

High Resolution Observations of Molecular Gas in the Outflow of M 82

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Abstract. We present a high-resolution ($3.6''$, 70 pc) CO(1–0) mosaic of the molecular gas in M 82 covering an area of $2.5' \times 3.5'$ ($2.8 \text{ kpc} \times 3.9 \text{ kpc}$) obtained with the OVRO millimeter interferometer. The observations reveal the presence of huge amounts of molecular gas ($> 70\%$ of the total molecular mass, $M_{\text{tot}} \approx 1.3 \times 10^9 M_{\odot}$) outside the central 1 kpc disk. Molecular streamers are detected in and below M 82's disk out to distances from the center of $\sim 1.7 \text{ kpc}$. Some of these streamers are well correlated with optical absorption features; they form the basis of some of the prominent tidal HI features around M 82. This provides evidence that the molecular gas within M 82's optical disk is disrupted by the interaction with M 81. Molecular gas is found in M 82's outflow/halo, reaching distances up to 1.2 kpc below the plane; CO line-splitting has been detected for the first time in the outflow. The maximum outflow velocity is $\sim 230 \text{ km s}^{-1}$; we derive an opening angle of $\sim 55^{\circ}$ for the molecular outflow cone. The total amount of gas in the outflow is $> 3 \times 10^8 M_{\odot}$ and its kinetic energy is of order 10^{55} erg , about one percent of the estimated total mechanical energy input of M 82's starburst. Our study implies that extreme starburst environments can move significant amounts of molecular gas in to a galaxy's halo (and even to the intergalactic medium).

1. Poster

Given the limited space, only the key figures are presented here. For more information, color figures and a full list of references the interested reader is referred to Walter, Weiss & Scoville (2002).

References

Walter, F., Weiss, A., & Scoville, N. 2002, *ApJ*, 580, L21

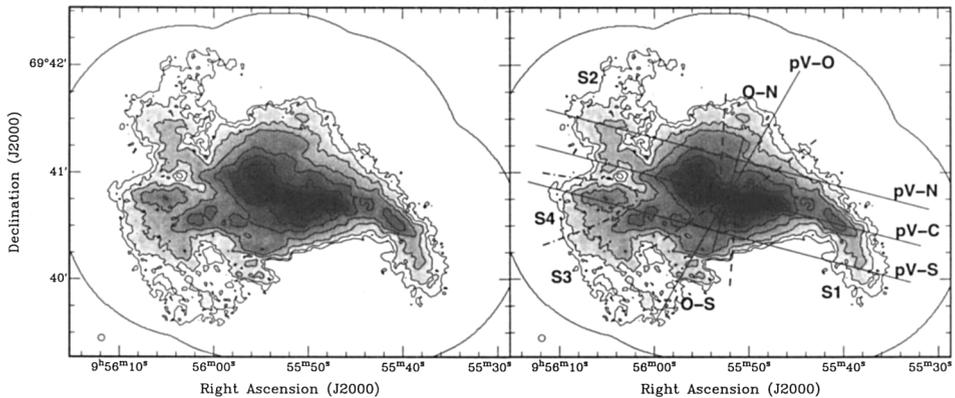


Figure 1. *Left:* Logarithmic representation of the integrated CO(1→0) map of the zero-spacing corrected OVRO mosaic. The OVRO mosaicked field of view is indicated by the outer envelope. *Right:* Same plot with superimposed labels of the molecular streamers (S1–S4) and the outflow gas (O–N and O–S). The dashed lines indicate the derived opening angle of the molecular outflow (50°, south; 60°, north, see Walter et al. 2002 for details).

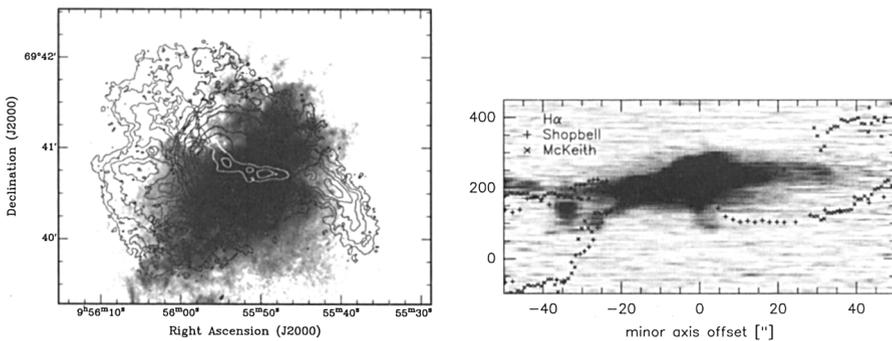


Figure 2. *Left:* $H\alpha$ image of M82 (greyscale). *White contours:* M82 disk, *Grey contours:* M82 streamer (S1–S4), *Black contours:* molecular gas associated with the outflow (O1+O2). Note that molecular gas is clearly associated with M82's prominent outflow of ionized gas. *Right:* CO pV diagram along the outflow in M82 (PA=150°, see 'pV-O' in Fig. 1 for orientation). The crosses and pluses represent the $H\alpha$ velocities. Towards the south, CO line splitting is detected.