A Massive Galaxy Cluster at the Core of the Great Attractor

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A deep survey for partially-obscured galaxies behind the southern Milky Way using the IIIaJ film copies of the ESO/SERC sky survey reveals the cluster A3627 at Galactic co-ordinates l = 325°, b = –7° to be the most prominent cluster in the southern hemisphere, were its galaxies not overlaid by the dust and stars of the Milky Way. Subsequent follow-up observations find this strongly obscured galaxy cluster to be the nearest, rich, massive cluster in the Universe, comparable to the well-known Coma cluster identified already by Wolf in 1906. Moreover, this massive cluster lies – within its errors – at the centre of the Great Attractor and most likely constitutes the previously unidentified bottom of this potential well (cf. Kraan-Korteweg et al., 1996 for further details).

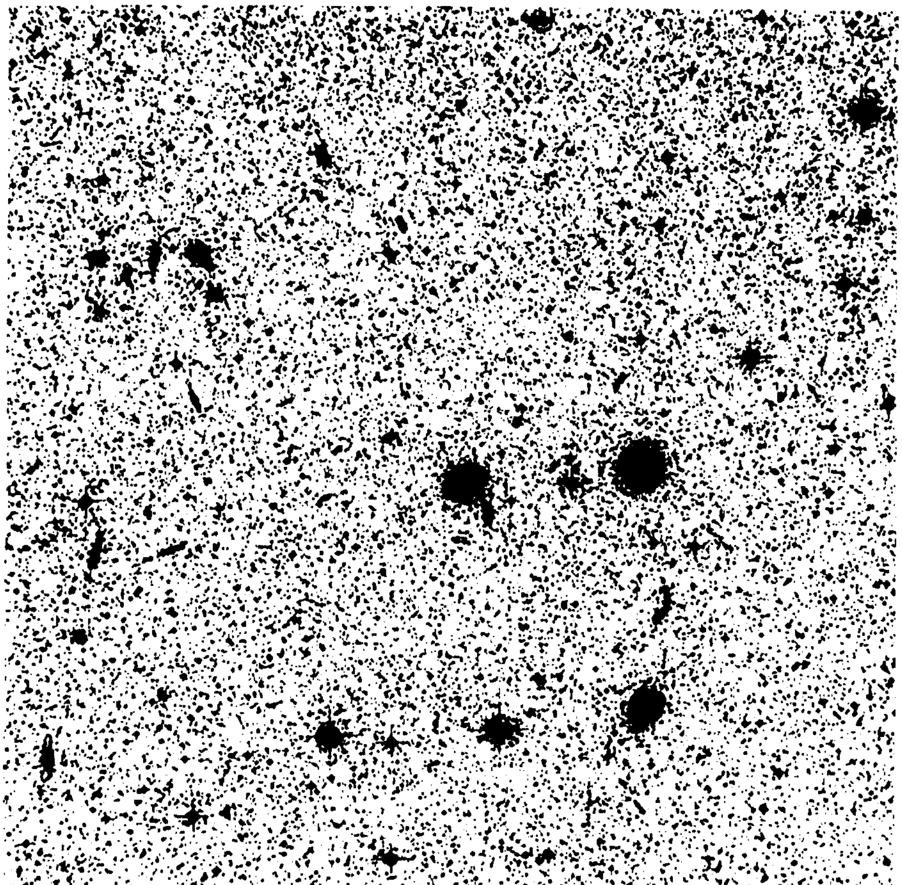
Systematic deviations of galaxies from the uniform expansion field indicate the existence of a "Great Attractor" (GA) – a large mass concentration of ~ 5 × 10^{16} $M_{\odot}$, at a redshift v ~ 4500 km/s, close to or behind the southern Milky Way (Lynden-Bell et al., 1988). The nature and extent of the GA has been the quest of many optical and IRAS galaxy surveys, as well as X-ray searches. While there is a considerable excess of optical-IRAS galaxies in this region, the absence of a dominant rich cluster at its centre remained peculiar.

However, our Milky Way cuts across the central part of the large-scale overdensity of the GA (cf. Fig. 3b and 6b in Kolatt et al., 1995). Even if the core of the GA were in the form of luminous matter, it would be overlaid by the dust and the numerous foreground stars of our Milky Way – our Galaxy blocks the view of about 25% of the extragalactic sky.

