Clumpy molecular structures revolving the B[e] supergiant MWC 137

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1. Motivation

The Galactic object MWC 137 is a peculiar early-type star surrounded by the optical nebula Sh 2-266 ($80'' \times 60''$) of unclear origin. The large-scale structure seen in Hα images suggests that Sh 2-266 is a ring nebula probably produced by the interaction of the stellar winds with the ambient medium, with a possible bipolar outflow perpendicular to the ring/disk plane. A collimated outflow with several knots was indeed recently detected in the light of the [N II] 6583 line (Mehner et al. 2016). Moreover, near-infrared spectroscopic observations displayed intense, kinematically broadened CO band emission in both isotopes ^{12}CO and ^{13}CO (Oksala et al. 2013). The observed enrichment in ^{13}CO implies that MWC 137 is an evolved object (Muratore et al. 2015). This result combined with the high luminosity of the star ($\log(L/L_\odot) \sim 6$, $d = 5.2 \pm 1.4$ kpc, Mehner et al. 2015) suggests that it belongs to the group of B[e] supergiants. To investigate the spatial distribution of the hot atomic and molecular gas we obtained K-band IFU observations with the ESO/SINFONI spectrograph in its high spatial resolution mode in two different epochs. In addition, to map the cold molecular gas regions, we collected molecular line observations in the sub-mm range with APEX.

2. Small-scale structures with near-infrared IFU spectroscopy

- Medium-resolution ($R \sim 4\,000$) K-band IFU observations were obtained on 2014 Dec. 30 and 2016 Mar. 19 using the ESO/VLT spectrograph SINFONI (FOV = $0.8'' \times 0.8''$; pixel size = 12.5 mas).
- Fig. 1 shows spatially resolved images of a few prominent emission features, while the full spectrum, extracted over a circular aperture, is displayed in Fig. 3.
- Br γ images (Fig. 1 second column) display two "ears" (bulge?) in east-west direction and one blob in the south. Faint, extended Br γ emission appears distributed in a double-cone structure in east-west direction.
- The southern blob in the Br γ images is also seen in all other images (CO, He I and Na I).

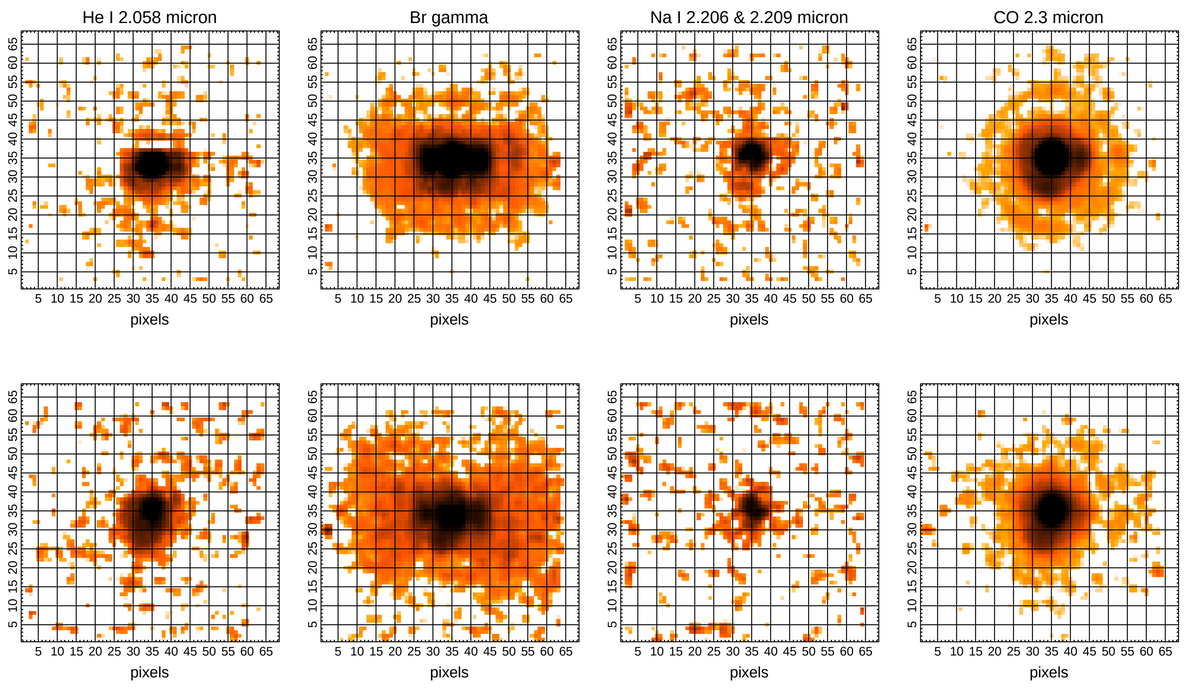

Figure 1: Continuum subtracted images of different emission features observed with SINFONI in 2014 (top) and 2016 (bottom). The images in 2016 were observed under poorer conditions, hence faint features are not resolved anymore. In all images north is up and east is to the left.

