A Search of the Zone of Avoidance in Scorpius

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Abstract. An optical search of the Scorpius region – close to the Galactic bulge – has revealed some 1400 partially-obscured galaxies. Redshifts have been obtained for nearly a hundred of these objects. Preliminary indications of large-scale structures are reported.

1. Introduction

As outlined in the introductory paper to this session (Kraan-Korteweg, these proceedings), deep optical galaxy searches in the Zone of Avoidance (ZOA) narrow the band of obscuration down to on average 5 or 6 degrees (see Fig. 4 in Kraan-Korteweg, these proceedings). Moreover, optical searches have the advantage over both HI and infrared surveys that they can uncover clusters rich in E/S0 galaxies which generally trace the mass density peaks in the Universe. The nearby rich cluster ACO 3627, believed to lie at the centre of the Great Attractor, is the most conspicuous case (Kraan-Korteweg et al. 1996, Woudt et al., these proceedings).

This conference has brought together all the researchers primarily responsible for systematic optical searches – Weinberger, Kraan-Korteweg and Woudt, Saito and Wakamatsu. Thanks to their industry, all but one small sector of the Milky Way had been surveyed by 1998. The only remaining sector was the Scorpius region, between Galactic longitudes of $330^\circ \leq \ell \leq 350^\circ$, outlined in Fig. 1 (thick contour) in a distribution of galaxies larger than $D \geq 1/3$ centered on the southern Milky Way. The previous search areas are indicated as well (for details see Kraan-Korteweg, these proceedings). The Scorpius region was surveyed by the first author (Fairall) in late 1998, whilst on sabbatical leave from the University of Cape Town, based with Kraan Korteweg at the Department of Astronomy of the University of Guanajuato. This was particularly opportune because it allowed the use of the same viewing machine employed in the earlier searches by Kraan-Korteweg (2000), and those carried out under her direction by Woudt (1998) and Salem (Salem & Kraan-Korteweg, in prep.).
Figure 1. Distribution in Galactic coordinates of galaxies with $D \geq 1'3$. The ZOA (running horizontally through the centre of the diagram) shows an absence of galaxies. Various researchers have conducted deep optical searches in the ZOA (marked areas). This paper reports on the Scorpius search (thick contour) centred on $\ell = 345^\circ$. Note the almost complete absence of Lauberts galaxies in the region.

2. The Search

Sixteen fields of the SERC IIIa-J Sky Survey (226-228, 274-280 and 330-335) were searched within Galactic latitudes of $|b| < 10^\circ$. Small portions of Fields 068 and 181 – omitted in earlier neighbouring surveys – were also searched. The viewing machine with which the plates were examined displays a 50-times magnified segment. Adjacent strips of the width of 4 mm (on the plate) were systematically searched for galaxies, offset by 3.5 mm to allow some overlap. Working close to the Galactic bulge, the images reveal up to several hundred stars on the screen at any one time. Amongst these, the eye must discern the occasional fuzzy image of a galaxy. It seems a curiously old-fashioned technique to employ in this computer age, but past experience has shown that computer algorithms, searching for galaxies, are too easily confused by the abundance of overlapping stellar images (see Kraan-Korteweg & Lahav 2000). The eye is still the most efficient means of reliably identifying partially obscured galaxies.

As with the previous searches of Kraan-Korteweg and collaborators, a diameter limit of 12 arcsec (10 mm on the screen) was employed. However, diameter limited catalogues strongly favour edge-on spirals. Therefore elliptical and S0 galaxies with diameters somewhat below the 12" limit were also recorded. Working at such low Galactic latitude, planetary and reflection nebulae often mimic the appearances of distant galaxies; these too were registered.

In all, about 1900 potential galaxies were listed. This number includes objects counted twice in regions of overlapping fields – and also includes galaxy candidates on the borders of the previously surveyed neighbouring Great At-
Figure 2. The same as Fig. 1, but now including galaxies with $D \geq 12''$ found in the optical searches. The ZOA has been narrowed to about a third of what it was previously. The extinction contour of $A_B = 3^m0$ (according to the DIRBE dust maps; Schlegel et al. 1998) is also shown.
Fig. 3. Galaxies corrected for extinction with $D' \geq 1'3$ and $A_B \geq 3^m0$, the completeness limit of deep optical searches. Only a reduced ZOA still obscures the view.

tractor region which will be used for consistency check of the parameters of the uncovered galaxies. After removing duplicates, and rejecting marginal objects, the number drops to 1422 galaxies, of which just below a thousand meet the diameter limit of $D \geq 12''$. These are displayed in Fig. 2, together with galaxies larger than $D \geq 12''$ identified in other optical galaxy searches as well as the previously known galaxies with $D \geq 1'3$.

