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CO ($J = 1 - 0$) Observations of the Non-Barred Seyfert 2 Galaxy NGC 4501

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Abstract

We report high resolution ($1'' \sim 5''$) CO ($J = 1 - 0$) observations in the central 5 kpc region of the Seyfert 2 galaxy NGC 4501 with the Nobeyama Millimeter Array (NMA). The major features seen in a low resolution map are (1) spiral arms penetrating into the nuclear region, (2) a nuclear condensation with a radius of $3''$ (230 pc), which is resolved into double peaks in a high resolution map. Though feature (2) is reminiscent of the gas features often seen in barred galaxies, this galaxy shows no clear sign of a bar. Thus, we propose a "spiral-driven inflow" model as a mechanism for producing the gas condensation in the central region of this galaxy, instead of a bar-driven inflow.

1 Observations and Reduction

We carried out the observations of NGC 4501 with the Nobeyama Millimeter Array (NMA) from 2000 December to 2002 March. The raw visibility data were calibrated with NRO/UVPROC2 software and mapped with the NRAO/AIPS package. We applied the CLEAN procedure with two ways of weighting to obtain low and high resolution maps. The synthesized beam sizes, velocity resolutions and rms noise for the two maps were listed in Table 1.

Resolution	Beam FWHM (arcsec)	Velocity resolution ($\mathrm{km\,s^{-1}}$)	rms noise σ ($\mathrm{mJy\,beam^{-1}}$)
Low	5.6×3.7	10.5	16
High	1.8×1.7	41.9	14

Table 1: Parameters of Maps

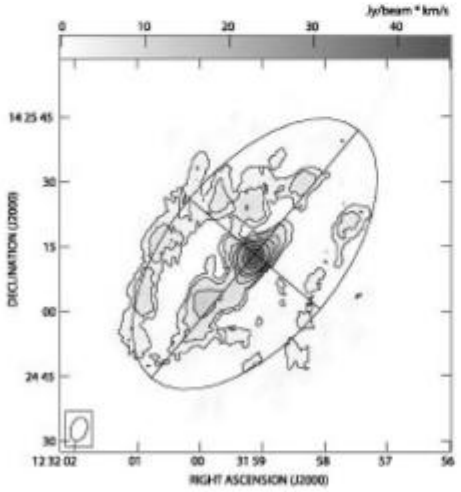

Figure 1: The low-resolution map. The synthesized beam ($5.6'' \times 3.7''$) is shown in the lower left corner. The contours are drawn at 5, 10, 20, 30, 40, 60, 80% of the peak value. The ellipse indicate a projected circle with the radius 75 $''$, the inclination 58° and position angle 140°. The ellipse center is the dynamical center.

2 Results

On the obtained low resolution CO maps (Figures 1 & 2), we found 2.5 kpc spiral arms and a strong central condensation.

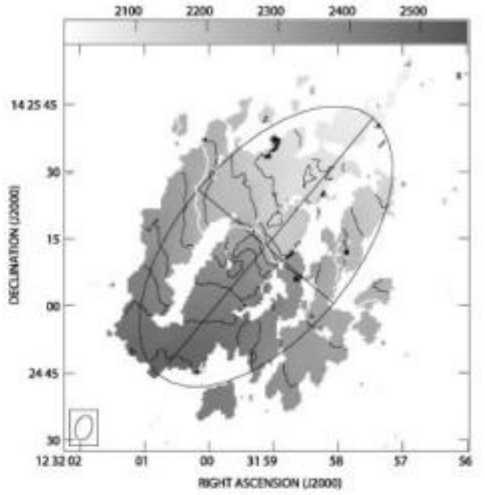

Figure 2: Low resolution velocity field. The contour drawn every 50 km/s, in the range of 2050–2550 km/s. white line indicate the system velocity 2261 km/s. The el is the same as that of Figure 2.

2.1 Spiral Arms

Spiral arms are fragmented in our low resolution map, w outer parts are less clear owing to the primary beam a uation. These spiral arms are coincident with the dust in optical images. Distortions on the velocity field are f along these arms, which we can consider to be caused b spiral density waves.

2.2 Central Condensation Consisting of D Peaks

The low resolution map shows a central condensation of r (230 pc). The total CO flux of this component is $S_{CO}=$ km s^{-1}, which corresponds to $M_{gas} = 4.2 \times 10^7 M_\odot$ for a version factor of $N_{H_2}/I_{CO} = 1.8 \times 10^{20}\,\mathrm{cm^{-2}}$(K km s^{-} The low resolution velocity field map indicates axisymm rotation of this component. In the position-velocity diag this nuclear component shows a high velocity $\sim$ 200 kn and is resolved into two bright peaks (Figure 3). These d peaks appear also in the high resolution map (Figure 4). high resolution map shows that the double peaks inhabi root of spiral dust lanes penetrating into the nucleus tha seen in the HST F606W image.

3 Discussion: Gas Dynamics in NGC 4501

Based on a statistical study, Sakamoto et al. (1999) rep that molecular gas tends to be more concentrated in the tral kiloparsec in barred galaxies than in unbarred ones. result infers the bar-driven gas transport to galactic cen In their work, the degree of central concentration in NGC is relatively high in their sample. Although this central centration and the double peaks are reminiscent of the features often found in barred galaxies, NGC 4501 show sign of a bar. Several works have examined this galaxy fo axiality, such as a bar, by means of elliptical isophote fittin optical and near-infrared images (e.g. Jungwiert, Comb Axon 1997). However, the highly inclined disk of NGC prevents us from a reliable identification of a bar. On other hand, our CO velocity field shows axisymmetric m in the central region. Besides, the HST F606W image s the spiral arms penetrating into the nucleus. All of them port the absence of a bar. Thus, we conclude that NGC

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