- CO images (Fig. 2) display an outer ring (spherical shell?) with $r_{\rm out}$ = 225 mas (dashed black circle) and an inner disk or ring (green ellipse). The major and minor semiaxes are 112.5 mas and 97.5 mas, resulting in an inclination of $\sim 30°$. These were determined by the position of the maximum intensity of the blobs and the constraint that the disk should be roughly perpendicular to the optical jet. The CO structure inside the white circle remains unresolved.
- The two blobs show an angular motion of $\sim 10°$ within 15 months. This would translate into $v_{\rm rot}$ = 375 km s^{-1} at a distance of 5.2 kpc, which is too fast for Keplerian rotation.

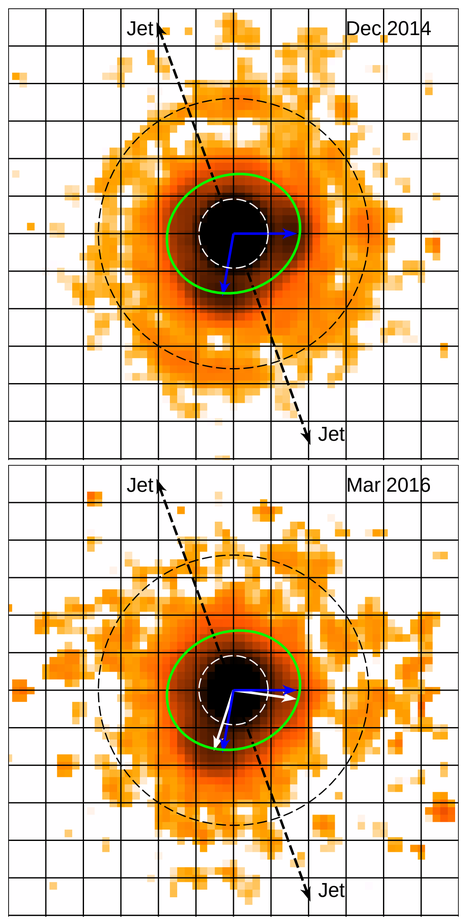

Figure 2: Movement of the CO blobs.

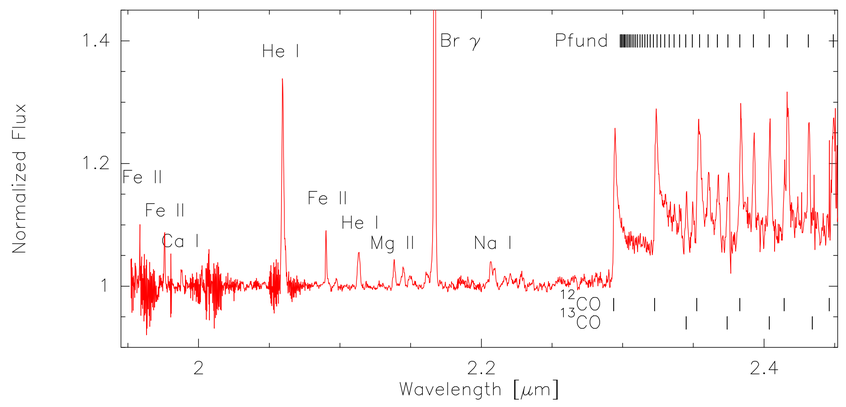

Figure 3: SINFONI K-band spectrum of MWC 137.

