Nearby Large-Scale Structures and the Zone of Avoidance
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Deep Near-Infrared Survey of PKS 1343-601 and CIZA J1324.7-5736

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Abstract. We present the results of deep near-infrared surveys around the giant radio elliptical galaxy PKS 1343-601 ($36' \times 36'$) and of the X-ray cluster CIZA J1324.7-5736 ($36' \times 36'$) in the Great Attractor region. They are both suggested to be unknown rich clusters related to the Great Attractor.

In the PKS 1343-601 region, 19 obvious galaxies have been detected; only three of them were previously identified as a galaxy. After extinction correction, the number density of galaxies brighter than 13 mag in the K_s band is 42 galaxies deg^{-2}, five times as high as the over all average in the GA region. However, the number of galaxies in the central 270 kpc radius is less than that of the Norma, Pavo and Centaurus clusters, the known clusters in the GA region.

In the CIZA J1324.7-5736 region, we found 97 galaxies and prospective candidates, in which 35 objects are already known as galaxies in the WKK catalogue and/or the 2MASS Extended Source Catalogue. Our data analysis is not finished, but the subsequent study will reveal the richness of the CIZA J1324.7-5736 cluster.

1. Introduction

In the Great Attractor (GA) region, some clusters of galaxies and wall-like structures are identified as being part of the overdensity of galaxies. One of these clusters, the Norma cluster (A3627; Abell, Corwin & Olowin 1989) at $(l, b, v) =$ (325°, -7°, 4848 km s^{-1}) is the most massive cluster of galaxies (M$\sim 5\times 10^{15}$M$\odot$, Kraan-Korteweg et al. 1996) in the GA region known to date, possibly lying at the bottom of the potential of the GA (Kraan-Korteweg & Lahav 2000). However, further unknown rich clusters, which could contribute to the mass of the GA might still remain hidden at the low Galactic latitudes due to the heavy interstellar extinction. There are two candidates of unknown rich clusters in the low Galactic latitude of the GA region: the strong radio galaxy PKS 1343-601 and the X-ray cluster CIZA J1324.7-5736. It is difficult to search for galaxies around them in optical wavelength due to the Galactic extinction. Near infrared observations, less affected by dust extinction ($A_K \sim 0.1 A_V$, Rieke & Lebofsky

1985; Cardelli, Clayton & Mathis 1989), provide prospective tools to search for galaxies in the Zone of Avoidance.

2. PKS 1343-601

PKS 1343-601 ($(l, b, v) = (309.7^\circ, 1.7^\circ$, 3872 km s^{-1})) is the fifth strongest extragalactic radio continuum source in the sky (Jones, Lloyd & McAdam, and references therein), located 10° away from the predicted centre of the GA. The optical counterpart to PKS 1343-601 was identified as a giant elliptical galaxy on near-infrared photographic plates (Laustsen, Schuster & West 1977; Goss, Tritton & Longmore 1978) and its recession velocity was measured to be 3872 km s^{-1} based on the Hα-[NII] emission lines (West & Tarenghi 1989). The presence of a radio-loud giant elliptical galaxy with the recession velocity similar to that of the GA is suggestive of a rich cluster associated with the GA. Recent deep HI observations revealed the agglomeration of galaxies around (l, b, v)=(311°, 3°, 3900 km s^{-1}), very close to PKS 1343-601 (Kraan-Korteweg et al. 2003).

We carried out the near infrared survey around PKS 1343-601 in 2001 May. The observations were made with SIRIUS, a simultaneous imager in the J (λ=1.26μm), H (λ=1.63μm) and K_s (λ=2.14μm) bands, covering an area $7'.7 \times 7'.7$ with a pixel scale of $0''.45$ (Nagashima et al. 1999; Nagayama et al. 2003) on the Infra-Red Survey Facility (IRSF) 1.4m telescope at the Sutherland site of the South African Astronomical Observatory. We observed for 5 $\times$5 fields of view ($36' \times 36'$ or 0.34 degrees^2) around PKS 1343-601 with 900 sec exposure. The sky conditions were good for photometry and the typical seeing was $1''.2$ (FWHM) in the K_s band throughout the observing run.

