The Low Surface Brightness Universe, IAU Col. 171
ASP Conference Series, Vol. 170, 1999
J. I. Davies, C. Impey and S. Phillipps, eds.

The Structure of the Superthin Spiral Galaxy UGC7321

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Abstract. UGC 7321 is an edge-on low surface brightness (LSB) spiral galaxy with a number of extraordinary properties. Its vertical scale height ($\sim$70 pc) is one of the smallest ever measured for a galaxy disk. Its disk also exhibits strong vertical and radial color gradients. UGC 7321 appears to be an extremely unevolved galaxy in both a dynamical and in a star-formation sense.

1. Motivation

Among the latest-type spiral galaxies there exist objects that when viewed edge-on, exhibit extraordinarily thin disks, and often, very low optical surface brightnesses. These and other features suggest these are some of the least evolved nearby galaxies in terms of their dynamical properties and star-formation histories. Studies of the vertical structures, color gradients, and global properties of these "superthin" spirals can shed new insight into the structure, stability, and evolution of galaxies.

We have obtained new multiwavelength observations of the nearby, LSB, superthin spiral UGC 7321 (Fig. 1). From these data we have measured the global properties of this galaxy (see Fig. 1) and have undertaken an analysis of its vertical structure and disk color gradients. Details concerning the analysis and interpretation of our new UGC 7321 observations can be found in Matthews (1998).

2. Summary of Key Results

The superthin galaxy UGC 7321 exhibits strong radial color gradients: $B - R \sim 2.0$ near the galaxy center, while along the major axis, $B - R$ reaches $\sim$0.20 at the easternmost edge of the disk, and $\sim$0.4 at the western edge. This is one of the strongest color gradients ever observed in a galaxy disk. UGC 7321 also exhibits vertical color gradients of several tenths of a magnitude in $B - R$.

UGC 7321 has one of the smallest disk scale heights ever measured for a spiral galaxy: $\bar{h}_z = 70$ pc at the disk center (r=0). The ratio of the disk scale length to the disk scale height at r=0 is ~20. UGC 7321 thus appears to have undergone little dynamical heating and has likely remained unperturbed over its lifetime.

The disk of UGC 7321 is not purely isothermal over most of its radial extent (cf. van der Kruit & Searle 1981). At r=0, the vertical light profile can be fit with a single exponential function (with scale height $\bar{h}_{z,c}$=70 pc; Fig. 2). For $|r| \leq 0.'5$, the vertical light profile becomes less peaked than an exponential and can be adequately characterized by the sum of two sech functions of differing scale heights ($\bar{h}_{z,2}$=60 pc and $\bar{h}_{z,3}$=109 pc). We interpret the exponential profile at the disk center as the superposition of a third disk component with a very small scale height ($h_{z,1}$ <46 pc). We also find marginal evidence for a fourth, faint disk component with $h_{z,4}$ >111 pc.

We attribute the smallest scale height disk component of UGC 7321 to a "nuclear disk" with a very small radial extent. The $h_{z,2}$ and $h_{z,3}$ disk components may be analogous to the "young disk" and the "thin disk" of the Milky Way, respectively. Counterparts to these components are visible in our optical images and color maps. The nature of the fourth disk component is uncertain.

UGC 7321 is underluminous for its observed rotational velocity compared with the prediction of the Tully-Fisher relation. This indicates the galaxy is likely to be dark matter-dominated even within its inner disk. This assertion is strengthened by simple analytical arguments that indicate that a significant fraction of the total mass of UGC 7321 must lie in a dark matter halo in order to prevent "firehose" instabilities. *Taken together, the global, kinematic, and structural properties of UGC 7321 suggest it is an extremely unevolved galaxy.*

Acknowledgments. LDM acknowledges the financial support of the WFPC2 IDT and a Peter B. Kahn Fellowship from the State University of New York at Stony Brook.

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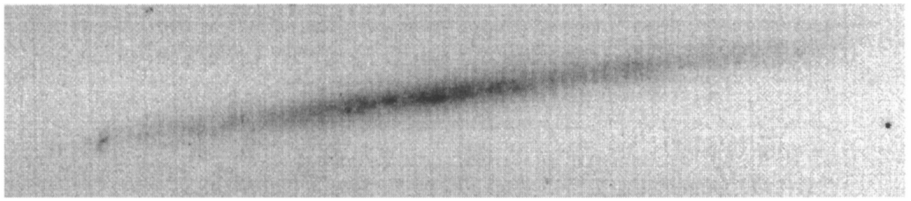

Figure 1. *R*-band CCD image of UGC 7321 obtained with the WIYN telescope. Field size is 5.'0×0.'8. We measure absolute magnitude: M_B=-14.64 (for A_B=0.04), linear diameter: A_{25}=8.14 kpc, H I mass: $\mathcal{M}_{HI}$=2.8×10^{8}M$_\odot$, radial velocity: V_{HI}=406.7 km/s, and H I line width: W_{20}=233 km/s. We assume a distance of 5 Mpc (Tully *et al.* 1992).

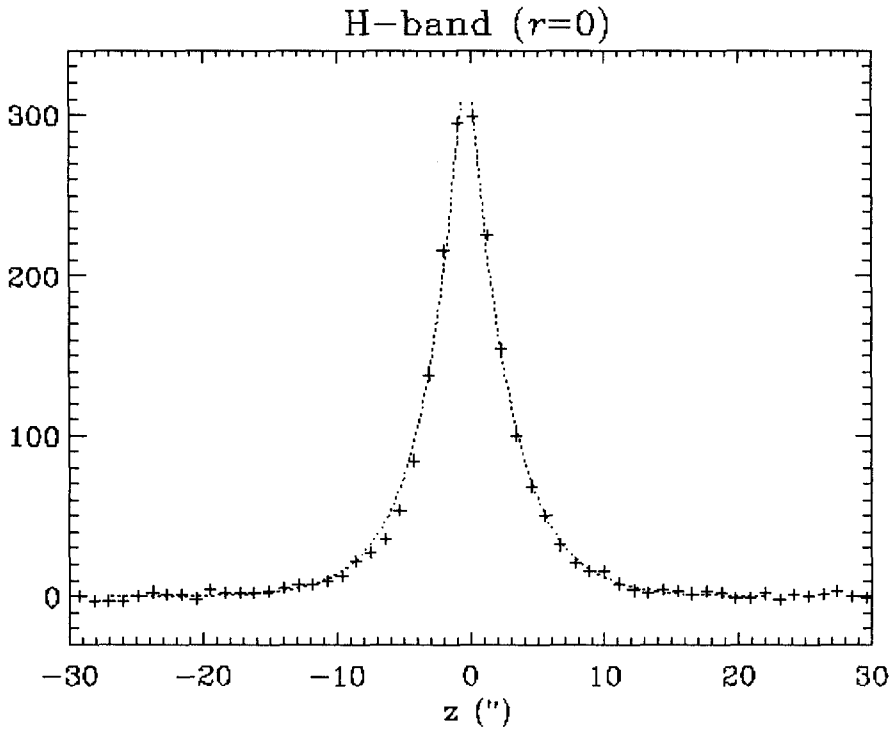

Figure 2. *H*-band vertical brightness profile of UGC 7321 along the galaxy minor axis (r=0). The best-fitting exponential model with h_z ~70 pc is overplotted as a dotted line. Axes are distance from the galaxy plane, in arcseconds, versus detector counts in arbitary units.

https://doi.org/10.1017/S0252921100054336 Published online by Cambridge University Press