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POSSIBLE COSMOLOGICAL CONNECTION BETWEEN QUASARS AND Ly_α ABSORBING SYSTEM CLUSTERING

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Abstract. The possible cosmological connection between quasars and Ly_α absorbing system clustering has been discussed. The distribution of quasars and absorbing system clustering as a function of cosmological redshift indicates that absorbing material is bound in collapsed objects.

1. INTRODUCTION

Quasars may indicate the existence of at least a fraction of collapsed objects at any epoch at which they are observed. On the other hand, high-z population of Lyα and other absorbing clouds is supposed to trace the diffuse, intergalactic and protogalactic gas, not yet assembled (or in process of assembling) into collapsed structures, i.e. galaxies, groups and clusters (Sargent *et al.* 1980; Rauch 1998). This principal distinction could, in principle, raise hopes of getting into details of this process of assembling of the baryonic content of the universe by investigating the changes in densities and correlations of these two populations with cosmic time (i.e. decreasing redshift). This hope is partially fostered by the success of observations during the last decade which (i) enabled a complete sample of low and intermediate-redshift objects within a field of a QSO to be obtained (Lanzetta et al 1995), and (ii) somewhat clarified the situation with baryonic census of the universe, showing that part of baryons erstwhile residing in high-z Lyα forest are most probably now associated with field galaxies and small groups (Fukugita *et al.* 1998). The goal, therefore, is to try to learn something about the structure formation through comparison of QSO and absorber statistics and compare these still largely uncertain entries with rather well-known low-redshift data.

2. RESULTS AND DISCUSSION

In order to investigate the possible cosmological connection between collapsed objects (QSOs, quasars and quasar candidates) and Ly_α absorbing systems we have analyzed the distribution of these objects in different epoch of Universum. In Fig. 1 the distribution of a sample of quasars brighter than absolute magnitude -23 (Veron-Cetty

& Veron 1996), faint QSOs (Boyle *et al.* 1991) and high probability quasar candidates (Beauchemin *et al.* 1990, Iovino *et al.* 1996) is presented. Also, in Fig. 1 the distribution of Ly_α absorption systems is presented. The data for distribution of Ly_α absorption systems are taken from literature (Sargent *et al.* 1980, Savaglio *et al.* 1994, Petitjean *et al.* 1994, Cristiani *et al.* 1995, Dobrzycki & Bechtold 1996). The spectral analysis of the collapsed objects distribution is shown in Fig. 2. As we can see from Figs. 1 and 2 the maximal density of collapsed objects is at redshift 1.91, 1.31 and 0.95, when Ly_α absorbing systems have maximal density at redshift between 2.2 to 3.1. Two rival processes are influencing the number of Ly_α absorbing systems are taking place at these redshifts:

(1) Physical disappearance of the absorbing clumps of gas, due to their accretion onto galactic- sized halos, presumably created by the dark matter, and/or their continuous merging.

(2) Evolution of the intrinsic collapsed objects number-density.

The process (2) is important for two distinct reasons. Not only turning- on the QSOs enables us to detect absorbing clouds, but they can be used, with varying accuracy, as the tracers of the underlying population of collapsed objects.

