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DISCOVERY OF A SMALL GROUP THAT DRIVES THE EVOLUTION OF THE EDGE-ON SPIRAL GALAXY UGC 10043

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RESUMEN

La galaxia espiral UGC 10043 presenta algunas peculiaridades morfológicas que la relacionan con objetos inusuales como galaxias "polar ring" y sistemas con bulge ortogonalmente desacoplados, los cuales se distinguen por tener componentes con rotación ortogonal y son probablemente resultado de procesos evolutivos atípicos que incluyen mergers, acreciones u otros eventos secundarios. Por ello, observamos UGC 10043 con el VLA en modo espectral en la banda de H I con el fin de investigar su estructura y dinámica interna, y aclarar así su historia de formación. Nuestros resultados indican que UGC 10043 es parte de un pequeño grupo de galaxias y está interactuando actualmente con su vecina MCG+04-37-035Ėste descubrimiento permite comprender algunas de las peculiaridades detectadas en UGC 10043, e indica que su morfología y cinemática están determinadas en gran medida por su ambiente local.

ABSTRACT

UGC 10043 is an edge-on spiral galaxy with some peculiar morphological features that relate it to unsual objects with orthogonally rotating components like polar-ring galaxies and orthogonally decoupled bulge systems, which are the result of peculiar evolutionary processes that probably include mergers, acretions or other "second events". We observed UGC 10043 with the VLA in H I spectral imaging mode in order to further investigate its structure, kinematics and evolutionary history, and find that UGC 10043 is forming part of a small group environment and most important, it is presently interacting with its neighbour galaxy MCG+04-37-035Ṫhe discovery of this interaction helps us understand some of the peculiarities seen in UGC 10043, and shows us that its morphology and kinematics have been strongly affected by its local environment.

Key Words: galaxies: evolution — galaxies: interactions

1. INTRODUCTION

UGC 10043 is an edge-on spiral galaxy located at ~ 32 Mpc, which shows several morphological peculiarities (Matthews & de Grijs 2004). In particular, optical images show that the bulge is elongated perpendicular to the galaxy's major axis, and is bisected on its SW quadrant by a minor axis dust lane. Additionally, there is a large-scale galactic wind probably powered by a faint central starburst and the stellar disk is thin, dusty, and dinamically cold.

Such structural complexities relate UGC 10043 to relatively rare objects like orthogonally decoupled bulge systems (Bertola et al. 1999) and polar ring galaxies (Whitmore et al. 1990), which exhibit components with angular momentum paralell to the galaxy's major axis. Orthogonal rotation suggests a peculiar formation history that must have included a significant "second event" like a merger or accretion. In the case of UGC 10043, Matthews & de Gris (2004) proposed three plausible formation scenarios: accretion of gas around a pre-existing spheroid (*"Dressing a Naked Spheroid"*), acquisition of a bulge after the disk had formed and settled (*"Capture"*) and simultaneous formation of disk & bulge through the merger of two moderate galaxies.

We observed UGC 10043 with the VLA in H I spectral imaging mode in order to gain further insight into the structure and kinematics of its gas, and thus constrain its history. We used configurations C (14 hours) and D (106 min), with effective bandwidths of 2.64 MHz and 6.25 MHz and resolutions of ~ 5.2 km s^{-1}and ~ 41.8 km s^{-1}respectively.

2. HI DISTRIBUTION AND KINEMATICS

Our VLA data was reduced using standard AIPS routines and the squint-correcting algorithm (Uson & Cotton 2008) available in the *Obit* software package (Cotton 2008), and we produced channel images and moment maps. For UGC 10043 we mea-

