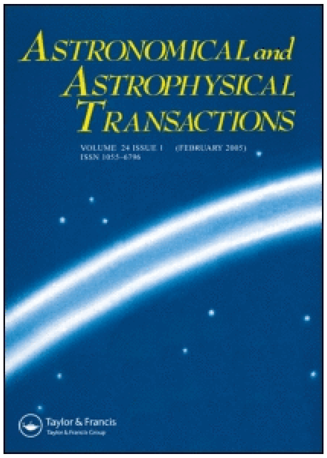

Astronomical & Astrophysical Transactions
The Journal of the Eurasian Astronomical Society
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t713453505

The large scale structure at high redshifts

B. V. Komberg [a]; V. N. Lukash [a]
[a] Astro Space Center, Academy of Sciences, Moscow, Russia

Online Publication Date: 01 January 1994
To cite this Article: Komberg, B. V. and Lukash, V. N. (1994) 'The large scale structure at high redshifts', Astronomical & Astrophysical Transactions, 5:1, 71 - 74
To link to this article: DOI: 10.1080/10556799408245856
URL: http://dx.doi.org/10.1080/10556799408245856

Astronomical and Astrophysical Transactions, 1994,
Vol. 5, pp. 71–74
Reprints available directly from the publisher.
Photocopying permitted by license only

THE LARGE SCALE STRUCTURE AT HIGH REDSHIFTS

B. V. KOMBERG and V. N. LUKASH

Astro Space Center, Academy of Sciences, Profsoyuznaya 84/32, 117810 Moscow, Russia

(22 December 1992)

KEY WORDS Young clusters, Quasars, large-scale structure.

We analyse the evolution of large structures using the quasar clustering. Assuming that the majority of quasars at $z > 0.5$ are associated with the first caustics forming in precluster clumps we relate the positions of distant quasars with young clusters, and hence the QSO structures (groups and wide pairs) appearing in nearby regions ($z \leq 1.3$) indicate the concentrations of clusters which are just distant great attractors ranging in typical scales $l \in (5\text{–}150)h^{-1}$ Mpc.

Nowadays, there exist two principal experiments to probe the cosmological spectrum Δ_k of primordial density perturbations on large scales $l \equiv \pi/k \geq 5h^{-1}$ Mpc,

$$\langle(\delta\rho/\rho)^2\rangle = \int \Delta_k^2 \, d \ln k. \tag{1}$$

• Anisotropy of $\Delta T/T$ ($\Theta \geq 3'$), the temperature of the relic background radiation.

• Observations of the large scale structures.

The latter is seen up to the typical scale $l_{\text{LS}} \sim 100\text{–}150h^{-1}$ Mpc as great attractors (GAs) and great repulsors (voids) where the density contrast does not exceed 20% at that scale. Since the GA scales, $l_{\text{GA}} \in (10\text{–}150)h^{-1}$ Mpc, are still developing in a quasilinear regime today, we can directly reconstruct its background evolution and, thus, recover the primordial spectrum Δ_k in the corresponding range of wavenumbers.

Basically, there are two possible ways to extract the information here: to study the distribution of the structures in a nearby region, $z \leq 0.1$ (e.g., the two-point correlation functions of radio or IRAS galaxies, Abell clusters, etc.) and to study the evolution of structures going to a higher redshift (e.g., quasars, absorption and emission clouds, X-ray clusters, radio-sources and any AGNs, etc.)

Below we discuss the latter dynamical approach using the quasar statistic (see Komberg & Lukash 1994; Lukash 1992a).

The idea is to relate the structures appearing in QSOs at closer redshifts ($z < z_{\text{LS}} \simeq 1.3$)—namely, physical QSO groups (QGs) and wide QSO pairs (WQPs),—to the cluster concentrations and, by this means, with the patches of enhanced total density which we define as distant GAs. The latter step just assumes that clusters, where they are concentrated, trace the mass density enhancements and, vice versa, cluster voids indicate the decreased density regions. This is confirmed in the nearby space by the peculiar velocity measurements and by the alignment of the cluster and relic background dipoles.

The crucial moment is to relate the distant QSOs broadly peaked at $z \sim 2.3$ to young clusters. First, we outline observational indications and then present the physical arguments.

There are few observational approaches as far as the relationship between quasars and clusters is concerned:

1) The construction of the QSO correlation functions and the comparison with clusters correlations;

2) The similarity between the distributions of the cluster pairs and the WQPs;

3) The direct investigations of the QSO environments.

