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ABOUT SEVERAL PROBLEMS OF MODERN COSMOLOGY

II. ABOUT THE NUMBER OF COSMIC SYSTEMS IN THE UNIVERSE

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ABSTRACT

For the euclidean space new equations are given regarding the dependence of the number of extragalactic objects on redshift and apparent magnitude. For the number of extragalactic systems dN within a redshift interval dz the maximum is at z = 0.6915. The average redshift is expected to be at $\langle z \rangle \approx 0.2189$, assuming that the maximum redshift depending on the distance is $z_{max} \approx 5$. Since hardly any redshift with $z \geq 5$ can be found, the formation of galaxies could possibly have started at the corresponding moment. The finding of $\langle z \rangle$ with the help of measuring techniques would define the beginning of the formation of galaxies in the redshift space.

Subject headings: cosmology: distance scale --- cosmology: theory --- galaxies: distances and redshifts --- galaxies: statistics --- quasars: general

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1. PRELIMINARY REMARKS

The dependence of the number of extragalactic objects on the redshift z and the apparent magnitude m respectively belongs to classical tests of theoretical cosmology. Both effects shall be considered more detailed here.

In part I of this article series (Haase 2000) we have given the following easy relation for the apparent radial distance D between any two cosmic objects

$$D = S_A r_S - S_E r_Q = R_{SA} - R_{QE} = c\,(t_A - t_E) \qquad \text{(I,6)}$$

where in a first approximation we got the value 3206 Mpc for R_{SA}. R_{QE} denotes the source location of the photon at time t_E of the emission and $R_{SA} = D_A$ represents the location of the observer at time t_A of the absorption of the photon. The distance D is the way covered by the photon between these times and thus not the present distance between both locations, because the emission galaxy is in the meantime not located any more at R_{QE} caused by general space expansion. In the meantime observer galaxy has also moved. Equation (I,6) expresses, that the observer is not located in the origin of the coordinate system, and that generally the light source also cannot claim this. This view of the homogeneous and isotropic flat universe is at the same time the important difference to the known model representations in the literature. There the source location of the photons will be usually located in the origin of the coordinate system with $r_Q = 0$.

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2. DERIVATION OF THE NUMBER-EQUATIONS N(z) and N(m)

The sphere volume V in the euclidean space a photon goes through radially is given by

(1) $$V(D) = \frac{4\pi}{3} D^3 \quad ,$$

where D denotes the way covered by the light particle. For this line segment the redshift distance

(I,16) $$D(z;D_A) = D_A \left[1 - \frac{1}{(z+1)^{3/2}}\right] \quad ,$$

from part I is used, to obtain the count redshift law we seek for. This process corresponds to forming a mass sphere, whose volume depends on z in the redshift space according to

(2) $$V(z) = \frac{4\pi}{3} D_A^3 \left[1 - \frac{1}{(z+1)^{3/2}}\right]^3$$

For uniformly distributed extragalactic systems the number of observable objects is proportional to the volume. This gives the relation

(3) $$N(z) = V_A \eta \left[1 - \frac{1}{(z+1)^{3/2}}\right]^3 \quad ,$$

where $V_A = (4/3)\ D_A^3$ is the maximum volume which is possible for today's observation and the constant number density. If the redshift z approaches infinity (for this is valid D-->D_A), we get the number $N_A = V_A$ of objects in the considered sphere. Thus the wanted count redshift law we looked for is in logarithmic form

(4) $$lg N(z; N_A) = 3 \log\left[1 - \frac{1}{(z+1)^{3/2}}\right] + \log N_A \quad .$$

It is therefore sufficient, to form a complete measuring series which is limited in z, to find N_A. It is desirable, to choose the limit redshift as large as possible. Besides it is useful, to normalize equation (4) to a square degree. This restricts the needed measuring expenditure considerably. The assumption that the considered extragalactic objects are uniform distributed can be tested later by measurements in different sky directions. Fig. 1 shows the course of the logarithmic count redshift law per square degree with $N_A = 10^9$. We can recognize, that the number N approaches the number N_A relatively fast while z is increasing, i.e. as the redshift is increasing we will find less and less objects. Observations show only a few extragalactic systems beyond $z \approx 3$, indeed.

For comparison the equation derived in the literature for the flat redshift space ($q_0 = 1/2$) is given (see e.g. A. Sandage 1995):

(yyy) $$V(z) = \frac{32\pi c^3}{3 H_0^3}\left[1 - \frac{1}{\sqrt{1+z}}\right]^3$$

The redshift term shows an essential difference compared to equation (2). Therefore we get a rough deviation from the observed values (see Fig. 4).

