The Shapley Supercluster: the Largest Matter Concentration in the Local Universe

Dominique Proust[1]
Hernán Quintana[2]
Eleazar R. Carrasco[3]
Andreas Reisenegger[2]
Eric Slezak[4]
Hernán Muriel[5]
Rolando Dünner[2]
Laerte Sodré Jr.[6]
Michael J. Drinkwater[7]
Quentin A. Parker[8]
Cinthia J. Ragone[5]

[1] GEPI – Observatoire de Paris-Meudon, France
[2] Pontificia Universidad Católica de Chile, Santiago, Chile
[3] Gemini Observatory, La Serena, Chile
[4] Observatoire de la Côte d'Azur, France
[5] Observatorio Astronómico, Córdoba, and CONICET, Buenos-Aires, Argentina
[6] IAG-USP, São Paulo, Brazil
[7] University of Queensland, Australia
[8] Macquarie University and AAO, Australia

Since the 1980s, we have known that the *Local Group* of galaxies is moving at a velocity of 366 ± 125 km/s in the direction of Centaurus. In this region, the well-known Shapley supercluster of galaxies (SSC) consists of many clusters and groups of galaxies in the redshift range 0.04 < *z* < 0.055. An international collaboration has highlighted this greatest matter concentration in the local Universe, less than 500 million light years from us. The SSC may be able to account for half of the sought for 'Great Attractor'.

The supercluster of galaxies Shapley 8 (SSC), located in the north of the constellation of Centaurus (α 13^h25^m, δ -30°), was observed in 1930 by Harlow Shapley; he then noticed an oval cloud of galaxies in Centaurus which appears to be one of the richest currently detected, having dimensions of approximately 2.8° by 0.8°. In the 1980s, this structure interested astronomers particularly because they discovered that the Local Group, formed by about thirty galaxies surrounding us, moved with respect to the cosmic microwave background frame of reference at the velocity of 366 ± 125 km/s in the direction of Centaurus (Dressler et al. 1987). This meant that an enormous amount of matter attracted our Galaxy and the surrounding galaxies; it took the generic name of *Great Attractor*. In this direction, there is already the Hydra-Centaurus supercluster, whose galaxies have on average a recession velocity of 4 000 km/s. However, in spite of its wealth of galaxies, this huge complex has only a negligible gravitational effect on the Local Group. This is why we undertook a dynamical analysis of the SSC by studying galaxies as faint as magnitude $m_b = 18.0$, beyond the Hydra-Centaurus complex, in an area of the sky extending over 30° × 12°.

The galaxies were selected from photographic plates of ESO, then digitised on the MAMA at Paris Observatory. The observations were carried out with the 2.5-m Du Pont telescope at Las Campanas with the spectrograph 2D-frutti, the ESO 3.60-m telescope with the OPTOPUS and MEFOS spectrographs, and the 1.8-m UKST telescope at the Anglo-Australian Observatory with the spectrographs FLAIR and 6dF. By supplementing the observations with velocities from the NASA extragalactic database (NED), 10 529 velocity measurements were gathered, corresponding to 8 632 galaxies. In the central part of the supercluster, 92 % of the galaxies could be measured, and on the whole 61 % of the objects were observed.

