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M 1-92: the death of an AGB star told by its isotopic ratios.

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Ongoing improvements in the sensitivity of sub-mm- and mm-range interferometers and single-dish radio telescopes allow the more and more detailed study of AGB and post-AGB objects in molecular species other than ^{12}CO and ^{13}CO. With a new update introduced in the modelling tool SHAPE+shapemol, we can now create morpho-kinematical models to reproduce observations of these shells in up to 10 different molecular species, allowing an accurate description of their physical features as well as their molecular abundances and isotopic ratios.
The pre-planetary nebula M1-92 (Minkowski's Footprint) is one of the most complex objects of this kind, with a wide range of physical conditions and more than 20 molecular species detected. We model this nebula, reproducing the observational data from IRAM-30m spectra and NOEMA interferometric maps, trying to understand the unusual evolution of its central star in the last phases of its life.
The results show interesting features that tell us the story of its death. A ^{17}O/^{18}O isotopic ratio of 1.6 indicates that the central star should have turned C-rich by the end of the AGB, as opposed to its O-rich nebula. The most plausible way of reconciling this discrepancy is that M1-92 resulted from a sudden massive ejection event, which also interrupted the AGB evolution of the central source, preventing its transformation into a C-rich star. We also detect different ratios of ^{12}C/^{13}C across the nebula, which is particularly relevant in the inner equatorial region traced by HCO^+ and $H^{13}CO^+$, indicating an isotopic ratio variation taking place at some point during the last 1200 yr.

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