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THE ASSOCIATION OF ALL SKY QUASARS WITH THE ABELL CLUSTER OF GALAXIES

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The association of the quasars with galaxies or cluster of galaxies is one of the most interesting topics in cosmology. We choose "A Catalog of Rich Cluster of Galaxies" (Abell, Corwin and Olewin, 1989) as the foreground objects, which has all sky covering and well studied selection effects, so it provides a tracer of most dense galactic environment. The quasar sample is taken from "A Revised and Updated Catalog of Quasi-Stellar Objects (Hewitt A. and Burbidge G., 1993). These quasars were discovered by all various methods in different wavelength band, which can avoid some unknown selection effects due to unique special identification method. The advantage of this paper is that the numbers of objects and all sky coverage of our samples are much larger than previous work, and the reliable cross-correlation function can be determined with the heterogeneous quasars catalog as long as the selection function of the Abell cluster is well characterized, allowing creation of detailed " random" comparison samples. To avoid incompleteness at low galactic latitude we only use the both samples at $|b| > 40^o$ region, and to avoid bias we exclude the QSOs identified by Bahcall et.al. (1973) at the direction toward the rich clusters. There are totally 2905 Abell clusters and 6301 quasars.

The correlation function (CF) is defined as the probability of finding quasar- cluster pair above the expected number from the random coincidence, the operational definition is:

$$W_{cq}(\theta) = \frac{N_{cq}(\theta + \Delta\theta)}{N_r^-(\theta + \Delta\theta)} - 1 \qquad (1)$$

where $N_{cq}(\theta + \Delta\theta)$ is the observed value of quasar-cluster pairs within angular separation $\theta + \Delta\theta$, and $N_r^-(\theta + \Delta\theta)$ is the mean value of quasar- cluster pairs average over 10 random cluster samples which have the same distribution character as the ACO sample. For obscuration correcting, we model this selection function as (see Bahcall et.al, 1983):

$$P(b) \approx 10^{0.3(1-csc|b|)} \qquad (2)$$

We find that the correlation function for all quasars and clusters are nearly equal to 0 in the region of $\theta < 3^o$, and strong negative value at the region of $3^o < \theta < 10^o$. The minimum is located at $\theta \approx 6^o - 7^o$, and differs from 0 at 4σ level.

We also calculated the CF for Abell clusters with radio, optical, color-selected (UBV objects) and x-ray selected quasars separately. The distribution of radio quasars is independent on the Abell clusters. The anti-correlation between all quasars and Abell clusters is mainly caused by optical-selected quasars. This result supports the hypothesis that the deficit of quasars around the clusters of galaxies is due to the obscuration and intervening absorption. Comparing to previous results carefully, we find one important difference at small separation region ($\theta < 3^o$): there is no obvious deficit of quasars (Romani, Maoz, 1992; Boyle et al. 1988). If there exists only intervening absorption effect, the Wcq at $\theta < 3^o$ must be negative. But Fig. 1 in fact shows the Wcq are nearly equal to 0 ! So we believe that there must exist another opposite effect which influences the quasars number around clusters and only exists in the very dense, central parts of the clusters. The both effects put together and cancel each other, then make Wcq equal zero.

The tendency of negative CF value extends to about 25^o, formed a long "tail".It could be explained by the auto-correlation function of clusters. (The scale of the angular auto-correlation of the Abell clusters is just about 25^o).

We also divide the HB quasars into three subsamples : $Z < 0.5, 0.5 < z < 1.5$ and $z > 1.5$. The CF of the Abell clusters with these redshift ranges look very similar. This is favorable to the interpretation of the intervening absorption effect, which works alike for all quasars at different distances. It does not seem to support the gravitational lensing effect, in which the magnification is proportional to $D_l D_{ls}/D_s$, since for the fixed lens distance (Abell clusters have average distance around z = 0.2), the gravitational lens effect should be different for different redshift quasars, and the most efficient magnification should happen for the quasars with $z \approx 1$.

We conclude that:

i) At the angular separation region $> 3^o$ the quasars show anticorrelation with Abell clusters. This is mainly responsible by optical-selected quasars. The distribution of radio-selected quasars is independent with the Abell clusters. This fact is favorable to the explanation that the anticorrelation is caused by obscuration of the intercluster dust.

ii) At small angular separation $< 3^o$ the value of CF close to 0, which reminds us that beside the obscuration effect there is another effect which enhance the number density of quasars around clusters.

iii) We test the gravitational lensing hypothesis by study the relation between association and redshifts of quasars, and find no difference between different redshift ranges of quasars. This result is inconsistent with the hypothesis of the gravitational lensing effect.

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