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The interplay between molecular and ionised gas surrounding the massive embedded star AFGL 4176

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Abstract In order to investigate whether the feedback produced by photo-ionisation has an important effect on the geometry of the circumstellar dust and gas around forming massive stars, we have observed the luminous southern embedded star AFGL 4176 in transitions of NH_3 and the hydrogen recombination line H68α. We present our preliminary results, which show a compact HII region embedded in a parsec-scale (radius $\sim$0.7 pc) rotating envelope/torus. In addition, the HII region is found to be offset from the centre of the envelope, and the velocity gradient in the ionised gas is not aligned with the rotation axis of the envelope, suggesting complex dynamics and multiplicity.

1 Introduction, Observations and Results

As massive protostars greater than $\sim$10 $M_\odot$ can be on the main sequence while still accreting [**?**], they must do so while producing vast amounts of ionising radiation. Characterising both the ionised and molecular gas around massive stars can therefore determine how they manage to accrete while an HII region forms around them.

To do so, we observed AFGL 4176, a highly luminous (1.7×10^5 $L_\odot$ at 5 kpc) embedded massive star with a compact HII region [**?**], whose cm flux corresponds to that of a B0-type star. Here we present our first results from ATCA observations of NH_3(1,1) and (2,2) as well as the radio recombination line H68α, to trace both the molecular and ionised gas respectively.

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The left panel of Fig. 1 presents the first moment map of the main hyperfine component of NH_3(1,1), overlaid with contours of integrated NH_3(1,1) and H68α emission. There is a clear southwest-northeast velocity gradient across the NH_3 emission, which we interpret as rotation of the outer envelope of AFGL 4176 (with radius ∼30" or 0.7 pc). By fitting the NH_3(1,1) and (2,2) line profiles, we have also uncovered a temperature gradient which increases towards the north of the molecular envelope, likely due to the presence of the HII region heating the surrounding gas. The right panel of Fig. 1 shows the first moment map of the H68α emission, covering the area shown by the white box in the left panel of Fig. 1. Here there is instead a roughly north-south gradient in the velocity of the ionised gas. As the velocity gradient is in the opposite sense to that of the NH_3, we conclude that the main component of this velocity gradient cannot be due to inheritance of the envelope rotation by the ionised gas, and instead may be explained by an ionised outflow. The HII region traced by H68α also does not lie towards the centre of the NH_3 emission, but is offset by 8.4″ (0.2 pc at 5 kpc). Given this offset, the high luminosity of AFGL 4176, and the offset between the HII region and the infrared source (4.5″ or 0.1 pc, see Fig. 1), it is likely that there are in fact multiple young stars forming in the vicinity of AFGL 4176.

References

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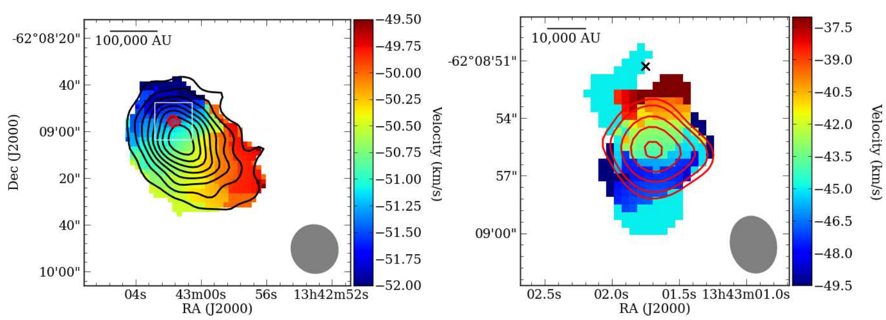

Fig. 1 *Left panel:* First moment map of the NH_3(1,1) emission, imaged with a 20" FWHM beam to recover extended emission. Black contours: integrated NH_3(1,1) emission, peak: 0.45 Jy beam^{-1} kms^{-1}. Red contours: integrated H68α emission, peak: 0.62 Jy beam^{-1} kms^{-1}. The white box shows the area covered by the right panel. *Right panel:* First moment map of the H68α emission. Beam: 3.0 × 2.4", P.A.=13.7°. Red contours show integrated H68α emission. The cross marks the 2MASS position of the associated IR source, which dominates the near- and mid-IR.