IC 5181: An S0 Galaxy with Ionized Gas on Polar Orbits

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Abstract. The nearby S0 galaxy IC 5181 is studied to address the origin of the ionized gas component that orbits the galaxy on polar orbit. We perform detailed photometric and spectroscopic observations measuring the surface brightness distribution of the stars (I band), ionized gas of IC 5181 (Hα narrow band), the ionized-gas and stellar kinematics along both the major and minor axis, and the corresponding line strengths of the Lick indices. We conclude that the galaxy hosts a geometrically and kinematically decoupled component of ionized gas. It is elongated along the galaxy minor axis and in orthogonal rotation with respect to the galaxy disk. The result is suggesting that the gas component is not related to the stars having an external origin. The gas was accreted by IC 5181 on polar orbits from the surrounding environment.

1. Introduction

IC 5181 is a large (2'.6 × 0'.8; de Vaucouleurs et al. 1991, hereafter RC3) and bright (B_T = 12.51; RC3) early-type disk galaxy. It is classified as edge-on SA0 in RC3 due to the presence of a flattened thick disk. Its total absolute magnitude is M_{0,B,T} = −19.48 corrected for inclination and extinction (RC3) and adopting a distance of 24.8 Mpc (Tully 1988). IC 5181 is a member of the loose NGC 7213 group (Maia et al. 1989, Garcia 1993). It forms a pair with the edge-on spiral galaxy NGC 7232A at 8.1′ separation corresponding to a projected linear distance of 58.4 kpc.

In the framework of acquisition events occurred in the lifetime of galaxies, we present IC 5181 as a new case of a disk galaxy characterized by a geometric and kinematic orthogonal decoupling between its stellar body and the ionized-gas component.

2. Observations

The photometric observations of IC 5181 were carried out at the European Southern Observatory (ESO) in La Silla with the 2.2-m MPG/ESO telescope equipped with the Wide Field Imager (WFI) on July 22, 1999. The I-band and Hα-narrow band filters have been used. The spectroscopic observations were carried out at ESO in La Silla with the 1.52-m ESO telescope on June 9-11, 1999 and the telescope was equipped with the Cassegrain Boller & Chivens spectrograph. The complete description of the
3. Results

The Hα image of the galaxy shows an ionized gas structure perpendicular to the stellar disk of IC 5181. The disk and bulge are featureless and regular as expected for an S0 galaxy. The only noticeable fact is the change in position angle (PA) of the isophotes around $5'' < R < 15''$ and that the disk is edge-on ($i_{\text{disk}} = 77^\circ$). The kinematics of the stellar component show no anomalies. The ionized gas is instead moving on polar orbits and its extension along the minor axis is twice the extension along the major axis.

We interpret these results as the indication that IC 5181 has a central triaxial structure (a bar or a bulge) and that the ionized gas is moving onto a plane perpendicular
Ionized Gas on Polar Orbits in IC 5181

Figure 2. Left panel: Kinematic parameters of the stars (circles) and ionized gas (crosses) and the line-strength indices measured along the major axis of IC 5181 (PA = 74°). The radial profiles of Gauss-Hermite coefficients $h_4$ and $h_3$, velocity (after the subtraction of systemic velocity), velocity dispersion, and line-strength indices Fe5335, Fe5270, Mg$b$, Mg$2$, and H$\beta$ are plotted (from top to bottom). The vertical dashed lines correspond to the radii ($R_{bd}$), where the surface-brightness contributions of the bulge and disk are equal. Right panel: As the left panel for the minor axis (PA = 164°).

to its long axis. To check if this picture is consistent with the observations, we build a geometric model of the galaxy. We derived its asymptotic circular velocity from the stellar kinematics finding $v_{circ} = (305 \pm 10)$ km s$^{-1}$. We measure a projected asymptotic velocity of the ionized gas of $v_{gas} = (201 \pm 6)$ km s$^{-1}$ (Fig. 2 right panel). Assuming that the ionized gas is moving with the same $v_{circ}$ as the stars, we derive its inclination: $i_{gas} = 41° \pm 3°$. The two angles describing the orientation of the galaxy are therefore known: the inclination of the stellar disk $i_{disk} = 77°$ and the inclination of the ionized gas $i_{gas} = 41°$. The direction of the angular momentum of the gas can be found and it lies along PA$_{gas} = 62° \pm 2°$. This is consistent with the orientation of the ionized gas seen in the H$\alpha$ image (Fig. 1 right panel). If the gas is orbiting in the equilibrium plane perpendicular to the long axis of a triaxial structure, PA$_{gas}$ is also the position angle of this structure (e.g., Bertola et al. 1985). A scheme of the geometric model can be found in Fig. 3. The small difference ($\Delta$PA = 12°) between the position angles of the disk major axis and bulge/bar long axis and the high inclination have prevented to decompose it properly in a two-dimensional surface photometry analysis.

The kinematical decoupling between the gaseous and stellar components suggests the occurrence of an accretion event or merging (Bertola & Corsini 1999). Therefore, it is straightforward to explain the existence of the orthogonally rotating gas in IC 5181 as
the end result of the acquisition of external gas by the pre-existing galaxy. The nearby environment of IC 5181 shows no strong evidence of such an event. IC 5181 does not interact with its closest companion, NGC 7232A, and is one of the few galaxies of the NGC 7213 group to be undetected in H I (Barnes & Webster 2001). Bettoni et al. (2001) proved that the environment of galaxies that experienced past gas accretion do not appear statistically different from those of normal galaxies. In addition, the polar orientation of the ionized gas and its possible low metal content fits well with the scenario proposed for the formation of polar ring galaxies, where the gaseous ring is formed by the accretion of material from a cosmic filament (Macciò et al. 2006; Brook et al. 2008; Snaith et al. 2012).

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