Hubble imaging of V1331 Cygni: proper motion study of its circumstellar structures ()

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Aims: The young star V1331 Cyg received previous attention because it is surrounded by an optical, arc-like reflection nebula. V1331 Cyg is commonly considered to be a candidate for an object that has undergone an FU-Ori (FUOR) outbreak in the past. This in turn could lead to a time-varying appearance of the dusty arcs that may be revealed by multi-epoch imaging. In particular, a radial colour analysis of the dust arcs can then be attempted to check whether the radial grain size distribution was modified by a previous FUOR wind.
Methods: Second-epoch imaging of V1331 Cyg was obtained by us in 2009 using the Hubble Space Telescope (HST). By comparing this to archival HST data from 2000, we studied the time evolution of the circumstellar nebulae. After a point spread function subtraction using model point spread functions, we used customised routines to perform a proper motion analysis. The nebula expansion was derived by deconvolving and correlating the two-epoch radial brightness profiles. Additional data from other facilities - TLS, UKIDSS, Spitzer, and Herschel - were also incorporated to improve our understanding of the star in terms of environment, viewing angle, bipolar outflow length, and the FUOR phenomenon.
Results: The outer dust arc is found to be expanding at ≈14.8 ± 3.6 km s^{-1} on average. The expansion velocity for the inner ring is less consistent, between 0.8 km s^{-1} and 3.0 km s^{-1}. The derived radial colour profiles do not indicate a spatial separation of the dust grain sizes. The Herschel 160 μm images show for the first time thermal emission from dust probably residing in the outer arc. By viewing V1331 Cyg almost pole-on, the length of the bipolar outflow exceeds previous estimates by far.
Conclusions: The outer arc expansion timescale is consistent with the implantation time of the CO torus, which supports the hypothesis of an outburst that occurred a few thousand years ago. The azimuthal colour variation of the outer arc is probably due to changes of the scattering angle, imposed by a tilt or helical geometry of the dust configuration.

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