SURVEYS OF LOW SURFACE BRIGHTNESS GALAXIES WITH 4415 FILMS

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1. Introduction

During the past few years there have been a number of surveys for low surface brightness galaxies (LSBGs). Searches using both photographic and CCD data have shown that LSBGs are actually very numerous (Impey, Bothun & Malin 1987; Irwin et al. 1990). However, they are seriously biased against in any random sky survey, and even in a cluster area there are inherent size and signal-to-noise problems. The number of objects we can detect are therefore limited in two ways.

Conventional CCDs, while allowing us to go deep, fail to sample large areas in a reasonable time. Large format CCDs (and reducing optics) can make significant gains in this direction, as with our survey of A3574 (Turner et al. 1993; see also Phillipps et al., this meeting).

However, it is important to realise, if we are searching for galaxies of extremely low surface brightness, that (at a fixed surface brightness) we obviously maximise our S/N for large images, that is, nearby galaxies. We therefore need large search volumes of low depth. In other words, we need the very wide angle surveys which are clearly still the province of photographic photometry. With conventional UKST plates there is a limit to the surface brightness we can reach (because of the S/N considerations) which does not encompass the dimmest objects now known (and which are probably quite common).

We can now, though, utilise the new fine grain, high DQE Kodak 4415 films being taken at UKST (see Parker et al., this meeting) to improve our detection efficiency and image S/N. Thus we can lower significantly our surface brightness limit while maintaining the huge area advantage of Schmidt plates relative to CCD images (a factor 500 even for the large format f/1 system and around 8000 for a standard RCA CCD on the AAT, for example).

2. Photometry with the 4415 Films

To quantify the advantages of the 4415 films for galaxy surface photometry we have had long exposure films of a region of the Virgo Cluster scanned by COSMOS at ROE. If we first consider the noise, the COSMOS data shows that on 1" scales we have pixel to pixel fluctuations of only 0.8%. This is a factor 3 better than for IIIa plates. Furthermore, over separate scan areas

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a quarter of a degree square systematic background variations are at the 0.1% level, even with no additional processing ('flat fielding'). Just in terms of 'sky' noise this makes the films equivalent to at least 2 minute CCD exposures on a 4m class telescope (Phillipps & Parker 1993).

If we next look at some of the previously mapped galaxies which lie in our survey area, we can note how 4415 performs, in various respects, on real images (see Figs. 1a - f).

VCC 1017 — Here we show a comparison of the radial intensity profile of the LSBG VCC 1017 (Binggeli, Sandage & Tammann 1985) as obtained from 2 films (x, +) and an INT CCD image (□). This highly irregular galaxy provides a stringent test of the consistency and reliability of the film data on both large and small scales.

