isms of central transmission, put forward by myself and colleagues[7] (*b* in the figure), receptors may be grouped quantally in the postsynaptic membrane. We suggest that the membrane opposing a single bouton may contain a variable number (0 to about 4) of these quantal groups, all of which are saturated by release of a single vesicle of transmitter. Such a hypothesis puts in doubt even the interpretation of failures, as release of a vesicle may not produce a postsynaptic response.

Before the question of the pre- or postsynaptic origin of long-term potentiation can be resolved, it seems the details of signal transmission in the central nervous system must be clarified. Indeed, even when a clear model is established, as Larkman *et al.* suggest, "a more complete quantal analysis will be required to quantify the relative importance of pre- and postsynaptic changes". □

Frances Edwards is in the Department of Pharmacology, University College London, Gower Street, London WC1E 6BT, UK.

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COSMOLOGY

A quasar superstructure

Joseph Silk and David Weinberg

THERE have been occasional reports over the past decade of groupings of quasars, the most luminous and most distant objects in the Universe. Clowes and Campusano, reporting in the latest *Monthly Notices of the Royal Astronomical Society*[1], now present evidence of an elongated grouping, which may both exceed in scale and be far more distant than any known large structure of galaxies.

Clowes and Campusano obtained their data in an automated search of a field of some 25 square degrees, in an area where earlier investigations had suggested an anomaly in the quasar redshift (distance) distribution. An objective prism used with the UK Schmidt telescope allowed low-resolution spectra of many objects to be obtained over a wide area. Quasar candidates were distinguished by a computerized search that looked at both emission lines and excess ultraviolet light. Follow-up spectra were obtained to confirm the quasar identifications and obtain precise redshifts. A total of about 60 quasars were discovered in the field.

By inspecting the redshift distribution the authors found ten quasars with redshifts between 1.2 and 1.4 (about a quarter of the distance to the most distant known objects). Although there were other peaks in the distribution, statistical analysis suggested that only these ten quasars form a grouping that is likely to be physically associated. The group is elongated, presenting a profile about 1° by 2.5–5°. Its depth probably exceeds $100h^{-1}$ megaparsecs (the exact size depends on the value of Hubble's constant, normally given as $100h$ km s^{-1} Mpc^{-1}, with $0.5 \leq h \leq 1$). Clowes and Campusano found unambiguous evidence for clumping in the field over 1° (or $35h^{-1}$ Mpc), and more tentative evidence for clustering over 5° (in particular, nine of the ten quasars lie above the main diagonal of the survey plate).

There have been several claims for very large structures in the local distribution of galaxies and galaxy clusters. These include the $150h^{-1}$ Mpc 'Great Wall' revealed in the Harvard–Smithsonian Center for Astrophysics redshift survey[2], the $300h^{-1}$ Mpc supercluster complexes identified by Tully[3,4] in the Abell cluster catalogue, and the signals of $120h^{-1}$ Mpc periodicity observed by Broadhurst *et al.* in deep redshift surveys through the galactic poles[5]. The challenge in such cases is to evaluate the statistical significance of the giant structures, especially because galaxies and clusters are already known to cluster strongly on smaller scales. Postman *et al.*[6] argue that Tully's results can be explained in terms of the known cluster correlations on scales of about $30h^{-1}$ Mpc; and Kaiser and Peacock[7] and Park and Gott[8] show that signatures of 'periodicity' can arise in pencil-beam surveys much like that of Broadhurst *et al.* as a result of small-scale galaxy clustering, without any special predisposition towards $120h^{-1}$ Mpc structure in the galaxy distribution.

Similarly, although the cold dark matter (CDM) model generates structure only weakly at $150h^{-1}$ Mpc, Park[9] and Gunn and one of us (D.W.)[10,11] find that structures such as the Great Wall arise in numerical simulations of CDM as occasional, chance alignments of three or four smaller superclusters. But statistical studies of the galaxy angular correlation function[12] and the variances of the galaxy density field revealed by the Infrared Astronomical Satellite (IRAS)[13,14], provide clear evidence of an excess of large-scale clustering over that predicted by the standard CDM model.

For the quasar survey by Clowes and Campusano[1], one must ask whether the $100–200h^{-1}$ Mpc structure is statistically significant, or whether it consists of smaller groups and chance outliers linked by a 'join-the-dots' philosophy. The question is difficult to answer with the current data because the larger scale is close to the angular size of the survey plate itself. An earlier study of a different field by Crampton *et al.*[15] found a grouping of 23 quasars at a redshift of 1.1, with an inferred physical scale of about $60h^{-1}$ Mpc. Such large quasar groups seem to be rare, because they have not been reported in other faint, wide-angle surveys. Complete surveys of larger areas and greater depths should make it possible to assess the frequency and statistical significance of large quasar groups.

In contrast to the large galaxy structures, rare groupings of rare objects need not be associated with physical increases in the local mass density. If quasars formed from rare peaks of primordial density fluctuations that had random phases, one can readily show that they would have enhanced correlations[16]. The clustering of Abell clusters has been explained in this manner, and if there is typically one quasar formed per galaxy cluster then similar correlations would result for the quasar distribution. This 'biasing' mechanism might easily give strong quasar correlations out to scales of about $20h^{-1}$ Mpc, but it is difficult to account for $100h^{-1}$ Mpc structure in this way because one would not expect the underlying density fluctuations to be coherent over such large scales.

One cannot automatically dismiss the alternative possibility that the quasar groups represent physical enhancements in the underlying density of the Universe. This is the more radical view, which might be supported by the discovery of associated enhancements in the distribution of galaxies or X-ray-emitting gas. Such structures would be remarkable both for their total size and because, at a redshift of 1.3, they must already have formed when the Universe was less than half of its present age. They are not yet in conflict with other observations — the isotropy of the cosmic microwave background provides the closest constraint — but they would provide a further nail in the coffin of CDM, and they would probably challenge the traditional assumption of gaussian primordial density fluctuations. □

Joseph Silk and David Weinberg are in the Department of Astronomy, University of California, Berkeley, California 94720, USA.

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