2 #5: a quadruple system?

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Fifty observations at frequencies between 1.4 GHz and 43 GHz of the 6.6-day O6.5-7+O5.5-6 binary object{Cyg OB2 #5} using the Very Large Array over 20 years are re-examined. The aim is to determine the location and character of the previously detected variable radio emission. The radio emission from the system consists of a primary component that is associated with the binary, and a non-thermal source (NE), $0.8arcsec$ to the NE of the binary that has been ascribed to a wind-collision region (WCR) between the stellar winds of the binary and that of a B-type star (Star D) to the NE. Previous studies have not accounted for the potential contribution of NE to the total radio emission, most especially in observations where the primary and NE sources are not resolved as separate sources. NE shows no evidence of variation in 23 epochs where it is resolved separately from the primary radio component, demonstrating that the variable emission arises in the primary component. Since NE is non-variable, the radio flux from the primary can now be well determined for the first time, most especially in observations that do not resolve both the primary and NE components. The variable radio emission from the primary component has a period of $6.7pm0.3$~years which is described by a simple model of a non-thermal source orbiting within the stellar wind envelope of the binary. Such a model implies the presence of a third, unresolved stellar companion (Star C) orbiting the 6.6-day binary with
a period of 6.7 years and independent of Star D to the NE. The variable non-thermal emission arises from either a WCR between Star C and the binary system, or possibly from Star C directly. The model gives a mass-loss rate of $3.4times10^{-5}$~M$_odot$,yr^{-1} for Cyg OB2 #5, unusually high for an Of supergiant and comparable to that of WR stars, and consistent with an unusually strong He,{sc i} 1.083-mum emission line, also redolent of WR stars. An examination of radial velocity observations available from the literature suggests reflex motion of the binary due to Star C, for which a mass of 23^{+22}_{-14}~M$_{odot}$ is deduced. The natures of NE and Star D are also examined. If NE is a WCR, as suggested by other authors, then the required mass-loss rate is an order of magnitude higher than expected for an early B-type dwarf, and only just consistent with a supergiant. This raises the question of NE as a WCR, but its non-thermal luminosity is consistent with a WCR and a comparison of reddening between object{Cyg OB2 #5} and Star D do not rule out an association, implying object{Cyg OB2 #5} is a quadruple system. Pursuing alternative models for NE, such as an unassociated background source, would require very challenging observations.

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