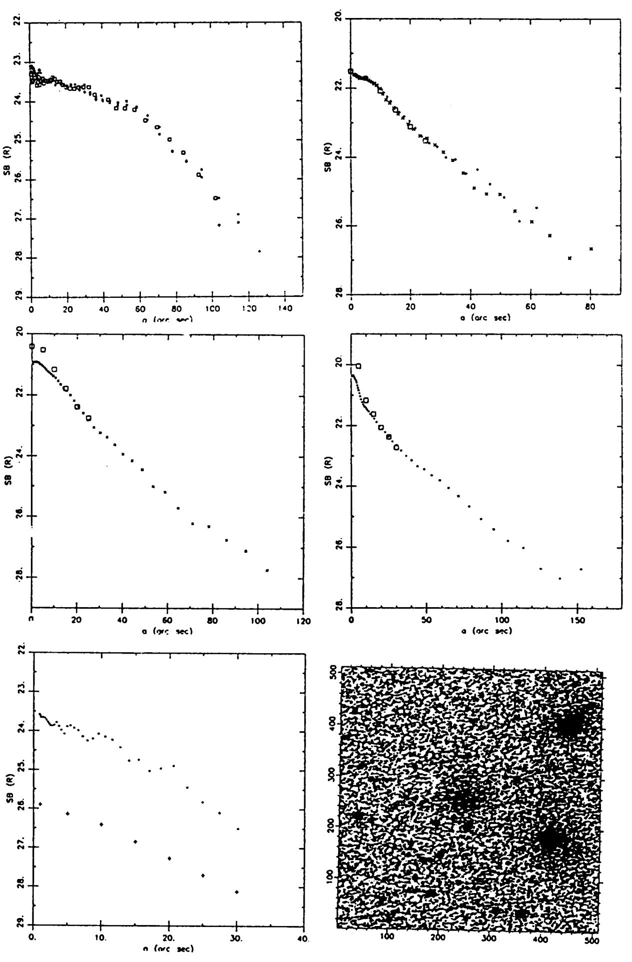

Figure 1. Surface brightness profiles (a) VCC 1017 (b) IC 3374 (c) IC 3430 (d) NGC 4641 (e) VCC 1336 and image grey scale (f) VCC 1336.

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IC 3374 — This lowish surface brightness irregular shows the extent to which we can trace out the radial profiles (x) compared to published CCD data (Gallagher & Hunter 1985) (□) and our own IIIa-F comparison plate (+). The film and plate data both have S/N (averaged around an ellipse) of 6 to 8 at the last measured points.

IC 3430 — This confirms the consistency of the absolute calibration of the data to within 0.07 magnitudes (there is no arbitrary scaling between this film profile and that of IC 3374), and the extent of the measured profiles (out to about 27 $R\mu$ or 0.3% of sky).

NGC 4641 — This again confirms the above points, but because of its high surface brightness central region also gives a measure of the dynamic range of the film plus COSMOS combination. Not surprisingly the film profile fails to follow the CCD right into the centre at less than 19 $R\mu$, but still demonstrates a dynamic range of about 7 magnitudes (factor 600).

VCC 1336 — The foregoing suggests that we should be able to see very faint LSBGs much more easily on the films than on corresponding plates. This is confirmed by the case of VCC 1336, one of the lowest surface brightness objects yet studied in any detail (Impey, Bothun & Malin 1987). This has a central surface brightness close to 26 $B\mu$ and 24 $R\mu$. At 4% of sky this leaves it only about 1.5 σ above the IIIa plate noise, but a clear 5 σ detection on the film.

3. Film Surveys

The next step, of course, is the search for even lower surface brightness objects which are currently unknown (as well as to make a *systematic* survey at the levels currently reached). This survey is currently underway, and we expect to routinely detect LSBGs with central surface brightness $\simeq 4\sigma$ or $\simeq 3\%$ above sky, i.e. around 24.5 $R\mu$. Sample data from a single 1/4 degree square region are shown in Fig. 2. The most extended objects closely follow the locus of exponential discs with central surface brightnesses four magnitudes below sky. Further processing

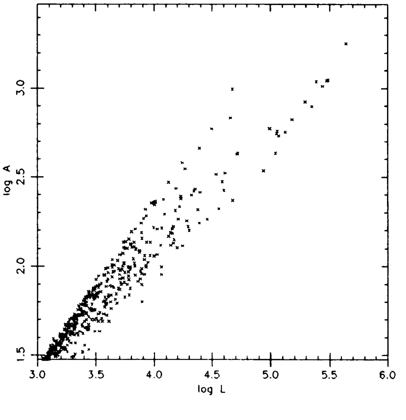

Figure 2. Isophotal area vs. isophotal magnitude plot for images detected in one area of a film.

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(cf. Irwin et al. 1990; Smith et al., this meeting) should extend the limits to at least 25.5 $R\mu$ for large objects. This is already as deep as the best current CCD surveys but with the huge gain in survey area noted above.

In addition, we have the exciting prospect of using co-added digital data from several films. We now have 6 good quality films of VirgoSE. The coadded data should then lead to gains of almost another magnitude in limiting surface brightness of our survey.

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