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NGC 4631: THE UNUSUAL STAR FORMING REGION AROUND CM67 — CO OBSERVATIONS WITH NMA AND PICO VELETA

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INTRODUCTION

The late-type edge-on spiral galaxy NGC 4631 is known for its high star formation rate and extended radio halo with a uniform magnetic field component ordered predominantly perpendicular to the plane of the galaxy in the inner 6 kpc (assuming a distance of 7.5 Mpc, $1' = 2.2$ kpc) (Hummel et al. 1988; Golla, Ph.D., in preparation). The strongest radio continuum source of NGC 4631 is located at the eastern edge of the central region near a giant HII region complex CM67 (Crillon and Monnet 1969). The magnetic field orientation going out from the central region and especially from the region CM67 as well as the prominent north eastern low frequency radio spur (cf. Hummel et al. 1991) indicate a **close connection between the synchrotron emission of the radio halo of NGC 4631 and star forming regions/CM67 in the disk** (Golla and Hummel, in preparation). Probably cosmic rays from star forming regions in the disk propagate along the magnetic field lines into the halo.

OBSERVATIONS

We compiled CO line observations of the central region with special emphasis on the eastern radio source with the IRAM 30-m telescope at Pico Veleta. First results were published by Sofue et al. (1991). The observations were continued and the CO(2–1) spectra are shown in Figure 1 with a resolution of 13″. They show enhanced line emission in the whole central region (indicating high star forming activity) and a region of strong emission at roughly the same position as the eastern radio source and CM67. It is the strongest molecular line emitter of this galaxy and will be called **region A** in this paper. The position-velocity diagrams indicate that the central region of NGC 4631, where the radio and molecular line emission is enhanced, exhibits rigid rotation whereas in the disk differential rotation with a velocity of about ± 150 km s^{-1} occurs. In the CO(2–1) line with 13″ resolution region A has one main velocity component at 705 km s^{-1} and possibly at least two other components. In Figure 1 the CO(2–1) spectra have been overlayed on the grey-scale image of the Hα distribution (Dettmar and Golla, in preparation). **Region A** does not coincide in position with the giant HII region but is **located just north western of CM67**. On the other hand the position of the **eastern radio source does coincide with region A.**

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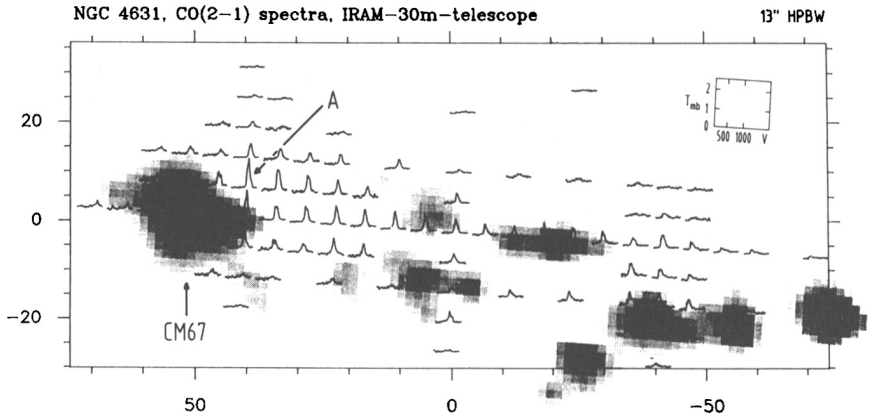

FIGURE I CO(2–1) spectra as obtained with the 30-m telescope at Pico Veleta overlayed on a grey-scale image of Hα (Dettmar and Golla, in preparation). The (0,0) position corresponds to $\alpha_{50} = 12^h39^m44\overset{s}{.}5$, $\delta_{50} = 32°49'07''$.

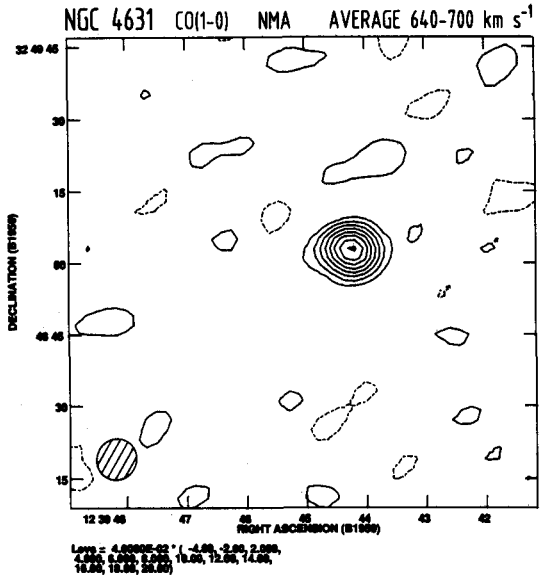

FIGURE II CO(1–0) distribution of **region A** as observed with NMA, averaged over the velocity range 640–700 km s^{-1}. The contour levels are given in Jy/b.a. The HPBW is shown by the dashed circle.

In May 1991 area A was observed in the CO(1–0) line with the Nobeyama Millimeter Array (NMA) for 7 hours. In order to increase the signal-to-noise-ratio the channels were smoothed to a velocity resolution of about 10 km s^{-1}. The data were tapered to an angular resolution of $8\overset{''}{.}5 \times 8\overset{''}{.}0$ (corresponding to an angular resolution of about 300 pc). With a primary beam width of 70″

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the nucleus itself could not be observed in this run. The observations covered a velocity range of 830 km s^{-1} centered on the systemic velocity. The r.m.s. noise in the single channel maps is 90 mJy/b.a. We detected a clear signal in 5 channel maps near CM67 covering the velocity range between 640 and 700 km s^{-1}. In one channel in between (at 664 km s^{-1}) no signal could be detected. There is no significant shift in position between the signals in different channels. Averaging the whole velocity range (640–700 km s^{-1}) gives Figure 2. This map has an r.m.s. noise of 45 mJy/b.a. and shows only one nearly point-like source with the maximum coinciding in position nearly perfectly with the maximum of CO(2–1) as observed with the 30-m telescope.

DISCUSSION

The CO cloud complex at region A seems to be very compact as it is even in the interferometer map only slightly extended in the east-west direction. Hence it seems to be confined to a projected area of about **300 pc in diameter** and is located just north western of the strong HII region complex CM67. The Hα emission of CM67 covers the velocity range between 620 and 760 km s^{-1} as observed by Roy et al. (1991). The line profile can be best fitted by three separate Gaussians. According to Roy et al. CM67 might be a tight cluster of giant HII regions or a conglomeration of different HII regions along the line of sight. The velocity of the main component in Hα differs from that of the strongest CO component only by about 15 km s^{-1}. A blueshifted component (-46 km s^{-1} in Hα) can also be observed in the NMA and IRAM CO-observations whereas a redshifted component ($+68$ km s^{-1} in Hα) can only be traced in CO(2–1) but not in the interferometer observations. This may indicate that this source is less compact. Because of the excellent agreement in the velocity range as a whole and even in the single components between the CO cloud complex and the HII region CM67 we conclude that both are also **physically related** and form a **huge star foming region** in NGC 4631. We further suspect that this intense and extraordinary star forming region may be responsible for the low frequency radio spur emerging from the disk.

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