The differentiation of the count redshift relation with respect to z

(5) $$\frac{dN}{dz}(z) = \frac{9}{2} N_A \frac{\left[1 - \frac{1}{(1+z)^{3/2}}\right]^2}{(1+z)^{5/2}}$$

is also very interesting. The corresponding diagram is shown in Fig. 2 for different N_A. No matter how N_A is chosen, the maximum of this curve is always close by z = 0.6915, i.e. most of the objects per z-interval will be found in this z-neighborhood. The value of N_A just has an influence to the height of the maximum and hence the slope of the curve.

Besides it is useful, to calculate the expected mean value <z> of the redshifts, to compare it with the measuring results. Using the mean value theorem of the integral calculation equation (5) gives

(6) $$\frac{1}{z_{max}}\left[1 - \frac{1}{(1 + z_{max})^{3/2}}\right]^2 = \frac{9}{2}\,\frac{\left[1 - \frac{1}{(1 + \langle z\rangle)^{3/2}}\right]^2}{(1 + \langle z\rangle)^{5/2}} \quad .$$

where z_{max} is the upper integration limit. Because we can solve equation (6) neither for <z> nor for z_{max} , a numerical procedure was used to get Fig. 3 . If the measurements show, that <z> is not equal to zero ($z_{max} = \infty$ for $\langle z\rangle = 0$), then we would have an explanation for the cut-off effect in the Hubble diagram related to the ordinate log cz, without knowing the real reason. An easy interpretation for a limitation by z_{max} is, that the extragalactic objects were formed only after the corresponding time. The mean redshift is for example $\langle z\rangle \approx 0.2189$ for a maximum redshift of $z_{max} \approx 5$ which is depending on the distance, whereas the mean redshift is $\langle z\rangle \approx 0.3042$ for $z_{max} \approx 3$.

The occurrence of a limited redshift also implies a limit m_{max} of the apparent magnitude because of the Hubble law (I,18), for which $m \le m_{max} \le m_A$. For example $m_{max} = 22.47$ for $z_{max} = 5$, whereas $m_{max} = 22.33$ for $z_{max} \approx 3$, assuming $m_A = 22.62$ is taken as base. Then the low magnitudes of galaxies beyond m_{max} are not only determined by the distance of this systems.

For the count magnitude relation we get

(7) $$N(m;m_A) = N_A\ 10^{0{,}6\,(m - m_A)} \quad .$$

New is the meaning of m_A: Normally all existing objects will be found up to this limit (or up to m_{max} , respectively) of the apparent magnitude. Extragalactic systems whose apparent magnitude is smaller than m_A and m_{max} , respectively are therefore naturally light weaker. Therefore the observer will find only a few objects beyond this magnitude limit. This situation leads to a more or less strong fraction at the end of the measuring point curve, which belongs to equation (7). This also explains, why the night sky is so black although the astrophysicists can measure apparent magnitudes, which are significantly weaker than $m_A = 22.62$. - Note that the limit of the apparent magnitude is generally different for each used photometric system (m_{pg}, U, B, V, R, I, J, H, K, L, b_J, b_F, ...).

The derivative of N(m) with respect to m is

(8) $$\frac{dN(m;m_A)}{dm} = 1{,}3816\ N_A\ 10^{0{,}6\,(m - m_A)} \quad .$$

Specifically the slope is still 0.6 in the logarithmic representation of counts for the whole curve.

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3. COMPARISION WITH THE ASTROPHYSICAL MEASUREMENTS

Unfortunately there is no a complete measurement series for the number of galaxies which is limited by the redshift. We therefore assume that the quasars which were found so far are uniform distributed over the whole sky. According to this assumption the measurement data by Véron-Cetty et al. (2000) and for comparison the catalog No.7158 of the Astronomical Data Center (Hewitt & Burbidge 1993) were used to fit the theory with the observations. The result is shown in Fig.4. The parameter N_A was always chosen so, that the theoretical curves just meet the measuring series for the greatest measured redshifts. Hereby we get the values $N_A \approx 16500$ for the year 2000 and $N_A \approx 8993$ for the end of the year 1993. The equation

(4) always describes really observed data very well. If the assumption above is quite reliable, we might think, that there do not exist considerable more than about 2×10^4 quasars, of which 13214 quasars were already known in march of the year 2000. However we can also see that N_A is increasing as the number of years is increasing. Fig.4 shows a significant surplus of quasars with large redshift, a lack of this objects for mean z and again a surplus for small redshifts. The dotted line corresponds to equation (yyy). As we can see, the corresponding theoretical derivation is not suitable for explaining the measured data.

