RevMexAA (Serie de Conferencias), **11**, 137–138 (2001)

KINEMATICS OF THE CENTRAL REGIONS OF NGC 1672

R. Díaz[1] and G. Carranza[2]

Observatorio Astronómico de Córdoba, UNC, Córdoba, Argentina

and H. Dottori[3]

Instituto de Física, UFRGS, Porto Alegre, Brazil

RESUMEN

Describimos espectroscopía bi-dimensional e imágenes de banda ancha de la galaxia LINER NGC 1672. El campo de velocidad y la morfología de los 2 kpc centrales indican una densidad de masa mayor que en las regiones centrales de espirales normales, diferencias entre la posición del baricentro de la emisión en continuo del núcleo y el centro cinemático, y entre éstos y el centro de simetría de la barra. Un modelo de Satoh ajustado al campo de velocidad observado reveló residuos no simétricos, no correlacionados con la barra ni con el anillo H II circumnuclear. La curva de rotación ubica al anillo sobre una Resonancia Interna de Lindblad, y no sobre el pico de $\Omega - \kappa/2$, como sugieren algunos trabajos, que afirman que el anillo rotaría más rápido que su ambiente, resultado no confirmado.

ABSTRACT

We present two-dimensional spectroscopy and broad band imaging of the LINER galaxy NGC 1672. The velocity field and morphology of the central 2 kpc indicate higher mass concentration than in normal spirals, offsets between the nuclear continuum baricenter and the kinematical center, and between both and the center of the bar. Satoh's model fit to the velocity field reveals non-axisymmetric residuals, not well correlated with the bar or the circumnuclear ring of H II regions. The inner rotation curve locates the ring of star formation on an ILR, and not near the peak of $\Omega - \kappa/2$, as suggested by previous works, also claiming the ring rotating faster than its ambient, result not confirmed here.

Key Words: **GALAXIES: KINEMATICS AND DYNAMICS**

NGC 1672 is a barred spiral with a circumnuclear ring of star formation surrounding a low activity nucleus (Verón-Cetty & Verón 1986). Numerical studies in barred spirals has shown plausible to associate ring-like gas concentrations with dynamical resonances between orbital motions and bar distortions (Combes & Gerin 1985). Active galaxies also present peculiarities like several dynamically distinct systems of ionized gas, and even displacements between mass and kinematic centers (Mediavilla & Arribas 1993). The few nuclear velocity fields published make difficult a systematic study. NGC 1672, with its distance implying 73 pc/($''$) (H_0 = 75 km/s/Mpc) and favorable inclination ($\approx$ 40 deg), suits studying the velocity field around the nucleus. The data were obtained in 1995/96 with the Multifunctional Integral Field Spectrograph (Díaz et al. 1997) on the f/21 Nasmyth focus of the 60-inch telescope at Bosque Alegre Station of Córdoba Astronomical Observatory. Almost 50 hrs of spectra were complemented with object and slit imaging, allowing accurate position-velocity measures. Standard techniques (Díaz et al. 1999). The uncertainty is $\approx$ 15 km/s; the Hα spatial profiles correlate within $0.3''$ with the Hα data by Storchi-Bergmann et al. (1996, SBWB). The spectral slices were referred to the nuclear continuum baricenter.

Velocity Field and Mass Distribution. The mean systemic velocity, 1325 ± 10 km/s, agrees with the molecular gas (Bajaja et al. 1995). The data completely cover the central kpc, with $1.4''$ resolution. The

[1]FOMEC, Facultad de Matemática, Astronomía y Física, UNC, Argentina.
[2]CONICET, Argentina.

oversampled central $4'' \times 4''$ present a strong velocity gradient, $\approx 50\,\mathrm{km/s/('')}$ towards the SE-NW. Other bisymmetrical features appear as secondary maxima and ridges. The data show a 60 pc shift of the kinematical center towards the NW of the continuum emission baricenter and the bar center shifted $\approx 2''$ N and $\approx 8''$ W of the nucleus; a total $\sim$ 600 pc WNW shift. Shifted bars have been found in barred galaxies (Dottori et al. 1996). Simulations (Colín & Athanassoula 1989) suggest shifted bars cause strong arm asymmetries as in NGC 1672.