For some years, two of us (RCKK and PAW) have led a dedicated effort to unveil the distribution of galaxies behind the southern Milky Way making use of the IIIaJ ESO/SERC survey. The films are inspected by eye with a 50 times magnification. All galaxies larger than D = 0.2 arcmin are recorded, i.e. a factor five smaller compared to the ESO/Uppsala Catalogue of Galaxies of the southern hemisphere. Although heavily crowded with the images of the stars of our Galaxy, careful scrutiny has revealed over 10,000 previously unknown galaxies – leaving, however, the innermost strip of the Milky Way completely opaque.

The cluster of galaxies Abell 3627 is close to that innermost strip. It had been catalogued in 1989 in the extended catalogue of rich clusters, because of the foreground obscuration only about 50 of the larger galaxies were noted. The true significance of the cluster became unveiled with the identification of over 600 additional cluster members, many of which are just below the Lauberts diameter limit of 1 arcmin. Correcting the observed properties of the galaxies for the foreground extinction would make this cluster the most prominent overdensity in the southern skies.

To arrive at the distribution of the uncovered galaxies in redshift space, observations have been made at the 3.6-m telescope of ESO using the multifiber system MEFOS built at the Paris-Meudon Observatory (cf. Felenbok et al., 1996), individual spectroscopy at the 1.9-m telescope of the SAAO (South African Astronomical Observatory), and HI observations of low surface brightness



A photograph of the innermost part of the cluster ACO 3627 (25 × 25 arcmin), i.e. approximately the region within the core radius $R_c \leq$ 10.4 arcmin, as seen on the ESO/SERC IIIaJ field 137. The central bright elliptical galaxy (a cD galaxy with blue magnitude B_J = 14.4) is the well-known radio source PKS 1610-60, one of the strongest radio sources in the southern hemisphere. Another cD galaxy is located to the left of the radio source (B_J = 14.0). Careful inspection will reveal 59 cluster members present in this photograph, a large fraction of those are early-type galaxies. Note furthermore the huge number of galactic foreground stars, which will give some inkling about the inherent difficulties in mapping the galaxy distribution across the Milky Way.

spiral galaxies with the 64-m Parkes Radio Telescope.

Within the Abell radius of the cluster A3627, 109 velocities have so far been reduced leading to a mean velocity of $< v_{obs} > = 4882$ km/s and a dispersion of $\sigma = 903$ km/s. This puts the cluster well within the predicted velocity range of the GA. The large dispersion of A3627 suggests it to be quite massive. Applying the virial theorem yields a mass of $\sim 5 \times 10^{15}$ $M_\odot$, i.e. a cluster on par with the rich, well-known Coma cluster – yet considerably closer. In fact, simulations show, that if Coma were at the position of A3627 in velocity space and subjected to the same foreground obscuration, the two clusters would be indistinguishable. A3627 even has – like Coma – 2 dominant cD galaxies at its core.

The most intriguing aspect of the recognition of the new cluster is its position at the approximate centre of the GA overdensity. Although very massive as a cluster, its mass contributes only about 10% of the total mass predicted for the Great Attractor. Hence, it is not "the" Great Attractor as such, but it is the prime candidate for being the hitherto unidentified centre of this large-scale overdensity. This is supported by the recent analysis of the ROSAT PSPC data of A3627 by Böhringer et al. (1996) which finds this cluster to be the 6th brightest X-ray cluster in the sky for the ROSAT spectral band and confirms its virial mass.

The results from our programme within the whole search area in combination with the Southern Redshift Catalogue suggest furthermore that A3627 is the dominant component of an apparent "great wall" structure – similar to the Coma cluster in the (northern) Great Wall – including the nearby Pavo, Indus clusters below the Galactic plane and the shallow overdensity in Vela above the Galactic plane at 6000 km/s. This whole large-scale structure embodies what has been dubbed in 1987 the then unseen Great Attractor.

References

Böhringer, H., Neumann, D.M., Schindler, S., & Kraan-Korteweg, R.C., 1996, *ApJ*, in press.

Felenbok, P, Guérin, J., Fernandez, A., Cayatte, V., Balkowski, C., & Kraan-Korteweg, R.C., 1996, *A&A*, submitted.

