

On the existence of C-rich massive evolved stars

G. Quintana-Lacaci^{1*}, J. Cernicharo¹, M. Agúndez¹, J.P. Fonfría¹, L. Velilla-Prieto², C. Sánchez Contreras³, V. Bujarrabal⁴, A. Castro Carrizo⁵, J. Alcolea⁶

¹Group of Molecular Astrophysics, IFF-CSIC, C/Serrano 123, E-28006, Madrid, Spain

²Dept. of Space, Earth and Environment, Chalmers Univ. of Technology, Onsala Space Observatory, 43992, Onsala, Sweden

³Centro de Astrobiología (CSIC-INTA), ESAC, Camino bajo del castillo s/n, Urb. Villafranca del Castrillo, E-28691, Villanueva de la Cañada, Spain

⁴Observatorio Astronómico Nacional (IGN), Ap. 112, 28803, Alcalá de Henares, Spain

⁵Institute of RadioAstronomie Millimétrique, 300 rue de la Piscine, 38406, Saint Martin d'Hères, France

⁶Observatorio Astronómico Nacional (IGN), Alfonso XII, 28014, Madrid, Spain

*Corresponding author e-mail adress: guillermo.q@csic.es

We studied the properties of a particular type of evolved stars, the C-rich evolved stars with high expansion velocities (HVC stars). For this purpose we selected the two best studied objects within this group, IRC +10401 and AFGL 2233. We obtained an estimate of their luminosity by studying their spectral energy distribution. Also we have obtained single-dish line profiles and interferometric maps of the CO $J=1-0$ and $J=2-1$ emission lines for both objects, as well as a $\lambda 3$ and 1mm line survey toward IRC+10401 to study their molecular census. We have modeled the CO emission using a LVG radiative transfer code to determine the kinetic temperature and density profiles of the gas ejected by these stars. We have found that the luminosities obtained for these objects ($\log(L/L_{\odot}) = 4.1$ & 5.4) locate them in the domain of the massive Asymptotic Giant Branch stars (AGBs) and the Red Supergiant stars (RSGs). In addition, the mass-loss rates obtained ($1.5 \times 10^{-5} - 6 \times 10^{-3} M_{\odot} \text{ yr}^{-1}$) suggest that while IRC +10401 might be an AGB star, AFGL 2233 could be a RSG star. These results, together with those from previous works, suggest that both objects are massive objects, IRC +10401 a massive evolved star with $M_{\text{init}} \sim 5 - 9 M_{\odot}$ which could correspond to an AGB or a RSG, and AFGL 2233 a RSG with $M_{\text{init}} \sim 20 M_{\odot}$. This would confirm the existence of massive C-rich evolved stars. Finally, two scenarios are proposed to form these types of objects. The existence of these objects has a direct effect on the nucleosynthesis models in the composition of the ejecta and therefore on the composition of the dust injected into the ISM.

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