The QSO correlation function in a closer region displays a strong QSO clustering at $r \sim 10h^{-1}$ Mpc and a weaker clumping at $\sim$20–30h^{-1} Mpc. It evidently grows to smaller redshifts: for $z \Rightarrow 0$ it looks like a clumped distribution of radiogalaxies, whereas for $z > 2$ the QSOs seem to be randomly distributed. As far as the WQPs are concerned ($\Delta\theta \leq 1.5°$, $\Delta v/c \sim 10^{-2}$) the QSOs there are mostly associated with different clusters, which is backed by the similarity of their distribution with that of the cluster pairs (the characteristic correlation scales in both cases are apparently the same: $\Delta v \sim 2000$ km/s, $\Delta l \sim 25h^{-1}$ Mpc, $M_{\rm eff} \sim 10^{16} M_{\odot}$, which are typical GA parameters).

Modern observations show that QSOs at $z > 0.5$ are frequently associated with rich clusters but QSOs at $z < 0.5$ seem to be found in poor systems like galactic groups. Another important result refers to the age of the groups and clusters where quasars are: the velocity dispersion of galaxies in such a cluster seems to be abnormally small. It gives a clue to how quasars form: the less is the velocity dispersion the larger is the probability for interaction and merging processes between galaxies in the cluster. These merging effects, supplying accreting material (to the massive black hole) just well enough for the QSO burning, can really exist in young clusters which are still in the process of the first collapse and first contraflows' origin, i.e., well before the cluster virialization and X-ray gas appearance.

Taking into account that the first violent crossings (caustics) of the cosmic primordial medium must certainly form in the central regions of young preclusters we may relate the majority of quasars at $z \sim 2.5$ with the epoch of the cluster formation. Certainly, not every QSO we do associate with young clusters. There were several generations of QSOs depending on the physical processes which provided for the formation of the accreting gas disk. It is the dense caustics with high merging activity of host QSO galaxies that we associate with a typical cluster mass. (The lesser mass collapse could not be as powerful as to ensure high gas densities, while the larger masses collapsed later in the medium already totally ionized by a broad class of the AGNs, including the QSOs, created at $z \gtrsim 2$).

If so, then at least two topics should be considered:

• It is possible to find distant GAs by groups and pairs of QSOs at the scale of a few dozens Mpc ($l_{\rm GA} \leq l_{\rm LS}$).

• The relationship between the epochs of cluster formation ($z \sim 2$–3) and GAs' appearing ($z < 1.3$) prompts the true model of the large scale structure formation.

Today we know few QGs. The one group (Webster 1982) at $z = 0.37$ consists of 4 QSOs within $\sim$75h^{-1} Mpc. Another group (Crampton, Cowley & Hartwick

1989) at $z = 1.1$ contains 23 QSOs within $\sim 60h^{-1}$ Mpc, and the next group (Clowes & Camusano 1991) of 13 QSOs occupies a region $\sim 35 \times 100 \times 150h^{-1}$ Mpc at $z = 1.3$. The authors emphasize that they do not see QGs at larger redshifts although the spatial number density of QSOs grows sharply up to $z \sim 2.5$. It is interesting to note that the number of wide observable QSO pairs also seems to decay beyond $z \gtrsim 1.3$.

If the GA structures really disappear at $z \gtrsim z_{LS} \sim 1.3$ and the cluster formation epoch (the first caustics of preclusters) lies in a broad interval centred at $z_{Cl} \sim 2.5$, then the Δ_k spectrum must be rather flattened within the scales encompassing both the clusters and the GAs, $l \in (5\text{–}150)h^{-1}$ Mpc. Taking into account time evolution $\delta \sim (1+z)^{-1}$ and thus the amplitude ratio $(\Delta_{k,Cl}/\Delta_{k,GA})^2 \simeq (1+2.5)^2 \simeq 10$, we have the following straightforward estimate for the spectrum of the Gaussian primordial density perturbations within the dynamical range:

$$\Delta_k^2 \sim k^{1 \pm 0.5} \tag{2}$$

This leads to the correlation function of the total mass $\xi(r) \sim r^{-(1 \pm 0.5)}$, which means that clusters are clumped in regions overdensed by the GA-scale perturbations. Note that the actual cluster correlation function $\xi_{cc}(r)$ deviates from the dynamical one, as the cluster formation time is strongly modulated by the GA-scale perturbations for the spectrum (2)—clusters form in the overdense regions and do not form in voids—which may naturally result in a highly "biased" distribution of the observable clusters (this effect disappears for steeper spectra, e.g., for the CDM).

