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The Fate of Captured Gas: NGC 3077 & Star Formation in the M81 System

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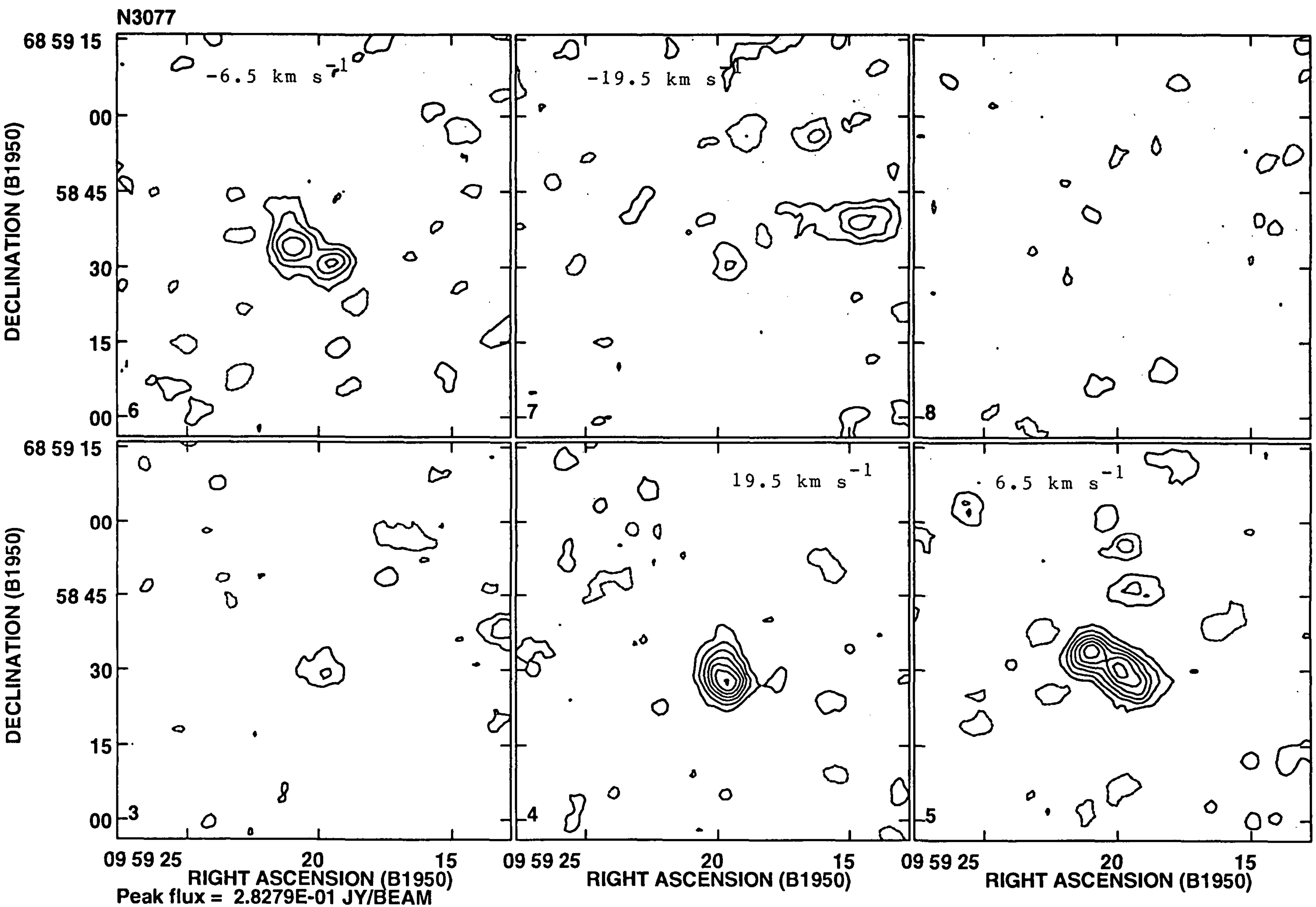
NGC 3077 is the third largest system in the M81 swarm of galaxies, after the giant spiral M81 itself and the dwarf oddity M82. As with most of the other dwarf companions in this system, NGC 3077 appears to have gravitationally stolen a significant amount of gas from the spiral — roughly 10^9 $M_\odot$ in this case — and is in the process of turning it into stars in its core. Thronson, Wilton, & Ksir (1991; MNRAS, 252, 543) note that the total gas mass in M82 and NGC 3077 is about the same, although the former is undergoing substantially greater star formation than is the latter. These authors suggest that while the efficiency of creating stars out of molecular material is similar in both objects, it is the preceding step — the creation of molecules out of the purloined atomic gas — which is less efficient in NGC 3077. Thronson, Wilton, & Ksir go on to argue that the higher kinematic "temperature" of this object relative to that of M82 played a major role in the low efficiency of atomic-to-molecular conversion.

We are interested in exploring the fate of molecular material in NGC 3077 further. For that reason we have mapped the distribution of $J = 1 \rightarrow 0$ CO emission in the central $\sim$ 1 arcmin (1 kpc) diameter region of the galaxy using the Owens Valley millimeter-array with an angular resolution of $6.''7 \times 5.''7$ (110 pc $\times$ 90 pc). The results are shown on the following page as a series of velocity channel maps with $\Delta v = 13$ km s^{-1}.

We find the gas concentrated to the central core of the galaxy, perhaps appropriate given the strong central gravitational potential well in dwarf elliptical systems (see also Becker, Schilke, & Henkel 1989; A&A, 211, L19). The conventional view is that star formation occurs most strongly in this region due either to an enhancement of cloud collisions or else an overpressure in the gas, which compresses H_2 clouds.

Our sensitivity and angular resolution have resolved three fairly distinct molecular complexes: two with $v \approx 0$ km s^{-1} near the nucleus, with a third about $30''$ to the west with $v \approx$ -20 km s^{-1}. Using standard techniques for estimating total H_2 masses, we estimate that the pair of central clouds have $M(H_2) \sim 10^7$ $M_\odot$, while the western cloud has $M(H_2) \sim 10^6$ $M_\odot$. The total molecular mass in this region of the galaxy is about 2×10^7 $M_\odot$, far less than the estimated HI mass over about the same region.

Comparing the distribution of CO with that of Hα (not shown) suggests that star formation is breaking out of the central condensation of molecular materials: molecular material forms a sort of basket partially surrounding the ionized gas. The appearance is reminiscent of the popular "blister" model for individual HII regions, although on a vastly larger scale in the galaxy. Of course, with a spatial resolution of only about 100 pc, it is almost certain that the actual structure of the H_2/HII clouds are far more complex than this simple description.



N3077
-6.5 km s^-1
-19.5 km s^-1
19.5 km s^-1
6.5 km s^-1
6
7
8
3
4
5
68 59 15
00
58 45
30
15
00
DECLINATION (B1950)
09 59 25
20
15
RIGHT ASCENSION (B1950)
Peak flux = 2.8279E-01 JY/BEAM