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NGC 404, A GALAXY WITHOUT DARK MATTER

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RESUMEN

Presentamos observaciones de alta resolución de la galaxia SO NGC 404. Derivamos una masa de H I de $M_{HI} = 6.7 \times 10^7\ M_\odot$, en acuerdo con mediciones previas. El H I está distribuido en un anillo ancho y se extiende hasta un diámetro de 9′, mas allá del diámetro óptico de 6′. El campo de velocidades es irregular y muestra, sorprendentemente, una curva de velocidad decayente. El comportamiento es puramente Kepleriano, sugiriendo fuertemente que toda la masa está contenida en los 200" interiores.

ABSTRACT

We present high resolution (15″ and 2.5 km s^{-1}) H I observations of the S0 galaxy NGC 404. We derive an H I mass of $M_{HI} = 6.7 \times 10^7 M_\odot$, in good agreement with previous measurements. The H I is distributed in a broad annulus and extends out to a diameter of 9′, well beyond the optical diameter of 6′. The velocity field is regular and shows, surprisingly, a declining rotation curve. This decline is purely Keplerian, strongly suggesting that all the mass is contained within the inner 200″.

Key Words: **GALAXIES: EARLY-TYPE — GALAXIES: INDIVIDUAL (NGC 404)**

1. INTRODUCTION

NGC 404 is an isolated early-type galaxy, for which we thusfar have obtained H I observations, CO data, narrow–band H_α, and near–infrared images. It is a typical example of a galaxy which shows more activity than expected from its Hubble type. It was classified a LINER by Schmidt et al. (1990). Morgan (1958) classified this galaxy as E_{pec}, because of the dust lane. Humason et al. (1956) and Sandage (1961) classified it as an $S0_3$. Based on photographic surface photometry, Barbon et al. (1982) show that the object consists of a bulge, lens, and exponential disk, characteristic of a lenticular galaxy. This easily rules out a classification as (dwarf) elliptical. NGC 404 has one major drawback which is that its distance is highly uncertain. With a radial velocity of -56 km s^{-1} the only statement which can be made with certainty is that it must be nearby.

2. HI MORPHOLOGY

In this contribution we will concentrate on the H I data. They were obtained with the NRAO[2] Very Large Array (VLA) in its C and D–array configurations. The H I is distributed as a bright doughnut with an inner diameter of $\simeq 3'$ and an outer diameter of $\simeq 9'$. At considerably lower signal–to–noise an outer ring can be discerned. Our VLA H I data imply a mass of $M_{H_I} = 6.7 \times 10^7 M_\odot$ in the "galaxy" and $M_{H_I} = 1.7 \times 10^7 M_\odot$

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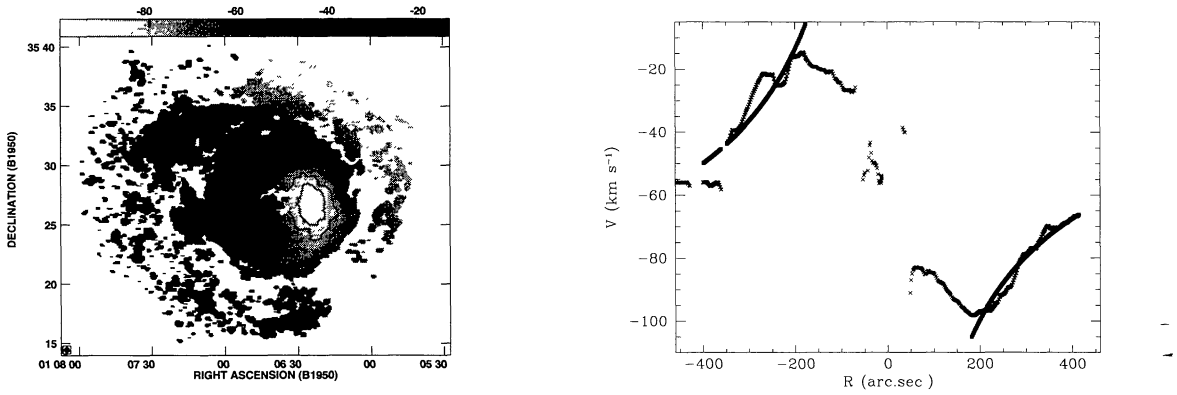

Fig. 1. *Left:* grey scale flux range= -99.6 -14.6 km s^{-1}, contour levels are drawn at -90, -80, -70, -60, -50, -40, -30 and -20 km s^{-1}. *Right:* observed rotation curve, uncorrected for inclination; crosses: observations; solid squares: Keplerian.

in the "annulus". There is considerable fine–scale structure visible, but no large scale pattern such as spiral arms. The doughnut is very nearly circular, suggesting an almost face–on orientation.

Figure 1*a* shows the velocity field based on our H I observations. The projected radial velocities range from -100 to -20 km s^{-1}. The systemic velocity we find is close to the value of -56 km s^{-1} quoted by Wiklind & Henkel (1990). We find a position angle of $\sim 70°$ NE. The isovelocity contours suggest a slight twist when going to larger radii. The velocities of the outer ring fall within the same range as those of the annulus, but the position angle is distinctly different, at $\sim 55°$ NE. What is especially striking in Figure 1*a* is that the isovelocity curves form closed loops, implying a declining rotation curve. In Figure 1*b* we show a cut along the kinematic major axis. We decided to plot the observed radial velocities rather than the true rotational velocities because of the uncertainty in the rather large (due to the low inclination) correction. The gap near the center is due to an absence of H I within the inner 3′. The rotation curve rises rapidly to an observed maximum of 40 km s^{-1} at a radius of 200″, after which it turns over and declines! As illustrated in Fig. 1*b*, the decline is very close to pure Keplerian. Fitting a Keplerian decline to the observed curve results in a correlation coefficient of better than 0.9. NGC 404 is the first and hitherto only galaxy to our knowledge which shows a purely Keplerian decline, implying that all the mass is concentrated within a 200″ radius and that no dark matter is required to explain the observed rotation.

3. SUMMARY

NGC 404 is a unique object, showing a large H I content for an early–type galaxy. This H I is distributed in a doughnut–shaped ring. A faint outer ring, apparently at a different orientation, is visible as well. The H I mass which we derive $M_{HI} = 6.7 \times 10^7 M_\odot$, is in good agreement with single dish observations. We find an H I mass–to–blue light ratio which is relatively high ($M_{\rm HI}/L_B \sim 0.2$). The H I kinematics show, surprisingly, a rotation curve which shows a purely Keplerian fall-off, suggesting that all the mass is contained within a 200″ radius. There does not seem to be a need for dark matter.

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