We inspected the composite images (blue for J, green for H and red for K_s) of the PKS 1343-601 region to search for galaxies by eye and detected 19 obvious galaxies and 38 prospective candidates. The spatial distribution of them are shown in Figure 1, together with the extinction map. The number density of galaxies brighter than 13 mag in K_s^{20} after extinction-correction around PKS 1343-601 is 42 galaxies deg^{-2} (14 galaxies per 0.34 deg^2), about 5 times as high as the average density of galaxies in the GA region. Thus, there exists an apparent galaxy enhancement toward PKS 1343-601. We call it "PKS 1343-601 enhancement".

We scrutinise the clustering properties of galaxies around PKS 1343-601 by comparing the K_s band luminosity function of galaxies (hereafter, KLF) of the PKS 1343-601 enhancement with those of five nearby clusters. Figure 2 shows the KLFs of five clusters of galaxies (solid line histograms), together with that of the PKS 1343-601 enhancement (grey histograms). We select galaxies lying within 270 kpc ($18'$ at the distance of PKS 1343-601) around the brightest galaxy of each cluster from the 2MASS XSC. The distance to the brightest galaxy is calculated from the redshifts listed in NED (NASA Extragalactic Database), assuming a Hubble constant of 75 km s^{-1} Mpc^{-1}. The peculiar motion of each cluster is assumed to be zero. We obtained the absolute K_s^{20} magnitude for selected galaxies assuming the same distance as the brightest galaxy. The KLF of the PKS 1343-601 enhancement is constructed from the 19 obvious galaxies. Omission of the remaining 38 galaxy-candidates in the construction of the KLF