The average rotation curve of the central 2 kpc was fitted with a Satoh's (1980) density law, combining spherical and disk-like mass distributions. The calculated mass in the observed region is $3.6 \times 10^9\,M_\odot$. The mass inside $r = 125\,\mathrm{pc}$ is $7 \times 10^8\,M_\odot$, corresponding to $\approx 2 \times 10^{11}\,M_\odot/\mathrm{kpc}^3$, a high density compared with the sample of 60 spirals of Rubin et al. (1985), where only NGC 4959 shows a denser center. This contradicts Salucci et al. (1999), who claim no mass concentrations $\gtrsim 1 - 2 \times 10^8\,M_\odot$ inside 250 pc in their sample of 500 late type spirals (implying no massive QSO renmants). This could be due to lack of resolution in their rotation curves and that an important fraction of their sample are edge-on galaxies: the opacity in the inner parts of large spirals tends to make the inner slopes of Hα rotation curves too shallow compared to the true rotation curves. Azimutally averaged radial profile of the central region were compared with Satoh's mass density profile, indicating a lower $(M/L)_{red}$ on the circumnuclear ring ($300\,\mathrm{pc} \leq r \leq 600\,\mathrm{pc}$). Inside $r \approx 300\,\mathrm{pc}$, $(M/L)_{red}$ grows to several times ita value at the outer part of the observed region, maybe due to high amounts of dust towards the nucleus, in agreement with strong infrared emission (De Grijp et al. 1987).

Nonaxisymmetric Components of the Velocity Field. An axial symmetric ($Z = 0$) Satoh's two dimensional radial velocity field was subtracted from the observed velocity field. The residuals reveal non-circular motions with an amplitude $\sim 50 - 60\,\mathrm{km/s}$. We identify three main lobes relative to the Satoh's distribution. The largest residuals were consistent with motion toward the nucleus. The field of residuals was tested against slight variations of the model parameters, maintaining basically the distribution and signs, although the amplitude of the central blue peak varies by $\approx 40\%$. Previous works (SBWB; Storchi-Bergmann et al. 1997) claim that the circumnuclear ring rotates faster than its ambient, mainly because the solid body plus outer flat part model yielded strong residuals at the ring. This motion is not confirmed by our twodimensional differential velocity map, as most of the ring area has pure circular motion.

Inner Lindblad Resonances. To construct the inner $\Omega - \kappa/2$ curve, we assume Buta's (1987) photometric bar size ($r \approx 5.1\,\mathrm{kpc}$) and corotation radius at the end of the bar. The resulting bar, $\Omega_b \approx 30\,\mathrm{km/s/kpc}$, sets an ILR at $r \approx 490\,\mathrm{pc}$ from the galactic center, coincident with the ring outer edge. The ring is not located on the $\Omega - \kappa/2$ peak, as might be inferred from Piner et al. (1995) and SBWB fitting to the rotation. A second ILR, suggested by the falloff of $\Omega - \kappa/2$, should be at $r < 30\,\mathrm{pc}$. Such distance from the nucleus is unreachable with our spatial resolution or that of SBWB. There is no evidence that the gas will retain its dynamical behavior so close to the nucleus. Nevertheless, the unresolved nuclear Hα and [N II]λ6548-84 Å emissions (FWHM$\approx 300\,\mathrm{km/s}$), are broader than the corresponding H II regions lines and marginally present double peaks. Higher spatial resolution and S/N will help to study the inner 30pc.

REFERENCES

Bajaja, E., Wielebinski, R., Reuter, H., Harnett, J., & Hummel, E. 1995, A&AS114, 147
Buta, R. 1987, ApJS, 64, 1
Colín, J., & Athanassoula, E. 1989, A&A, 214, 99
Combes, F., & Gerin, M. 1985, A&A, 150, 327
De Grijp, M., Miley, G., & Lub, J. 1987, A&AS, 70, 95
Díaz, R., Paolantonio, S., Goldes, G., & Carranza, G. 1997, Trab. Astron. A (120 pp.), Nat. Univ. of Córdoba
Díaz, R., Carranza, G., Dottori, H., & Goldes, G. 1999, ApJ 512, 2
Dottori H., Bica E., Claria J.J., & Puerari, I. 1996, ApJ, 461, 742
Mediavilla, E., & Arribas, S. 1993, Nat, 365, 420
Piner, B., Stone, J., & Teuben, P. 1995, ApJ, 449, 508
Rubin, V., Burstein, D., Kent Ford Jr., W., & Thonnard, N. 1985, ApJ, 289, 81
Salucci, P., SZuszkiewicz, E., Monaco, P., & Danese, L. 1999, MNRAS, 307, 637
Satoh, C. 1980, PASJ, 32, 41
Storchi-Bergmann, T., Wilson, A., & Stone, J. 1996, ApJ, 460, 252
Storchi-Bergmann, T., Wilson, A., & Stone, J. 1997, APJ, 472, 83
Véron-Cetty, M., & Véron, P. 1986, AAPS, 66, 335