Such flat spectra bring about the following conclusions.

(i) Today, the clusters should be well developed and concentrated where the GAs are (the clusters trace the mass in dense regions), while sparse young clusters might be found near voids.

(ii) If the majority of first cluster caustics gives birth to the QSOs broadly peaked at $z \sim 2\text{–}3$, and appear correlated with the GA-peaks, then the mean separation between distant quasars should also correlate with l_{LS} at $z \sim 2.5$, which is actually in a good agreement with observations: the comoving spatial QSO density, $n \sim (1+z)^{5\text{–}6}$, corresponds just to the change of the mean QSO separation from $\sim 10^3 h^{-1}$ Mpc at $z \lesssim 0.5$ to $\sim 100h^{-1}$ Mpc at $z = 2\text{–}3$.

(iii) Gaussian flat spectra (2) result by $z \lesssim 1$ in a great variety of coherent structures within $l \in 10\text{–}100h^{-1}$ Mpc (the hierarchies of walls, filaments, voids and GAs) produced by perturbations with nearly equal amplitudes in a wide scale range forming at the same recent epoch. Note that such structures form in the gravitating matter and do not require a biasing-type hypotheses.

(iv) If galaxies form before clusters, their first generation is not modulated by the GA-perturbations. However, merging and generating processes for galaxies going most active in dense regions, lead to the successive generations of bright galaxies namely in clusters and at the GA locations. A test for this suggestion could be a search for dwarf faint galaxies in voids and the disappearance of normal bright galaxies beyond the cluster formation epoch ($z > 2.5$).

(v) Obviously, spectra (2) are flatter than in the standard CDM (the latter anticipates $\Delta_k^2 \sim k^{2\text{–}3}$ in that scale range). One of the possible ways to realize them are the hybrid cold + hot dark matter models with $\sim 30\%$ of the total mass in the form of neutrino-like particles with the rest mass ~ 7 eV, (Lukash 1992b).

Note that Eq. (2) does not contradict to the possibility to have the Harrison–Zeldovich fundamental spectrum $\Delta_k \sim k^2$ at larger scales ($l > l_{LS}$).

Summarizing, we can say that the available data support the following two conjectures:

• QGs and probably WQPs indicate the patches of enhanced total density (distant GAs), they occur at the scales $l_{GA} \sim 10\text{–}150h^{-1}$ Mpc and extend up to $z_{LS} \sim 1.3$.

• The majority of distant QSOs is associated with the epoch of cluster formation, $z < 3$.

Both points are selfconsistent if and only if the QSOs belonging to the QGs were created not long before time where a given QG is observed, which is also consistent with a relatively short lifetime of the medium and bright QSOs. It means that first young clusters and associated QSOs at $z > z_{LS}$ appear more or less randomly in space, whereas the next-generation clusters and related QSOs appearing at $z < z_{LS}$ are born already in groups at the GA peaks.

The QSO test for the GA search proposed here can be successfully used at $0.5 \leq z \leq 4$, where large QSO number densities are observed. For the nearby region ($z \leq 1$), the same test can be applied to radiogalaxies which may be the evolutionary successors of radioloud QSOs. In this case the positions of powerful radiogalaxies must strongly correlate with rich X-ray clusters. Also, the promising samples are Syeferts and other AGNs, absorption and emission lines, as well as direct diffuse emissions from dense, hot regions.

References

Clowes, R. G. and Camusano, L. E. 1991, *Astr. Ap.*, **249**, 218.
Crampton, D., Cowley, A. P. and Hartwick, F. D. A. 1989, *Ap. J.*, **345**, 59.
Komberg, B. V. and Lukash, V. N. 1994, *M.N.R.A.S.* (in press).
Lukash, V. N. 1992a, Prepr. SISSa Ref. 187/92/A (Oct 92) (Proc. Int. Symp. "Observational Cosmology", Milano 1992).
Lukash, V. N. 1992b, *Annals New York Acad. Science* **899**, 100 (Proc. 15th Texas–ESO–Cern Symp., Brighton 1990).
Webster, A., 1982, *M.N.R.A.S.*, **199**, 683.