Warm Gas and Spatial Variations of Molecular Excitation in the Nuclear Region of IC342

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Using the IRAM 30m millimeter radio telescope we mapped the line emission of the J=1-0 and J=2-1 transitions of ^{12}CO, ^{13}CO, and $C^{18}O$ in the nuclear region of the spiral galaxy IC342. This study demonstrates the value of multi line studies to investigate the neutral interstellar medium in extragalactic sources. Our observations as well as calculations of simple models of CO excitation and radiative transport show that the molecular gas in the nucleus is warm and that physical conditions vary with position in the galaxy. The molecular gas in the central kiloparsec of IC342 has a kinetic temperature of at least 30K and a molecular hydrogen density of about 3×10^3 cm^{-3}. At distances more than 500pc north and south of the center the kinetic temperature is significantly less (≥13K). About 500 pc north east of the center we find evidence for optically thin CO emission originating in a component of warm gas with a temperature of at least 40 K. Our model calculations result in conversion factors between the H_2 column density and the ^{12}CO (1-0) line intensity close to the value of $3\text{-}4 \times 10^{20}$ cm^{-2}/K km s^{-1} derived for molecular clouds in the Galaxy. The molecular mass contained in the central two kpc of IC342 is of the order of 2×10^8 $M_\odot$.
The CO millimeter emission comes from a compact structure elongated at a position angle of zero degrees. After deconvolution with the beam profile the intrinsic source size is 30"x≤13" (FWHM). The emission is centrally peaked and shows an extension to the northeast. We also find underlying extended emission over more than 90" (2 kpc) at a position angle of 25°.
Our J=1-0 (resolution 21") and J=2-1 (resolution 14") maps are consistent with the ^{12}CO (1-0) interferometer map at 7" resolution (Lo et al. 1984) and the ^{12}CO(1-0) Nobeyama map (Hayashi et al. 1986) at 13" resolution. Minor differences among the maps can be explained by the different beam sizes or are due to the fact that components on size scales larger than 30" are resolved out by the interferometer. The extended emission in all three maps is consistent with the 65"

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resolution ^{12}CO (1-0) measurement by Rickard et al. (1981). In this map, the dominant central component is extended to the north and south.

The observed [CII] 158 μm brightness toward the center of IC342 is 4.5×10^{-4} ergs^{-1} cm^{-2} ster^{-1} (Crawford et al. 1985). We measure a [OI] 63 μm/[CII] 158 μm line ratio of 1.5±0.7. In collisionally excited neutral gas ($n_e \leq 10^{-3} n(H+H_2)$) with a O/C fractional abundance near the solar neighborhood value (≈2) this line ratio corresponds to a gas pressure $n(H)T \approx 3 \times 10^5$ cm^{-3} K. A comparison of the HI emission measured and predicted from the [CII] 158 μm line flux indicates that a significant fraction of the 21 cm HI emission may originate in warm, dense photodissociation regions at the surfaces of molecular condensations. This is in contrast to the standard interpretation (c.f. Kulkarni and Heiles 1987) that most of the HI column density originates in ≈80 K "HI clouds" of volume density 10 to 100 cm^{-3}.

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