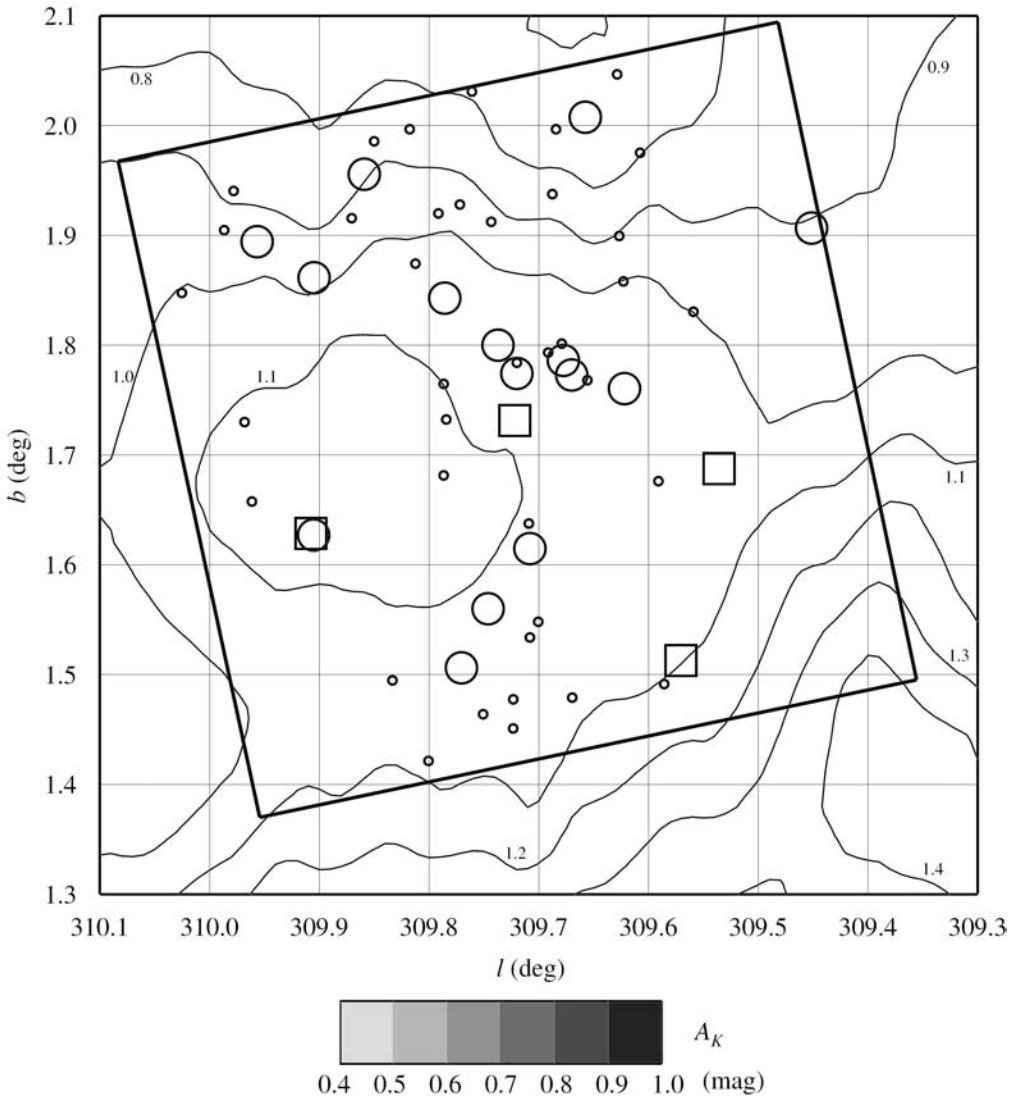

Figure 1. The spatial distribution of obvious galaxies and prospective candidates detected in the PKS 1343-601 region is shown (Figure 2 of Nagayama et al. 2004). The extinction maps derived from the $J-K$ colour of giant stars (grey scale) and taken from the IRAS/DIRBE maps (Schlegel, Finkbeiner & Davis 1998, SFD98) (contours) are also shown. The extinction level is represented in A_K. Our survey area is indicated by the thick solid lines. The big circles and squares represent the obvious galaxies (circle: spirals, square: ellipticals). The small circles are galaxy candidates.

does not influence the subsequent discussion, as these are all fainter than -21.0 mag, even if we apply a maximum extinction-correction to them.

We compare the KLF of the PKS 1343-601 enhancement with those of three rich clusters, Perseus (A426), Coma (A1656) and Norma (A3627) (upper row of Figure 2). They contain 31, 20 and 23 galaxies brighter than -22.5 mag,

