What causes the large extensions of red-supergiant atmospheres? Comparisons of interferometric observations with 1-D hydrostatic, 3-D convection, and 1-D pulsating model atmospheres

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We present the atmospheric structure and the fundamental parameters of three red supergiants, increasing the sample of RSGs observed by near-infrared spectro-interferometry. Additionally, we test possible mechanisms that may explain the large observed atmospheric extensions of RSGs. We carried out spectro-interferometric observations of 3 RSGs in the near-infrared K-band with the VLTI/AMBER instrument at medium spectral resolution. To comprehend the extended atmospheres, we compared our observational results to predictions by available hydrostatic PHOENIX, available 3-D convection, and new 1-D self-excited pulsation models of RSGs. Our near-infrared flux spectra are well reproduced by the PHOENIX model atmospheres. The continuum visibility values are consistent with a limb-darkened disk as predicted by the PHOENIX models, allowing us to determine the angular diameter and the fundamental parameters of our sources. Nonetheless, in the case of V602 Car and HD 95686, the PHOENIX model visibilities do not predict the large observed extensions of molecular layers, most remarkably in the CO bands. Likewise, the 3-D convection models and the 1-D pulsation models with typical parameters of RSGs lead to compact atmospheric structures as well, which are similar to the structure of the hydrostatic PHOENIX models. They can also not explain the observed decreases in the visibilities and thus the large atmospheric molecular extensions. The full sample of our RSGs indicates increasing observed atmospheric extensions with increasing luminosity and decreasing surface gravity, and no correlation with effective temperature or variability amplitude, which supports a scenario of radiative acceleration on Doppler-shifted molecular lines.

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