Kolatt, T., Dekel, A., & Lahav, O., 1995, *MNRAS* **275**,797.

Kraan-Korteweg, R.C., Woudt, P.A., Cayatte, V., Fairall, A.P., Balkowski, C., & Henning, P.A., 1996, *Nature*, **379**,519.

Lynden-Bell, D., Faber, S.M., Burstein, D., Davies, R.L., Dressler, A., Terlevich, R.J. & Wegner, G.,1988, *ApJ* **326**,19.

10- and 17-μm Test Images of the Galactic Centre: Massive Protostars Near SgrA*?

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Abstract

We have obtained 10 and 17 micron (N and Q band) images of the central square-parsec of the Galaxy. The images were taken with ESO's mid-infrared 64 × 64 pixel array camera TIMMI (Käufl et al., 1992, 1994) at the 3.6-m telescope on La Silla. The reduced images are displayed in Figure 1a,b: in total, 4 images are shown, two at each wavelength (i.e. a linear and a logarithmic stretch) in order to emphasise the full dynamic range. The images represent 1.5 and 7 minutes net on chip integration time at each wavelength, respectively. The images indicate that the morphological structure of the innermost parsec of the Galactic Centre is rather similar at both wavelengths, but differs significantly at certain locations, in particular at the position of IRS3. This compact source projected about 2 arcsec west and 4 arcsec north of SgrA* is found to have an extinction corrected spectral energy distribution νF_ν peaked near 10 microns and may be a massive protostar ($L_{bol} > 10^4$ $L_\odot$) or a cluster of protostars near the Galactic Centre. This might be possible, as there is indeed some dense gas in the innermost parsec from which stars can form (Jackson et al., 1993). In none of our images, mid-infrared emission from SgrA* is detected. Likewise, the strongest 2-micron source (IRS7) could not be detected, neither at 10 nor at 17 microns, to a 3-sigma limiting flux of about 0.3 and 4 Jy per arcsec^{-2}, respectively.

Technical Details

The N band images (λ = 10.1 micron, δ_λ = 4.0 micron) were taken with a pixel scale of 0.66 arcsec/pixel in 1.2 arcsec seeing. Due to the high thermal background (sky and telescope) the on-chip integration time of the individual frames had to be very short (7 ms). Otherwise standard infrared techniques were employed, i.e. chopping the secondary mirror (2.5 Hz) and nodding the telescope. Sky frames were taken in a location clear of 10-micron sources. The Q band images (λ = 17.15 micron, $\Delta\lambda$ = 1.5 micron) were taken with a smaller pixel scale (0.33 arcsec/pixel), a necessity due to the even higher thermal background at the longer wavelength. At 17 micron, the seeing FWHM was 1.5 arcsec – i.e. close to the diffraction limit at this wavelength at this telescope. Again, hundreds of short exposure frames were coadded, this time with an individual on-chip exposure time of 12 ms. The same chopping and nodding as for the N band images was employed, and approximately the same sky position was used. The overall on-source observing efficiency for the N and Q band integrations was 40%.

We note that the sky is fairly clear of sources at mid-infrared wavelengths, so that it is easy to find an empty sky position. The very Galactic Centre is the exception in this respect; there is no other clustering of strong mid-infrared sources in the Galaxy that rivals the innermost parsec.

The images shown have not been flat-fielded, as this appears to be unnecessary: the overall gradient in sensitivity across the array is less than 10%, and the pixel-to-pixel variations are even smaller (Käufl, 1995).

The star βGru was used as a point source calibrator (N = –3.55, Q = –3.58) and also to measure the seeing at mid-infrared wavelengths; α Cen (N = –1.52, Q = –1.55) was used, too.

Significance of the Images

A major goal of our observation was to compare the 17-micron image to the 10-micron image in order to find out which of the well-known 10-micron sources in the Galactic Centre (Gezari et al., 1985) have a rising flux density distribution towards longer wavelengths. The high spatial resolution mid-infrared TIMMI array data are superior to earlier single-beam raster-scan observations (Becklin et al., 1978, Rieke et al., 1978). The idea behind all this was to try to search for dust-enshrouded massive protostars, similar in kind to the Becklin-Neugebauer and IRc2 objects in