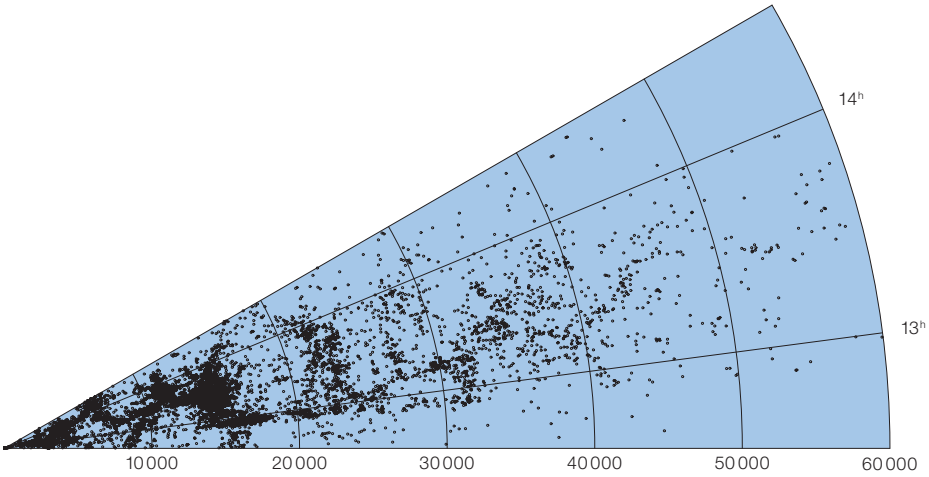


Figure 1: Cone diagram (right ascension) of the galaxies observed in the area of the Shapley supercluster (SSC) up to a recession velocity of 60 000 km/s.

Figure 1 shows the 'cone diagram' of these galaxies. Velocity is plotted versus right ascension, ranging between 12^h30^m and 14^h30^m. Each cluster of galaxies is characterised by an apparent elongated structure along the line of sight, due to the velocity dispersion inside the cluster. Note the presence of the foreground Hydra-Centaurus supercluster. It is connected by a bridge of galaxies to the Shapley supercluster itself, whose 5 701 galaxies have a mean recession velocity of 15 400 km/s. Many structures connect the SSC to other superclusters, underlining the filamentary distribution of the matter in the Local Universe. The longest one appears to extend out to 48 000 km/s, joining structures evidenced by Einasto et al. (2001). The analysis of the SSC made by Ragone et al. (2006) based on simulations, shows that it is composed of 122 galaxy systems; 60 are new and 44 belong to the supercluster (Figure 2). The galaxies contained in the SSC represent an average matter overdensity of 5.4 ± 0.2, definitely larger than nearby superclusters such as Horologium-Reticulum whose density excess is only 2.4. The SSC extends more than 120 million light years, its volume being equivalent to that of a sphere of 80 million light years in radius: it is the largest matter concentration in the Local Universe, less than 500 million light years from us.

Clusters of galaxies related with X-ray sources are located at the centre of the SSC, indicating the presence of gas at very high temperature, more than ten million degrees. They were analysed by Bardelli et al. (1996), deriving a mass $M = 3.1 \times 10^{14}\ h^{-1}\ M_{sun}$ within a radius of $2h^{-1}$ Mpc ($h = H_o/100$ km/s/Mpc). Using our catalogue, we determined the luminosity and the mass of the supercluster using various models such as the determination of the mass by X-ray properties, the analysis of the velocity fields of each galaxy cluster and the spherical collapse model. We obtained a total luminosity of about $1.4 \times 10^{14}\ h^{-2}$ times that of the Sun for a total mass of the supercluster $M_t = 5 \times 10^{16}\ h^{-1}\ M_{sun}$. Although very high, this mass would represent only half of that required to attract the Local Group (Hoffman et al. 2001) in the direction of the supercluster. In addition to this, at least an identical amount of matter in the same direction must be present in order to account for the particular motion of our Galaxy.

