M1-92 AND A MULTISPECIES MODELLING

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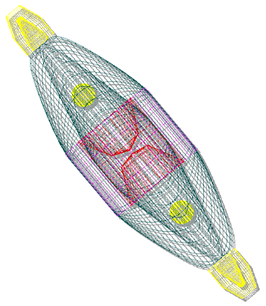

Figure 1: Wired representation of the best-fit model.

CONTEXT

Pre-planetary nebulae are the intermediate objects between AGB stars and planetary nebulae, and provide the most information about this transformation from spherical circumstellar envelopes into bipolar or multipolar objects [1,2]. In particular, 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 [3]. We model this nebula, reproducing the observational data from IRAM-30m and HSO/HiFi spectra and NOEMA interferometric maps in several transition lines from different molecular species, trying to understand the unusual evolution of its central star in the last phases of its life [4].

RESULTS & CONCLUSIONS

With a new update introduced in the modelling tool SHAPE + shapemol [5,6], we can now create morpho-kinematical models to reproduce these observations in these different molecular species, allowing for an accurate description of its physical features as well as its chemistry.

After developing our best-fit model (Fig. 1), we compare its results to the original data as seen in Fig. 2. From CO isotopologues we measure a $^{17}O/^{18}O$ isotopic ratio of 1.6, which indicates that the central star should have turned C-rich by the end of the AGB phase [7], as opposed to its O-rich nebula. This suggests 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 change during the post-AGB evolution. This might be related to the ongoing activity shown by the low-density and high-temperature areas of turbulent gas found across the nebula's symmetry axis.

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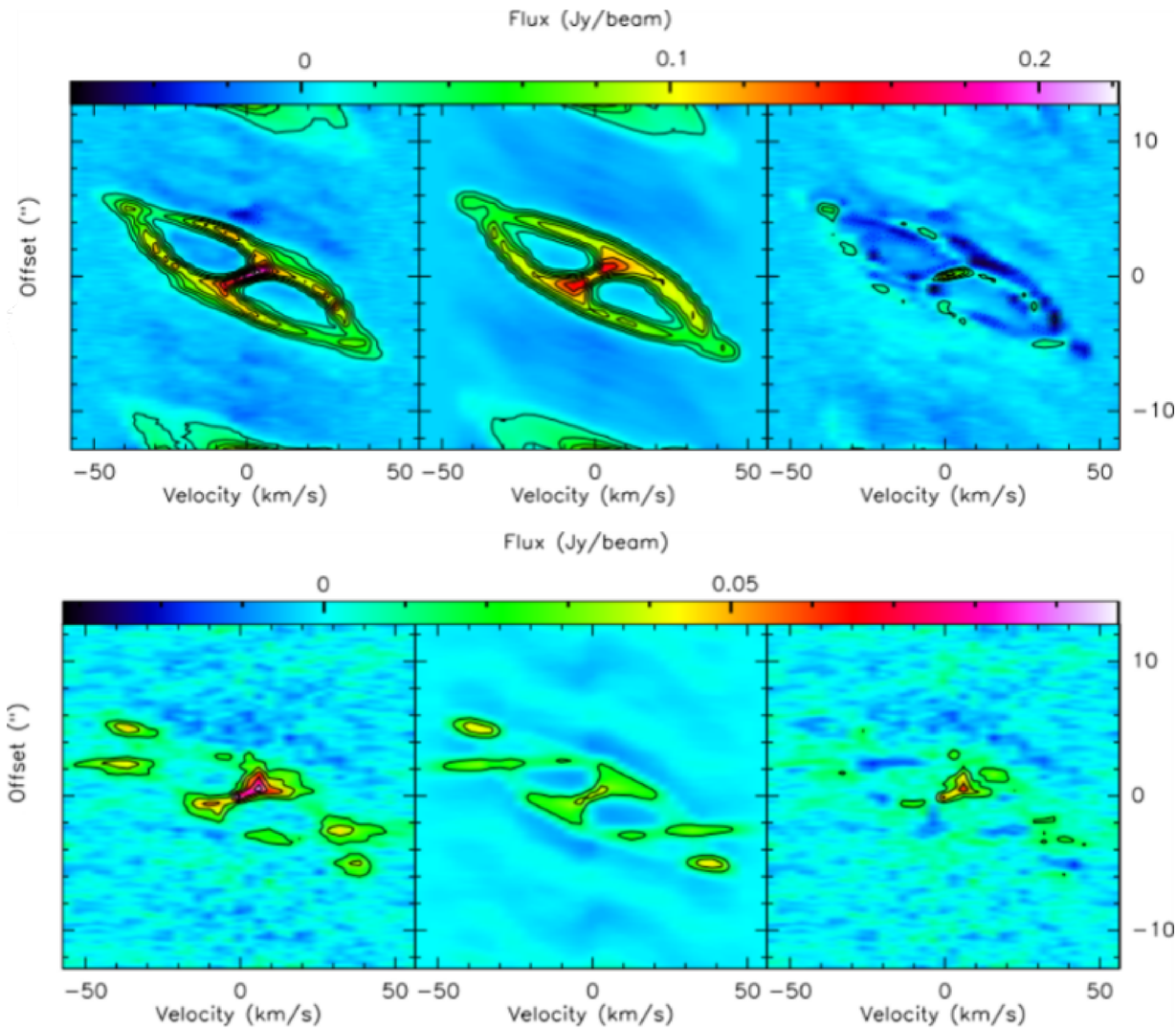

Figure 2: P-V diagram of observational data (left), model reproduction (center), and residuals (right) of ^{13}CO (up) and HCO^+ (down) interferometric observations.

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