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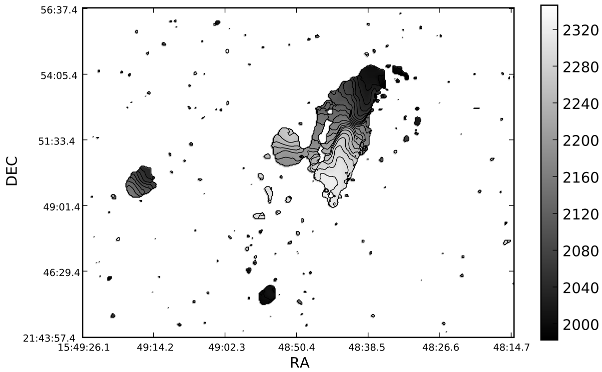

Fig. 1. HI Velocity field for UGC 10043. Contours are plotted over a linear colormap of the velocity field, ranging from 1956.92 to 2364.98 km s^{-1}, with a separation of 15.6 km s^{-1}. The grayscale bar shows velocities in km s^{-1}.

sure a total flux of 22.19 ± 0.14 Jy km s^{-1}, in agreement with observations by Giovanelli et al. (1997), and we also detect emission from three neighbouring galaxies, MCG+04-37-035, UGC 10049 and J1592443+215115, which reveals a small group environment (see Figure 1). UGC 10043 and MCG+04-37-035 are physically connected by a continuous gas bridge that runs parallel to the galaxy's major axis and falls on top of its bulge, close to the minor axis dust lane. The gaseous disk of UGC 10043 extends ≈3 times further than in the optical, and displays an integral-sign warp that could be originated by interaction with MCG+04-37-035 since warps can be excited by infalling satellites (Huang & Carlberg 2004; Velázquez & White 1999). We also detect radio continuum emission that is consistent with a central star-formation origin (Condon et al. 1998).

For a kinematic study of our system, we produced the first moment map shown in Figure 1. For UGC 10043, the velocity field reveals a diferentially rotating disk with angular momentum along the SW direction, smooth transitions and V-shaped isovelocity contours. In the case of MCG+04-37-035 there are also signs of a rotating disk but most striking, the rotation direction is opposed to that of UGC 10043, which is relevant for the interaction analysis. The velocity transition along the connecting gas bridge is very smooth, suggesting a true physical association, and we also detect a collection of small H I clouds on the NW of UGC 10043 and SE of MCG+04-37-035 that appear to trace an open orbit. Finally, there are no multispin components or signs of a classic polar ring, and we don't see bowl-shaped structures around the bulge region either, as expected if the galaxy had captured a pre-existing spheroid.

3. CONCLUSIONS

We found that UGC 10043 is presently interacting with MCG+04-37-035 which may account for some of the peculiarities described by Matthews & de Grijs (2004). First, the gas tidally stripped from MCG+04-37-035 is being dumped on to the central region of UGC 10043, so it can be related to the minor axis dust lane and would also help fuel the central starburst that powers the large scale galactic wind and radio continuum emission. The interaction is also consistent with the excitation of a warp in the gaseous disk, and the counterrotation is compatible with the coldness and thinness of the stellar disk since disks are less heated in retrograde encounters (Velázquez & White, 1999).

The complex configuration revealed by H I data reinforces that UGC 10043 has had a peculiar formation history, and the new data can help us discriminate between models. The *"naked spheroid"* scenario (Matthews & de Grijs 2004) could be supported by the ongoing accretion of gas from MCG+04-37-035, but this galaxy lacks enough mass to account for the whole disk of UGC 10043. The opposite picture is the capture of a small, gas-poor elliptical, but this mechanism would produce bowl-like shaped or ring structures around the bulge region, which are not detected. A *"major merger"* in the past cannot be discarded, and it is likely that the current interaction is actually a "third event" that is adding material to a pre-existing prolate bulge made of old, red stars.

Numerical simulations are needed in to derive a precise interaction model, but the encounter resembles the case of the **Whirlpool galaxy** (the **M51 system**), *"seen from the side"*. Anyhow, our H I VLA data has revealed an unexpected picture for UGC 10043, in which its morphological characteristics are strongly affected by its local environment and by past or ongoing interactions.

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