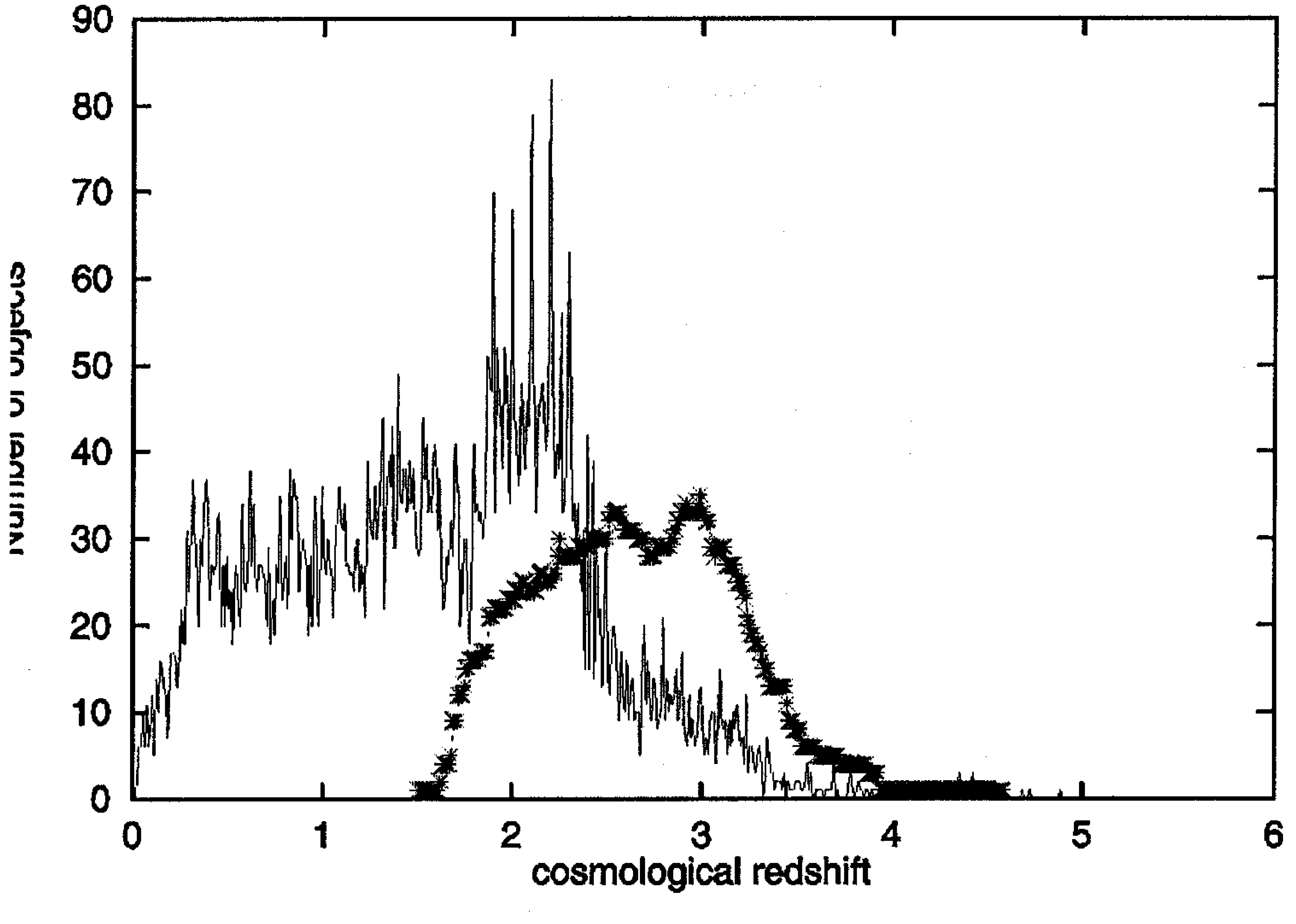

Fig. 1. The distribution of collapsed objects and Ly_α absorbing systems at different epochs of cosmic time.

It is interesting to consider these results in the framework of a general picture of two distinct populations of the QSO absorption lines: diffuse, weakly clustered intergalactic or pregalactic one, dominating at high redshift, and a strongly clustered galactic population of halo clouds which dominate at low and intermediate redshifts. The former evolves slowly over cosmic history into the latter population.

There are other arguments supporting the idea of two distinct populations of Ly_α forest clouds. It is well known from observations that galactic haloes with large covering factor are responsible for most (if not all) QSO absorption lines at $z \leq 1$ (Lanzetta *et al.* 1995; Chen *et al.* 1998). On the other hand, investigations of the absorber autocorrelation function indicate (in spite of still very sparse data) a significant decrease of clustering of absorbers with redshift (Cristiani *et al.* 1997; Ćirković & Lanzetta 1998).

Then we can try to estimate the *rate of incorporation* of Ly_α clouds into galaxies. This points out to structure formation scenario a la Searle-Zinn picture (Searle & Zinn 1978), with gas-rich protogalactic fragments forming first, and their continuously merging and accreting gas from the intergalactic medium being the second phase in the formation of structure which we see today. This is also in accordance with modern numerical simulations of the structure formation processes (e.g. Navarro & White 1994). In this framework, high-redshift Ly_α forest becomes a sensitive laboratory for determination of basic conclusions of the structure formation picture. Since it is quite plausible that Ly_α forest contains most of the baryons in the universe even at low redshift (e.g. Rauch & Haehnelt 1995), the case for its significance at $z \sim 3$ is a fortiori much stronger.

