A Survey for Low Surface Brightness Galaxies in Virgo using Tech Pan Films

1. Introduction

Searches for faint, low surface brightness galaxies (LSBGs) have in the past been limited either by detector area or detector efficiency. Conventional UKST plates cover large areas but have inherent signal-to-noise (S/N) limitations, while CCDs reach deep limits but sample much smaller areas of the sky in a given amount of time. A new, very promising way to overcome the S/N limitations of Schmidt plates while retaining the same area coverage is the use of Kodak Tech Pan 4415 film as a replacement for conventional IIIa plates.

The fine grain, high quantum efficiency and improved sensitivity of Tech Pan compared to traditional IIIa emulsions mean that fainter limiting isophotes can be attained in 75 minute sky limited exposures. A detailed photometric study of 5 known Virgo Cluster galaxies from COSMOS scans of Tech Pan films (Phillipps & Parker 1993) has shown that typical pixel-to-pixel variations on 1" scales are as low as 0.7%, i.e. a factor 3 improvement in uniformity over the corresponding IIIa-F emulsion. This very low sky noise means that we can perform surface photometry to a limiting isophote of 27.0 $R\mu$, equivalent to only 0.25% of the sky brightness. Tech Pan film therefore offers a gain of about 1.5 magnitudes over IIIa-F plates in this respect.

We are now benefiting from the substantial advantages of 4415 film in undertaking a survey of LSBGs in the Virgo cluster. Besides reaching fainter surface brightnesses than previous LSBG surveys (e.g. Binggeli et al. 1985; Davies et al. 1988; Impey et al. 1988), our higher S/N per pixel will allow the inclusion of objects with considerably smaller angular diameters, thus contributing a significant new population of LSBGs to that currently known.

2. The Virgo Film Survey

Nearby clusters such as Virgo offer the ideal environment in which to search for LSBGs. It is now known that LSBGs dominate cluster numbers (Turner et al. 1993, and references therein), and can therefore represent a significant fraction of a cluster's total baryon content. Furthermore, preliminary results from a CCD field survey (Schwartzenberg & Phillipps 1994) show that very few apparently large LSBGs are present in random field areas, and thus a cluster environment must be sampled if we are to find large numbers of LSBGs.

Our overall LSBG survey will be based on COSMOS digital scans of eight independent Tech Pan exposures ($\simeq$ 75 minutes each) of a $5^\circ \times 5^\circ$ area of the Virgo Cluster. A preliminary 'eyeball' search in a 0.5 square degree subset of this field, using just one film, has revealed previously uncatalogued LSBGs with central surface brightnesses $\mu_o(R) \simeq$ 23.5 - 24.0 and scale lengths 4 - 5 arcseconds (Schwartzenberg, Phillipps & Parker 1994a, b). We have also identified, with remarkable ease, some of the faintest LSBGs included in the study of Impey et al. (1988) who used photographic contrast enhancement techniques.

The search over the whole 25 square degree area will use co-added (or more precisely, median stacked) data from the set of available films and will be carried out in an automated fashion, using connected pixel detection algorithms which should enable the detection of LSBGs down to very small scale lengths, $\alpha \simeq$ 3", corresponding to about 250 pc at Virgo (assuming $d_{Virgo} \simeq$ 18.5 Mpc). This linear scale length is comparable to that of the dwarf spheroidals in the Local Group (Caldwell et al. 1992). We will therefore be sampling not only to fainter limits when compared to previous Virgo

surveys (Binggeli et al. 1985; Impey et al. 1988), but also to smaller angular sizes, thus allowing for the inclusion of the more numerous, physically smaller LSBGs (Irwin et al. 1990).

3. Conclusions and Future Prospects

Our discovery of new LSBGs in the Virgo cluster has highlighted the potential of Tech Pan films for the detection and photometry of faint galaxies. Further gains are obtained from the combined use of