As can be seen in Fig. 2, the yield in the Scorpius region is quite modest, substantially below the average recorded in the adjacent surveys further west (right in the diagram). The reason is obvious, however. The obscuration of the Milky Way broadens considerably in the region of the Galactic bulge (see the extinction contour $A_B = 3^m0$ in Fig. 2), particularly on the northern side of the Galactic plane. The reason for the drop-off on the southern side is not obvious, but a $1^\circ$ wide overlap with the neighbouring survey suggests it to be real. It presumably reflects the presence of nearby void.

Preliminary statistics indicate:

- Only 19 of the recorded galaxies have $D \geq 1'0$, the Lauberts limit. Only 11 have $D \geq 1'3$, the completeness limit of the Lauberts catalogue.

- 104 galaxies have been found in extinction layers with $A_B > 3^m0$. These most likely are heavily contaminated by Galactic objects.

- Of the remainder, 977 have $D \geq 0'2$, 13 have $D \geq 1'0$, and 6 have $D \geq 1'3$.

If corrected for extinction – applying the Cameron (1990) laws – these numbers would increase to 1294, 55 and 24 respectively. The last number allows us to extend the Lauberts galaxies plotted originally in Fig. 1 to reflect the
corrected sky distribution for this region, except in the now narrower Zone of Avoidance, delimited by $A_B = 3^m0$. Figure 3 shows the overall picture.

3. Redshifts

One hundred of the brightest objects in the survey (including the Field 068 and 181 annexures) have been observed spectroscopically in June 1999 with the 1.9 m reflector, UNIT spectrograph and CCD detector at the South African Astronomical Observatory at Sutherland. These allow preliminary plots on the distribution of the recorded galaxies in redshift space. Figure 5 indicates the coverage within our survey area. Figure 6 shows the same plot divided into redshift slices of 2000 km s$^{-1}$ thickness.

As seen in Fig. 5, galaxies lie mainly in the 4000 – 8000 or 10000 – 12000 km s$^{-1}$ redshift interval. The high redshift peak (at 11000 km s$^{-1}$) coincides with the highest surface density of galaxies found in the survey (at $\ell = 330^\circ$, $b = 8^\circ$) and seems to indicate a cluster complex, possibly a supercluster, in that region. The lower redshift range is suggestive of a possible overdensity around 6000 km s$^{-1}$. This is consistent with preliminary data from the full sensitivity blind H I survey of the southern ZOA ($|b| < 5^\circ$) performed at the Parkes 64 m telescope (see Staveley-Smith et al., these proceedings) which also finds a concentration around 6000 – 8000 km s$^{-1}$ in that region. None of the optical observations match the individual radio sources but the latter are detected at lower latitudes, confirming that the optical plus H I observations are complementary methods in tracing the galaxy distribution behind the Milky Way.

A number of interesting objects have been uncovered by the survey. One is an apparent cluster 1720–45 ($344^\circ, -5\circ3$) seen through the bulge of the Milky Way. Only three galaxies, those with the highest central surface brightnesses are optically detectable: one is a marginal Seyfert galaxy, the other two are E/S0. Two of these were spotted in the survey, the third was known previously from its infrared emission (but was re-observed here). Their redshifts are 5840, 5610 and 5633 km s$^{-1}$ respectively, confirming the cluster nature.

The ESO (Lauberts) galaxies in the region are mainly spirals (seen flat-on or close to flat-on), but which had no published redshifts. ESO 274-G019 has 3389 km s$^{-1}$, ESO 330-059 has 6538 km s$^{-1}$ and ESO 330-061 5681 km s$^{-1}$.

Field 330 also revealed two curious objects, which look exactly like elliptical galaxies but appear to stand in front dense dust clouds or were seen through them. There the representative star count – normally 35 to 40 – had dropped to 7. One of these objects has a redshift of 3932 km s$^{-1}$, so clearly is extragalactic.

Follow-up work on these objects and at least one further season of spectroscopic observations will be necessary to expand the sample and discuss the galaxy distribution in redshift space in more detail. We are also preparing the Scorpius galaxy data for publication in a catalogue similar to that of Kraan-Korteweg (2000).

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Figure 4. Galaxies observed spectroscopically within the Scorpius survey area. Filled squares indicate previously observed galaxies (from the NED database). The filled circles indicate the new observations. The extinction contours indicate $A_B = 1^{m}0; 3^{m}0$ and $5^{m}0$ respectively.

Figure 5. As in Fig. 4, but shown as slices of increasing redshift in increments of $2000 \text{ km s}^{-1}$. 
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