In the following, we discuss our new results on the outer shell of CW Leo from observations with the Thermal Pulse erupting over 6000 yr ago. The timescale inferred from the spacing between these of the arcs or shells. From large-scale mapping at a relatively low angular resolution of the CO J=1-0 on the asymptotic giant branch (AGB), pulsating and surrounded by an optically thick dust shell and spurred much interest. We now know that it is a carbon star in an advanced stage of stellar evolution.

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3. Bow shock, thermal pulse or both?

A bow shock in the form of an arc is seen at 160 µm, 250 µm, and 350 µm with a spatial scale as large as the extended emission matches the position and the shape of the FUV extended emission.

From the 1D intensity profile, an offset of ~20° is found between FUV and the far-IR intensity peaks which suggests a different origin of the two emissions.

The total flux (see Table 1) in the bow shock was calculated within the segment of an elliptical annulus matching the spatial scale of the extended emission (see Fig. 1). A dust temperature of ~50 K and a mass-loss rate of $10^{-5}$ M☉/yr is estimated.

The heliocentric space velocity components of the star can be converted to the heliocentric Galactic space velocity components [U, V, W] of (21.6 ± 3.9, 24.6 ± 3.5, 25.3 ± 1.3) km/s. The heliocentric ISM flow velocity is 17.6 km/s if the bow cone is facing us (i.e. the apex pointing toward us) and 82.6 km/s if the bow cone is facing away from us.

The comparison between the shape of CW Leo’s bow shock and Watson et al. (2007) 3D hydrodynamical models for AGB stars suggests that the density of the local ISM in CW Leo is probably higher than 2 cm⁻³ implying an upper limit of 75 km/s to Vl.}

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4. Space motion of the star and the ISM flow velocity

Using a distance of $d = 135$ pc and a mass-loss rate $M = 2.2×10^{-5}$ M☉/yr (Groenewegen et al. 1999), a gas expansion velocity of $v_{exp} = 15.4$ km/s, a stellar velocity $v_{stell} = 25.5$ km/s (Groenewegen et al. 2002), we derived the basic parameters of the bow shock and the star’s space motion.

The heliocentric space velocity of the star is estimated to be about 25 km/s at a heliocentric inclination angle of the open motion center of 47.8 degrees measured from the plane of the sky away from us and a PA of 81.3° for the proper-motion vector in the plane of the sky.

The stand-off distance is of (8.0 ± 0.3)×10⁶ µm with the apex of the shock oriented at 60.5°,-63° (it could be pointing from east to west) relative to the plane of the sky, the PA of 81.3°

From the rain pressure balance equation, the relative velocity of the star with respect to the ISM is $v_{rel} = 106.6$ km/s, where $v_{rel}$ is the number density of the ISM local to CW Leo in cm⁻³.

The ISM density is probably higher than 2 cm⁻³, but the ISM density of CW Leo is probably higher than 2 cm⁻³ if the star is facing us.

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4. Conclusion

For the first time, we derived the physical parameters of the wind motion of CW Leo. The wind properties of CW Leo were derived from the bow shock.

The ISM density of CW Leo is at least 2 cm⁻³, but the stellar velocity relative to the ISM is from 75 km/s. The ISM density of CW Leo is probably higher than 2 cm⁻³.

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References

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Fig. 1. Derived Dust Envelope of CW Leo. The bow shock is seen at 160 µm, 250 µm, and 350 µm.

Fig. 2. Heliocentric velocity components of the star and the ISM flow velocity.

Fig. 3. Modelled bow shock from the FUV map at 350 µm.

Fig. 4. Derived bow shock parameters from the FUV image at 350 µm.