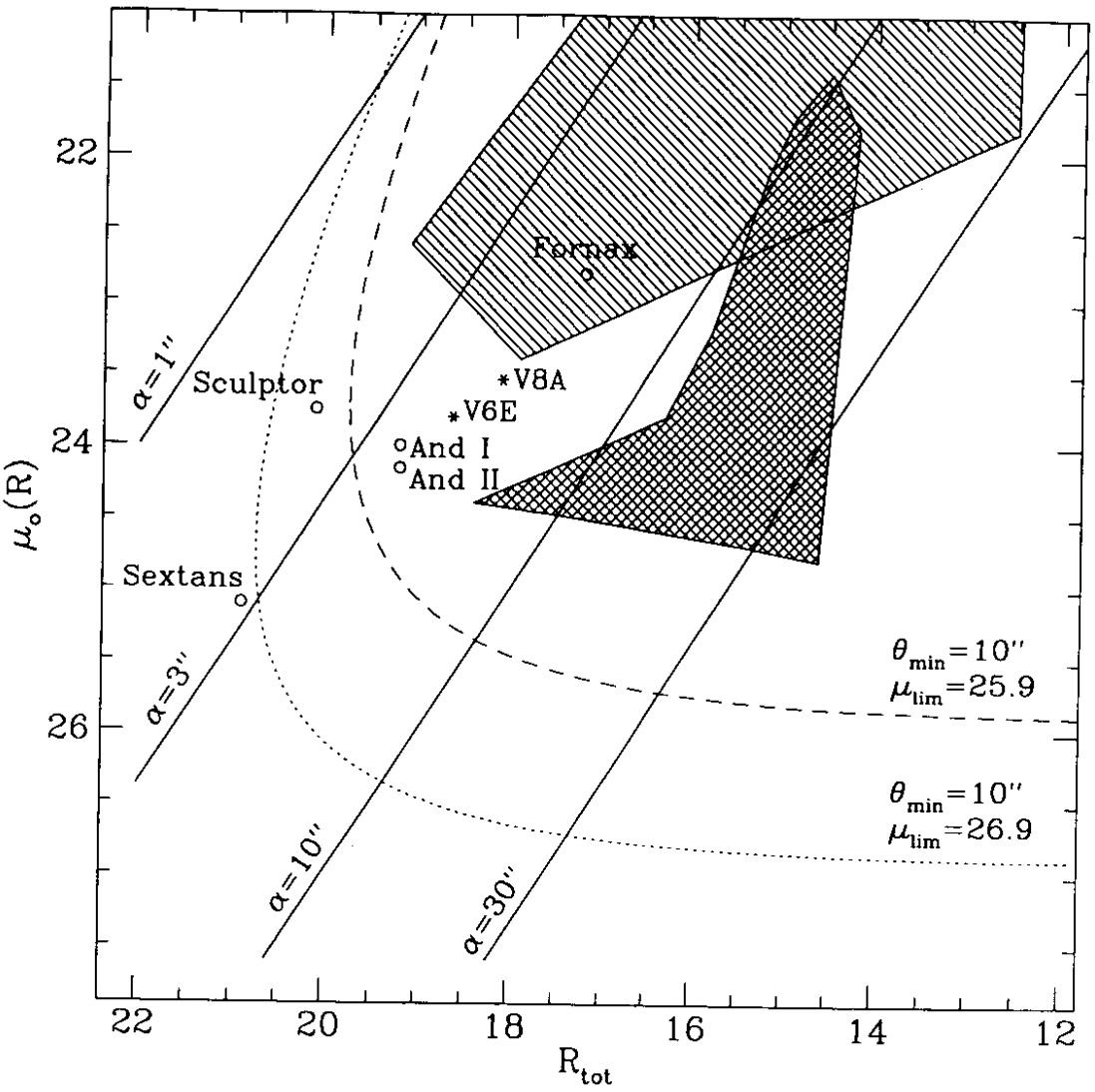

Figure 1. The distribution of Virgo LSBGs in the magnitude-central surface brightness plane. The hatched and cross-hatched regions represent the areas of parameter space covered by the Binggeli et al. and Impey et al. samples, respectively. The asterisks mark new Virgo LSBGs detected in our preliminary 'eyeball' survey. The dashed and dotted curves mark the loci of galaxies with image diameters of 10" at the isophotal levels reachable with a single film and with 6 stacked films. The diagonal long lines indicate particular galaxy scale lengths. The circles show the positions which some of the Local Group dwarf spheroidal galaxies would occupy if they were placed at the distance of Virgo, emphasising the point that even galaxies as small as these will be detectable in the current survey.

our six best individual exposures, which pushes the detection limit another 0.7 magnitudes fainter compared to the best single frame. Artefacts present on individual frames are also removed by means of median-stacking rather than simple addition. As the number of LSBGs increases rapidly with decreasing scale length ($n(\alpha) \propto \alpha^{-2}$ [Irwin et al. 1990]), the small angular size limit of our survey, combined with its fainter surface brightness limit, will allow us to detect many more cluster members than any previous survey. Thus we will be able to investigate in much more detail the contribution of LSBGs to the cluster luminosity function, their covering factor and their spatial distribution.

We show in Fig. 1 the regions of (scale-size, surface brightness) parameter space which will be accessible to the new survey. Indicated are the regions for which galaxies would have diameters above 10" at about the $26R\mu$ (single film) and $27R\mu$ (stacked film) isophotes. A particularly important point to note is that we are well into the regime of Local Group dwarf spheroidals (the positions some of these would occupy if at the distance of Virgo are also shown in the figure). This is the first time that any survey has been able to reach such objects anywhere outside our immediate environment.

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