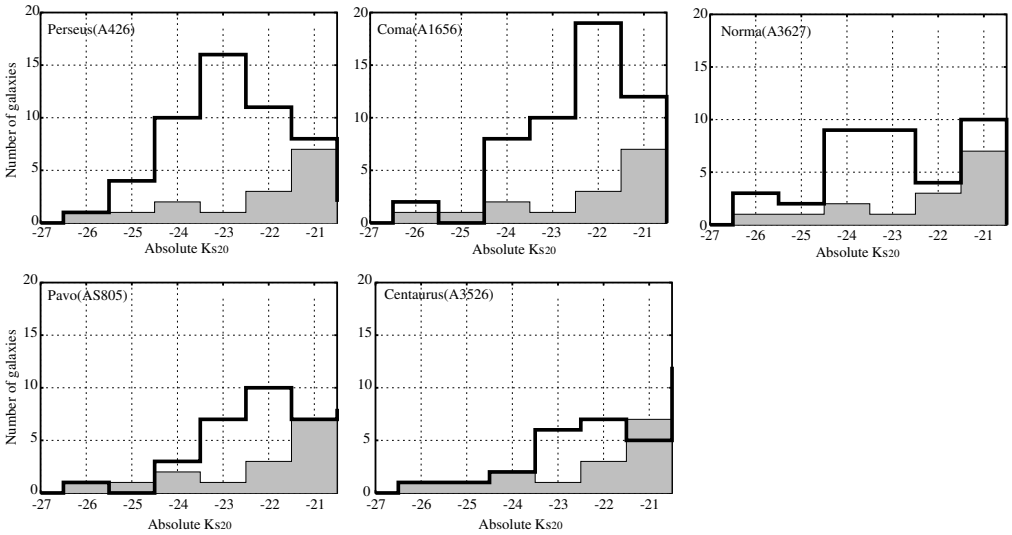

Figure 2. The K_s band luminosity function (KLF) of five nearby clusters of galaxies (the solid line histogram), together with that of the PKS 1343-601 enhancement (the grey histogram) (Figure 6 of Nagayama et al. 2004) . The absolute K_s^{20} magnitude of -20.0, corresponding to our completeness limit of galaxy-detection 13.5mag, is out of these figures. At the fainter end, the KLF for the Norma cluster could possibly be affected by increasing incompleteness of 2MASS XSC because it lies at $b = -7°$.

respectively, while the PKS 1343-601 enhancement contains only five galaxies brighter than -22.5 mag, less than one-fourth of those of the three clusters. We can see that the KLF of PKS 1343-601 lies below those of the three clusters for magnitudes fainter than -24 mag. The KLF for the Norma cluster is severely affected by the incompleteness of 2MASS XSC towards the low b of $-7°$. Hence, it is not justified to compare the KLF of the PKS 1343-601 enhancement with that of the Norma cluster. However, it is obvious that the PKS 1343-601 enhancement is smaller than the Norma cluster in the number of galaxies. Thus, the PKS 1343-601 enhancement is not as rich as the Perseus, Coma and Norma cluster.

We also compare the KLF of the PKS 1343-601 cluster with those of two less rich clusters, Pavo (AS805) and Centaurus (A3526) (lower row of Figure 2), lying in the GA region with a recession velocity similar to that of the PKS 1343-601. They contain 11 and 10 galaxies brighter than -22.5 mag, not as rich as the Norma cluster. The PKS 1343-601 enhancement shows a similar KLF to those of the Pavo and Centaurus clusters brighter than -24 mag but smaller numbers in the -23 and -22 mag bin. Consequently, the number of galaxies brighter than -22.5 mag in the PKS 1343-601 enhancement is less than half of those of the Pavo and Centaurus clusters. Hence, the PKS 1343-601 enhancement is indeed poorer than the Pavo and Centaurus clusters.

The detailed description about the survey for the PKS 1343-601 region is found in Nagayama et al. (2004).