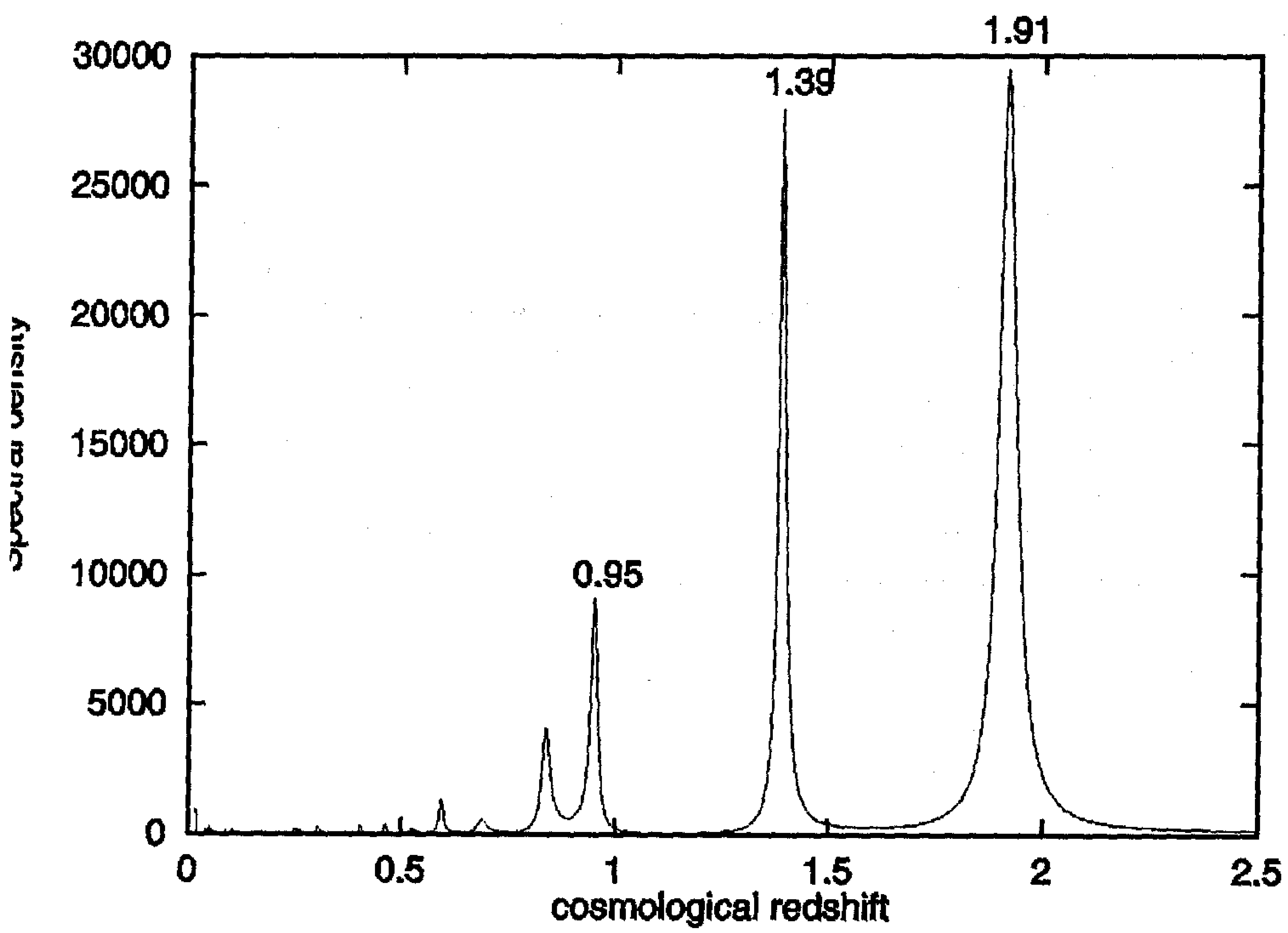

Fig. 2. Spectral analysis of distribution of collapsed objects.

At low and intermediate redshift, one can apply exact statistics of galaxies, obtained through deep surveys (and try to extrapolate them as far as possible).

3. CONCLUSION

Investigations along these lines should enable us to constrain the *duration* of the epoch of structure formation. If a significant fraction of absorbing material is bound in the collapsed objects (virialized halos of normal galaxies and/or minihaloes) as soon as the latter appear, and if emission QSOs are bound to the earliest sub-population of the *same parent population*, then the rate of change in relative abundance of absorption lines gives us the rate of gas removal from the early universe (and, potentially, constrains the cosmological rate of star + black hole formation as well). This gives hope that some empirical bounds can be imposed on the massive halo formation rate models, such as those following from the Press-Schechter theory (Percival & Miller 1998)

Plans for further investigations include comparison between the absorber and QSO autocorrelation functions and evolution of their amplitudes. In this manner, a contact with well-established observational data obtained at low redshift could be achieved.

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