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Nova 1670 Vul

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Abstract. We present radio and optical observations of CK Vul, an object associated with a nova-like outburst, observed in 1670-1672. A barely resolved point source is detected in the radio, which suggests thermal emission located at presumed position of the central star, which remains undetected in the optical. The measured proper motion of the nebula confirms that the observed object is indeed the remnant of the 1670 eruption. We also report the discovery of an extended, bipolar nebula, ejected in the same time.

1. Historical background

Nova Vul 1670 (CK Vul), was discovered by Hevelius and Don Anthelme, who observed a star for 3 years at a mean visual brightness $\sim 4^{\rm m}$ (exceeding $3^{\rm m}$ at maxima), showing long-standing declines and re-appearances within this period (Shara et al. 1985). 310 years later, a faint nebulosity was found near the position provided by the historical observations (Shara et al. 1985). However, no confirmed central star was identified and the nebular characteristic was uncommon for nova remnants. Dispute has started whether this object truly was the first nova ever observed. An alternative hypothesis suggests this object to be born again (Evans et al. 2002) or a stellar merger (Kato 2003) instead. In the former case, the brightening in 1670 would have been triggered due to a (Very) Late Thermal Pulse (V)LTP, and in the latter case due to the release of gravitational energy during the star merging event.

2. Observations and results

The observations of Nova 1670 Vul have been carried out with the VLA interferometer on April $9^{\rm th}$, 2006, in A configuration, in order to look for the ejecta from the eruption, suffering from high optical extinction. Deep optical images in Hα and r$'$ filters were taken with the INT on Aug $4^{\rm th}$, 2004. We also used a WHT image taken on August $10^{\rm th}$ 1991. The WHT image was aligned and degraded to the resolution of the INT image in order to measure the proper motion of the nebula.

Radio images at 5 and 8 GHz show barely resolved emission without an optical counterpart either in Hα or r$'$. The ionizing source may be hot and heavily obscured by dust, otherwise an enormously high amplitude of the eruption would be required. The measured spectral index of the radio flux $\alpha = 0.33 \pm 0.21$, and the apparent diameter of the source of $0.11 \pm 0.02''$ (60 AU for the distance of 550 pc) are consistent with a thermal free-free origin of the radiation.

Comparison of the Hα observations taken in 1991 and 2004 reveals the proper motion of the observed nebulosities, and confirms that the remnants originate from the 1670 explosion. The center of expansion is located close to the position of the radio emission. Deceleration due to interaction with the surrounding medium is not observed. This suggests radiative ionization of the ejecta. However, further analysis is highly desired.

The optical nebulosities extend $7''$ from the radio source. The deep images also reveal a strongly bipolar, much larger nebula extending $35''$ from the centre, axisymmetric with respect to the radio source. Comparison with the earlier data shows its expansion, and confirms that the outer nebula was also ejected during the 1670-1672 outburst.

3. Conclusions

The characteristics of the Nova 1670 Vul is different from what would be expected from nova. The H-rich ejecta rule out a VLTP, too, but an LTP remains as a possible explanation for this object. The radio source suggests the presence of non-expanding matter near the star, either H-poor or suffering high extinction or both. During the outburst, in 1670 the extinction was not high (the star reached $3^{\rm m}$ in V), but its onset may have contributed to the multiple declines.

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