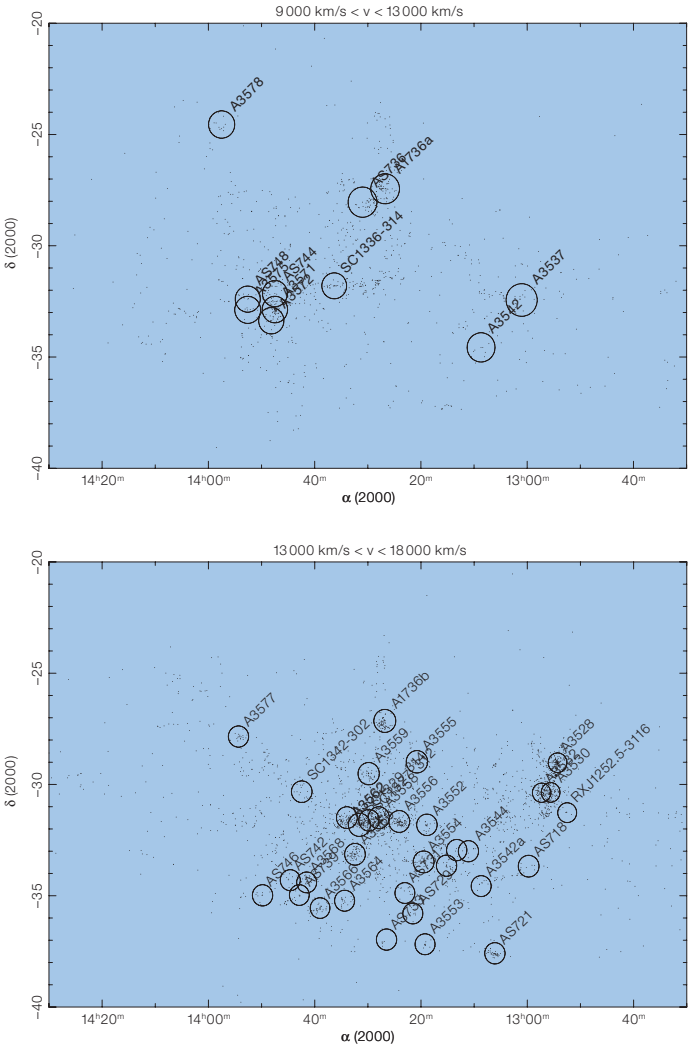
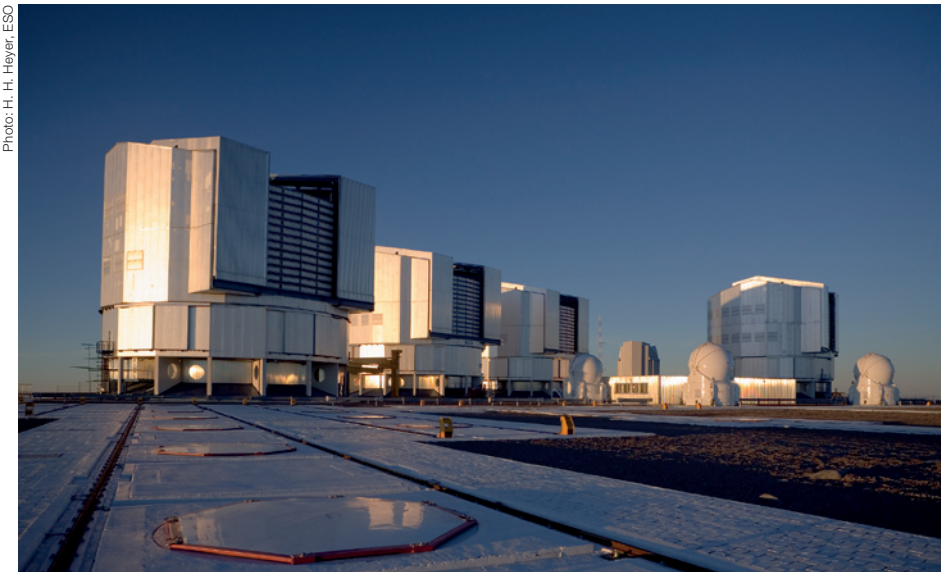


Figure 2: Distribution on the sky of the 44 clusters and galaxies in the velocity range of the SSC. **Upper panel:** clusters with velocities between 9 000 and 13 000 km/s. **Lower panel:** clusters between 13 000 and 18 000 km/s.

References

Dressler A. et al. 1987, ApJ 313, L37
Einasto M. et al. 2001, AJ 122, 2222
Hoffman Y. et al. 2001, arXiv:astro-ph/0102190
Proust D. et al. 2006, AA 447, 133
Ragone C. J. et al. 2006, AA 445, 819

Photo: H. H. Heyer, ESO



The VLT and its Auxiliary Telescopes at Sunset.