3. Large-scale structures with APEX and WISE

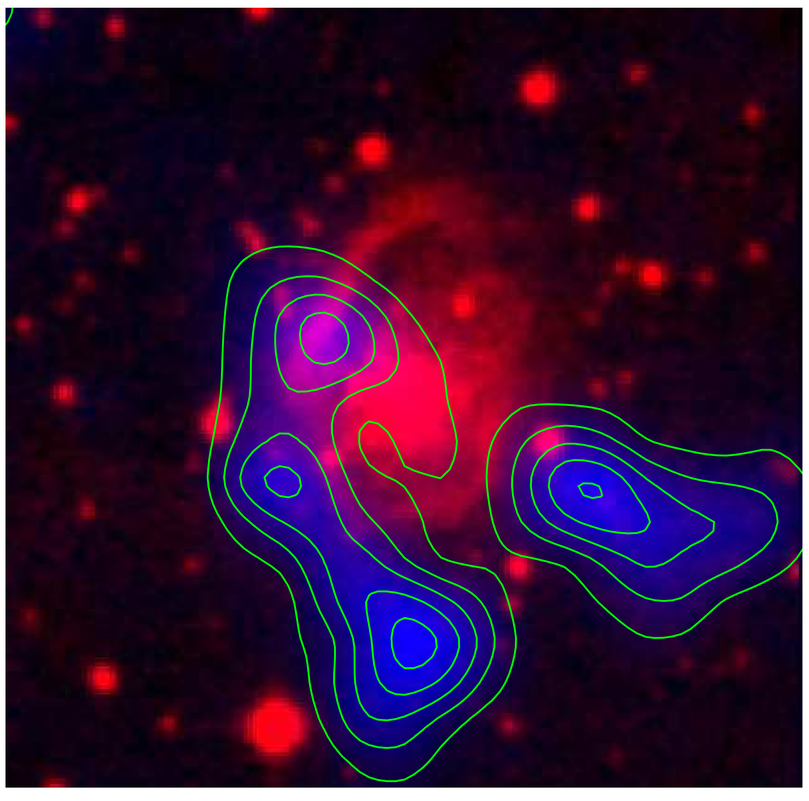

Figure 4: Overlay of the CO(3-2) emission ($3' \times 3'$ in size) in the velocity interval [+27.3,+28.5] km s^{-1} (in contours and blue) and the DSSR2 (in red). Contours correspond to 2, 4, 6, and 8 K ($T_{\rm mb}$, main-beam brightness-temperature).

- Observations of the ^{12}CO(3-2) line at 345 GHz were obtained with the Atacama Pathfinder EXperiment (APEX) in a region of $3' \times 3'$ centered in Sh2-266, with an angular resolution of $20''$.

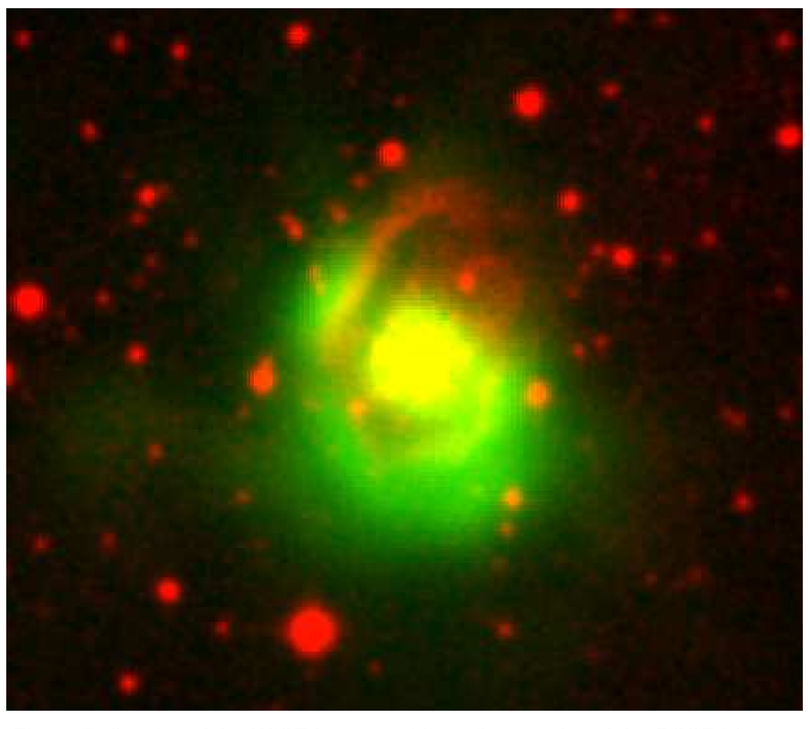

Figure 5: Overlay of the WISE image at 12 μm (in green) and the DSSR2 image (in red).

- The spatial distribution of the CO emission associated with Sh 2-266 is shown in Fig. 4. The image reveals a molecular envelope encircling the western, southern, and southeastern borders of Sh 2-266. The partial shell is detected in the velocity interval [+27.3,+30.3] km s^{-1}. According to circular galactic rotation models and the velocity field of the Galaxy by Brand and Blitz (1993), gas at these velocities is located at kinematical distances d = 5-9 kpc in good agreement with the estimates of Mehner et al. (2016).
- The composite image (Fig. 5) shows a comparison of the emission at 12 μm (in green) and the DSSR2 image (in red). The mid-IR image includes thermal dust emission and emission from PAHs, which delineate a photodissociation region (PDR) bordering the ionized gas. The comparison of Figs. 4 and 5 indicates that the emission in the mid-IR coincides with the molecular emission.

References

Brand J. & Blitz L. 1993, A&A, 275, 67 Mehner A. et al. 2016, A&A, 585, A81 Muratore M. F. et al. 2015, AJ, 149, 13 Oksala M. E. et al. 2013, A&A, 558, A17