Detections of extended galactic haloes of Virgo Cluster Galaxies

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Abstract

The UK Schmidt camera was used to observe the Virgo cluster of galaxies, where a total of 13 R-band Kodak Tech-Pan films were obtained. The latter, were scanned by the APM machine (Cambridge, UK), digitally aligned, co-added, corrected for vignetting effects and finally cleaned of stellar features. The resulting image covers an area of $\approx 6.2 \times 6.2$ degree^2 with a resolution of ≈ 2 arcsec pixel^{-1}, where extended objects with a surface brightness up to 28 mag arcsec^{-2} can been detected. Some of those results have already be published in previous papers. Here we wish to present a choice of faint detections and discuss some interesting implications of this project.

1 Introduction

The actual dimensions of the galactic haloes is still an open debate. Many authors including Kemp & Meaburn (1991a, b, 1993, 1994, 1995), Kemp (1994) and reference therein, have used sky-limited B-band photographic plates obtained from the United Kingdom 1.2-m Schmidt Telescope (UKST) of the Anglo-Australian observatory (AAO), to successfully detect extensive haloes of galaxies. More recently Katsiyannis et al. (1998, 2000, 2001) used newly developed digitized techniques to detect faint haloes of Virgo cluster galaxies utilizing the whole $6.2° \times 6.2°$ field of the UKST. To increase the Signal-to-Noise ratio (S/N), 13 R-band low noise Kodak Technical Pan (TecPan) films were co-added achieving detections of haloes with surface brightness down to 28 mag arcsec^2. They detected a number of extensive galactic haloes as well as filaments, details of galactic interactions, etc. This paper presents detections of more extensive halos of well known Virgo cluster galaxies.

2 Extensive haloes

M 60 (NGC 4649) is a giant elliptical galaxy with an S0(2) E2 morphological type (Arp 1968; Binggeli et al. 1985; Caon & Einasto 1995) and a heliocentric velocity of ~ 1095 km s^{-1} (Knapp et al. 1989; Faber et al. 1989). It is located in the eastern extension of the Virgo cluster, about 1 Mpc from the cluster centre (Trinchieri et al. 1997a). Figure 1 contains the M 60 galaxy in two different contrasts. The left-hand-side image is M 60 under normal contrast while in the right-hand-side is the same galaxy under the highest possible contrast. The dimensions of the halo are $\approx 17 \times 14$ arcmin^2 and assuming a distance of 17 Mpc (Mould et al. 1995) for all the Virgo cluster members we can derive the physical dimensions of this halo as $\approx 85 \times 70$ kpc^2. The apparent proximity with the NGC 4647 galaxy can be easily seen but there is no evidence in our data of any interactions

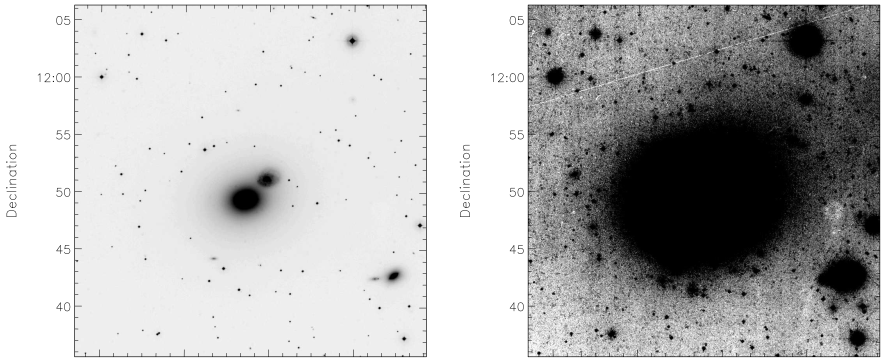

Figure 1: Deep extended image of M 60 in normal (left) and high (right) contrast. A halo of $\approx 85 \times 70$ kpc^2 can be clearly seen in the latter.

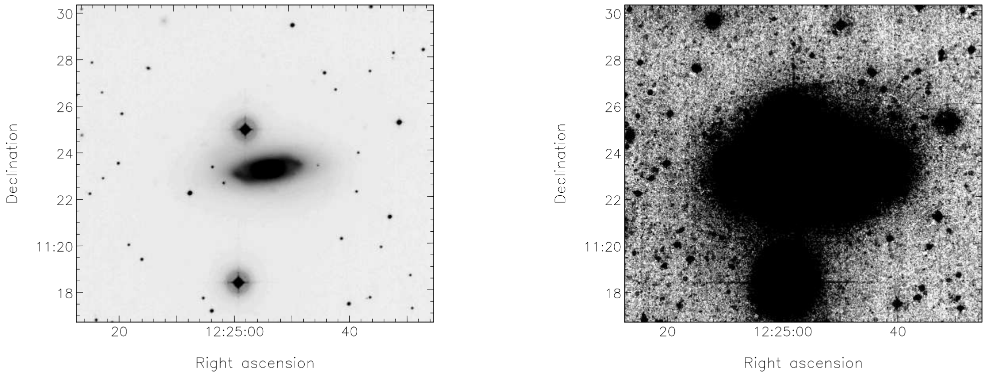

Figure 2: Deep extended image of NGC 4429. The images shown on the left and right hand-side are of normal and high contrast, respectively. The dimensions of the halo are $\approx 41 \times 17$ kpc^2.

