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HST WFPC-2 Imaging of Four Nearby LSB Galaxies

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Abstract. Between May, 1996 and January, 1997 HST WFPC-2 images of four nearby LSB galaxies were taken through both the 8140Å and 3000Å filters. The first galaxy imaged, UGC 12695, is a nearby (z$\sim$0.021) LSB disk galaxy. UGC 12695 has an unusual morphology, consisting of a Y-shaped nucleus surrounded by a faint spiral arm. Additionally, numerous HI regions are spread throughout the galaxy. One of the surprising discoveries with the WFPC2 imaging was that a number of what were previously believed to be structural peculiarities in the galaxy are actually background galaxies. Once the effects of these galaxies are removed, the resultant U$-$I color of UGC 12695 is only -0.2, making it possibly the bluest galaxy in the local universe. When combined with the metallicity studies of McGaugh (1992), these colors indicate UGC 12695 to be a highly unevolved galaxy.

The other three galaxies imaged – V1L4, V2L8, and V7L3 – are dwarf elliptical galaxies located in the Virgo cluster. The intent of their images was to determine the galaxies' small scale structure and place limits on the density and type of giant branch stars within each galaxy. Placed at the distance of the Virgo cluster, luminosity fluctuations indicate the galaxies to contain only from 4 – 13 stars per pixel, coinciding with a K/M giant ratio ranging from 6 to ∞ (no M giant stars). Additionally, we found no evidence for stellar clumping in these galaxies although an extremely red, extremely small bulge was found at the core of V2L8.

1. UGC 12695: A Remarkable Unevolved Galaxy at Low Redshift

Utilizing the 8140Å (F814W) and 300Å (F300W) filters, short exposure Hubble Space Telescope Wide Field Planetary Camera-2 (WFPC2) images were taken of UGC 12695 a nearby (z $\sim$ 0.021) low surface brightness disk galaxy. UGC 12695 has an unusual morphology, consisting of a Y-shaped nucleus surrounded by a faint spiral arm with a number of bright H II regions interspersed throughout the galaxy. Surface photometry indicates the majority of recent star formation in this galaxy occurred in these very localized regions, most of which have a radius of $\leq$2".

Some of the structural peculiarities of this galaxy arise because a number of background galaxies, previously thought to be morphological components of this galaxy (i.e. McGaugh, Schombert & Bothun 1995; McGaugh 1994; Klein, et al 1992), are showing through both the outer nucleus and spiral arms of UGC

Table 1. Global Properties of UGC 12695

RA	Dec	V (km/s)	d (Mpc)	M_{HI}	M_{dyn}	M_{HI}/L_B
23:36:02.0	12:52:32	6182	4590	9.62	9.98	1.28
	$f^B{}_g$	h (kpc)	M_B	$\mu_B(0)$		
	0.62	8.4	-18.92	23.8		

Table 2. WFPC2 Color of UGC 12695

	inner 2"			inner 10"			inner 30"		
	814		U−I	814	300−814	U−I	814		U−I
a:	22.22	-0.54	2.16	19.43	-0.44	2.26	18.07	-2.75	-0.09
b:	22.22	-0.54	2.16	19.51	-0.98	1.72	18.15	-2.88	-0.18
c:	22.22	-0.54	2.16	19.51	-0.97	1.73	18.15	-2.88	-0.18

Row a lists the colors with both the background galaxies and all H-α regions included.
Row b lists the results of masking the background galaxies.
Row c lists the results of masking both the background galaxies and the H-α regions.
All colors are within $\pm$ 0.05.

12695. When these galaxies are masked out, the resultant U−I color of UGC 12695 is -0.2 ± 0.1, making it perhaps the bluest galaxy every measured in this color system and confirming its nature as a very unevolved galaxy at low redshift.

McGaugh (1992) performed a metallicity study on a number of UGC 12695's H-α regions and found the average metallicity of the studied regions to be $\sim 0.4 Z_\odot$. When these are combined with the extremely blue colors of the same regions this indicates they are likely young starburst areas which have not yet enriched much of the gas.

In all, UGC 12695 proved to be a remarkable galaxy. It has an exceptionally high gas mass fraction, very low metallicity, very diffuse morphology, perhaps the bluest colors known for a galaxy, and an extremely transparent nature. Combined these indicate UGC 12695 to be a highly unevolved galaxy. Since UGC 12695 is at fairly low redshift, its properties indicate some potentials may well have late collapse and formation timescales. Additionally, and unlike most galaxies, UGC 12695 has the advantage of being relatively isolated, with its only nearest neighbor at a projected distance of 200 kpc. It is therefore likely UGC 12695 has been affected minimally (if at all) by other galaxies, and as such it provides an ideal study for low density galaxy evolution. Understanding this evolutionary process may shed considerable light into galaxy formation scenarios as a whole. More information on the WFPC2 study of UGC 12695 can be found in O'Neil, et al (1998).

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Table 3. Luminosity Fluctuations (in Electrons) From the Inner regions of V1L4, V2L8, V7L3

Galaxy	μ_I	Galaxy	Sky	σ	N	M_I(1 star)
V1L4	21.57	182.2 ± 20.3	146.1 ± 17.7	0.279	13	-2.03
V2L8	22.88	178.0 ± 19.5	168.2 ± 19.0	0.450	5	-1.66
V7L3	22.67	168.2 ± 19.3	155.0 ± 18.2	0.493	4	-2.01

The central surface brightnesses are given in mag arcsec^{-2}, while the fluctuations are in electrons.

2. Three Low Surface Brightness Dwarf Elliptical Galaxies in the Virgo Cluster

WFPC2 images through the F814W and F300W filters were taken of V1L4, V2L8, & V7L3, three LSB dwarf elliptical galaxies in the Virgo cluster. The intent of these observations was to determine the small scale structure in these enigmatic galaxies and to attempt to learn something about the nature of their giant branch through the detection of luminosity fluctuations. These luminosity fluctuations, found in the inner constant surface brightness regions, were unambiguously detected. At the nominal distance of the Virgo cluster, the measured luminosity fluctuations in the F814W band yields a density of 4-13 red giants/pixel. In the most extreme case, V7L3, this is equivilent to a surface density of giant stars of $\sim$ 1 per 10 pc^2. Additonally, we find no evidence for small scale clumping of stars in these systems at this much improved spatial resolution scale. In the case of V2L8, however, we have discovered what is likely the smallest bulge measured to date, having an effective radius of only 50 pc. This bulge is quite red (as red as giant ellipticals) and thus may well be substantially more metal-rich than the rest of the galaxy. Moreover, while we are able to derive differences in the mean spectral type of the giant branch causing the observed fluctuation we found 1) K/M giant ratios ranging from 6 to ∞ (no M giant stars) and 2) no correlation between mean spectral type and surface brightness in our small sample. The latter point is important because it indicates that conditions of low I-band surface brightness in these dEs are caused both by low giant star luminosity per pixel (*e. g.* K0 giants) and by large physical separation between individual giants (e.g. V7L3). Such large physical separation is a manifestation of the extremely low density of these systems and when imaged at high spatial resolution of the WFPC2 ($\sim$ 6 pc per pixel), the galaxies are easy to look right through without evening knowing they are present in the middle of the WFPC2 frame. More details on these observations can be found in O'Neil, Bothun, & Impey (1998).

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