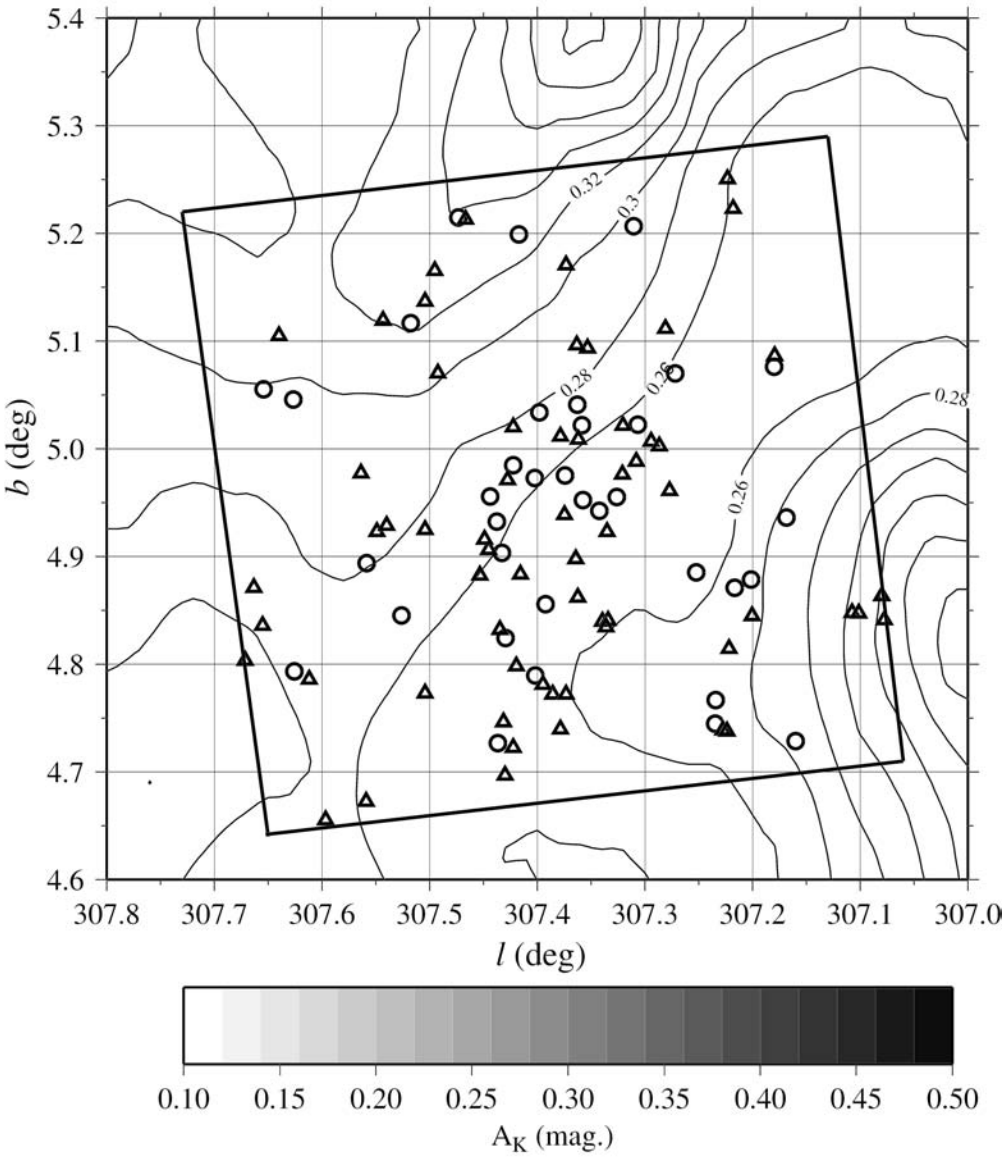

Figure 3. The spatial distribution of galaxies and prospective candidates are shown, together with extinction map derived from SFD98. The extinction level is represented in A_K. Our survey area is indicated by the thick solid lines. The circles are the galaxies listed in WKK catalogue and/or 2MASS XSC. The triangles are the newly identified galaxies or prospective candidates in our survey.

3. CIZA J1324.7-5736

CIZA J1324.7-5736 is an X-ray selected cluster detected in the CIZA survey, suggested to be comparably massive to A3627 (Ebeling, Mullis & Tully 2002). It is located at $(l, b, v) = (307.4°, 5.0°, 5700 \text{ km s}^{-1})$: 22° away from A3627 and

almost the same recession velocity as that of A3627. The foreground extinction is estimated to be $A_K = 0.2$-0.3 mag by SFD98.

The near infrared survey for CIZA J1324.7-5736 was also carried out with the SIRIUS camera on the IRSF telescope in 2003 April and May. We also observed 5 $\times$5 fields of view ($36' \times 36'$ or 0.34 degrees^2) centred on CIZA J1324.7-5736 with 600 sec exposure. The typical seeing was $1''.0$ (FWHM) in the K_s band throughout the observing run.

We have detected 97 galaxies and prospective candidates in our survey area by eye-inspection, though our data analysis is still underway. In 97 objects, 35 galaxies are already listed in the WKK catalogue (Woudt & Kraan-Korteweg 2001) and/or 2MASS XSC (Jarrett et al. 2000) but all the others are newly found in our survey. The spatial distribution of them is shown in Figure 3, together with the extinction map taken from SFD98. We can see the central concentration of galaxies around the giant elliptical galaxy WKK2189 ($l = 307.40°$, $b = 4.97°$). The position of WKK2189 corresponds to the peak of X-ray emission. According to the quick-look of each galaxy, CIZA J1324.7-5736 seems to be a rich cluster because there are many bright galaxies. The surface brightness photometry for detected galaxies will provide their morphological types (Elliptical or Spiral), isophotal magnitude (15 mag in K_s band) and luminosity function of them, revealing the property and richness of the CIZA J1324.7-5736 cluster.

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