between the two objects. De Vaucouleur et al. (1976) reported total magnitude of $B_T = 9.83$ while the total X-ray luminosity (ROSAT surveys) is ~ 1.5 to 1.8×10^{41} erg s^{-1} (Trinchieri et al. 1997b; Irwin & Sarazin 1998; Beuing et al. 1999). The radio and Hα luminosities are $L_R \sim 10^{38}$ erg s^{-1} (Stanger & Warwick 1986) and $L_{H\alpha} = 6.79 \times 10^{39}$ erg s^{-1} (Trinchieri et al. 1991), respectively.

NGC 4429, an early-type lenticular galaxy (S0/Sapec, Sandage & Tammann 1981; de Vaucouleur et al. 1991) is located in a group of ~ 60 galaxies with NGC 4472 at the group centre (Garcia 1993). Its total magnitude is $B_T = 11.15$ (Bingelli et al. 1985) and the X-ray luminosity 9.1×10^{39} erg s^{-1} (Burstein et al. 1997), while the radio flux density was measured by Niklas et al. (1995) to $S_{6.3\mathrm{cm}} \approx$ 1 mJy. In Figure 2, NGC4429's extensive halo is clearly visible. The left-hand-side image (Fig. 2a) is the galaxy under normal contrast, while the right-hand-side image is the same target at the highest possible contrast. The detected halo is $\approx 8.3 \times 3.5$ arcmin^2 or $\approx 41 \times 17$ kpc^2.

NGC 4473 is a highly elongated elliptical galaxy. Morphologically it is classified as E5 by Morton & Chevalier (1973) while Jaffe et al. (1994) classified NGC 4473 as Type II ('disky' elliptical galaxy) based on the galaxy's shape and brightness profile. Recently, Macchetto et al. (1996) and Ferrari et al. (1999) have shown a very small edge-on dust disk. Figure 3 presents another extensive halo detection. The normal contrast image (Fig. 3a) of NGC 4473 is $\approx 2 \times 4$ arcmin^2 ($\approx 10 \times$ 20 kpc^2), while the high contrast image reveals dimensions of $\approx 4.1 \times 6.3$ arcmin^2 ($\approx 20 \times 30$ kpc^2). Garcia (1993) has argued that NGC 4473 is located in a group of 25 galaxies within the 'Virgo II' cloud (named 'Southern Cloud II') and with NGC

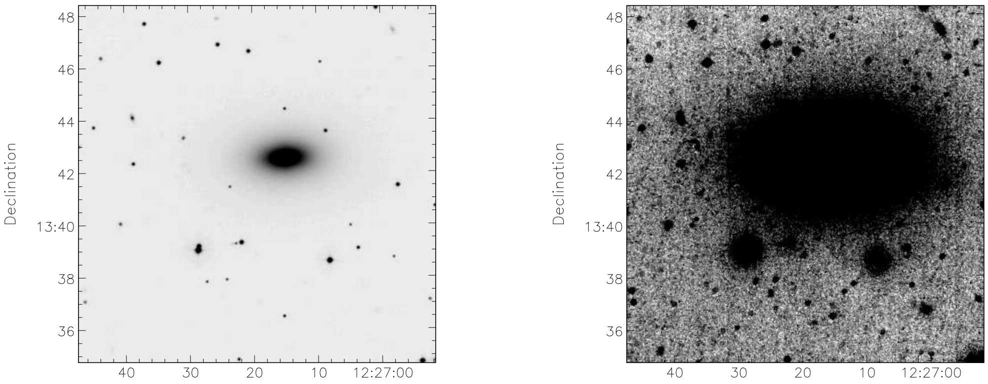

Figure 3: Normal and high contrast images of NGC 4473. The estimated halo dimensions are $\approx 20 \times 30$ kpc^2.

4501 to be at the centre of this group. One unusual feature of this galaxy is it's high redshift of 2236 ± 197 km s^{-1} (Young et al. 1978) as the average velocity of the cluster and its velocity dispersion is 110 ± 20 km s^{-1} (Williams 1977). Head et al. (1976) suggested a total magnitude of 11.08 ± 0.05 while the absolute B-band magnitudes for the B and V are -20.5 ± 0.5 (Malumuth & Kirshner 1985) and -22.57 (Gebhardt et al. 1996), respectively.

3 Conclusion

Previous publications have discussed many interesting conclusions concerning this project. The authors would like to emphasize the detection of previously unobserved extended galactic material in almost all of the ≈20 galaxies studied so far. As these detections were noise limited, we have no reason to believe that the majority of these detected haloes are not even further extended. Although our sample dealt mainly with the Virgo cluster, we believe that this important conclusion applies to most of the galaxies with similar angular dimensions.

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