Using the data material from Huchra et al. (1983), to form redshift mean values $<z>$ up to any different limits m_{limit} of the apparent magnitude, gives Fig. 5 . It is clear, that this mean value increases as the limit m_{limit} increases. Most probably this increasing continuous up to the apparent limit magnitude m_{max} and m_A, respectively, and stops there. Conversion on trial of limits of the apparent magnitude m_{limit} which were used in Fig.5 to the redshift limits z_{limit} with the help of the Hubble law (I,18) leads to Fig. 6 . We can see the trend the theory is asking for. Since the used measured values are not really a series which is limited by z we cannot expect a complete correspondence between the theory and the measured results. Therefore it is necessary, to provide complete measuring series in z, to really make statements about the time of origin of the first galactic systems.

A further note of the increasing of the mean redshift is for example also given in Kron (1993, Fig.7.1.). However there the mean redshift is evaluated within intervals of the apparent magnitude B_J. If no m-intervals are used, but $<z>$ is formed integrally up to certain limited apparent magnitudes, then it is clear, that these mean values are always below the greatest value given by Kron (1993), because then many objects with very small redshifts come into consideration. The fall of the mean redshift is strengthened as well by the fact, that there are hardly objects beyond $B_J = 27$ [compare with Yoshii (1993, Fig. 5a)], which could pull up the mean value. This corresponds to the expectation of the proposed theory, that according to equation (5) only a few objects are expected for large z. The mean value of the redshift is therefore relative small. The measuring results really point at a small redshift mean value. Equation (6) expects a possible maximum value of $<z>_{max} = 0.4192$ for $z_{max} = 1.3$ (compare with Fig.3). For each other z_{max} the mean redshift $<z>$ is always smaller.

Because of less data material being available to the author a conclusive evaluation of the count magnitude relations (7) and (8), respectively was not possible. Therefore it is just noted, that for example in the figures 5a to 5d from Yoshii (1993) the great lack of galaxies beyond certain apparent limit magnitudes is distinctly perceptible. To compare equation (7) with the measuring results, only objects, which are located with their apparent magnitude before this fraction point in the mentioned diagrams, can be considered because the galaxies behind have obviously a naturally lower magnitude and are therefore in this part of the diagram. Since their number is also missing to the left of the fraction point, the slope of the curve diminishes. Note also the occurrence of $m_{max} \leq m_A$, if a z_{max} exists. Hereby the fraction point, from which only a few objects will be found, will be shifted to smaller m-values, as expected else.

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FIGURES:

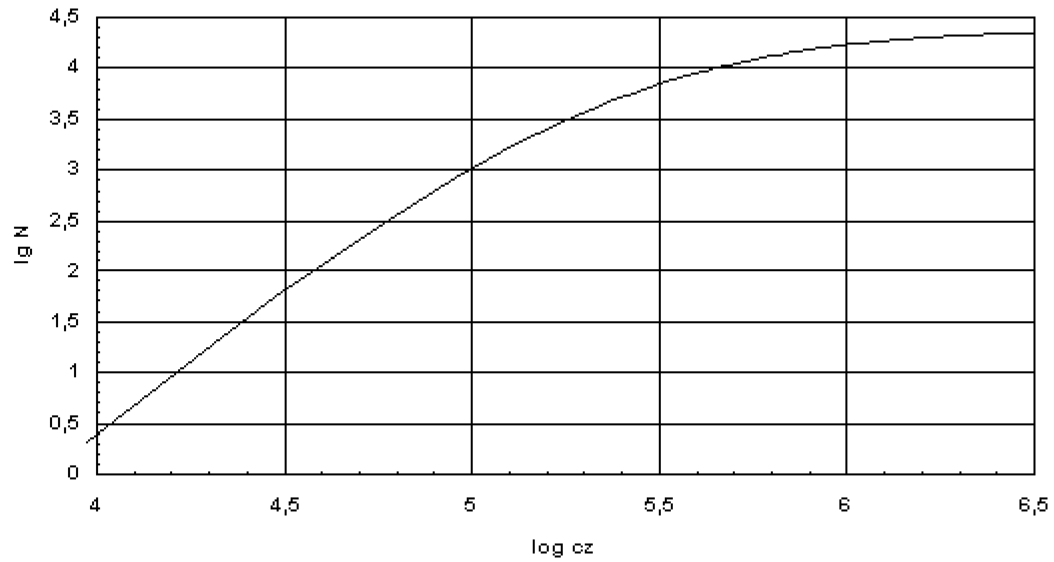

Figure 1.

Count redshift relation according to equation (4). The curve was normalized to one square degree and N_A was set to 10^9. For large redshifts the number of objects to be found increases insignificantly.

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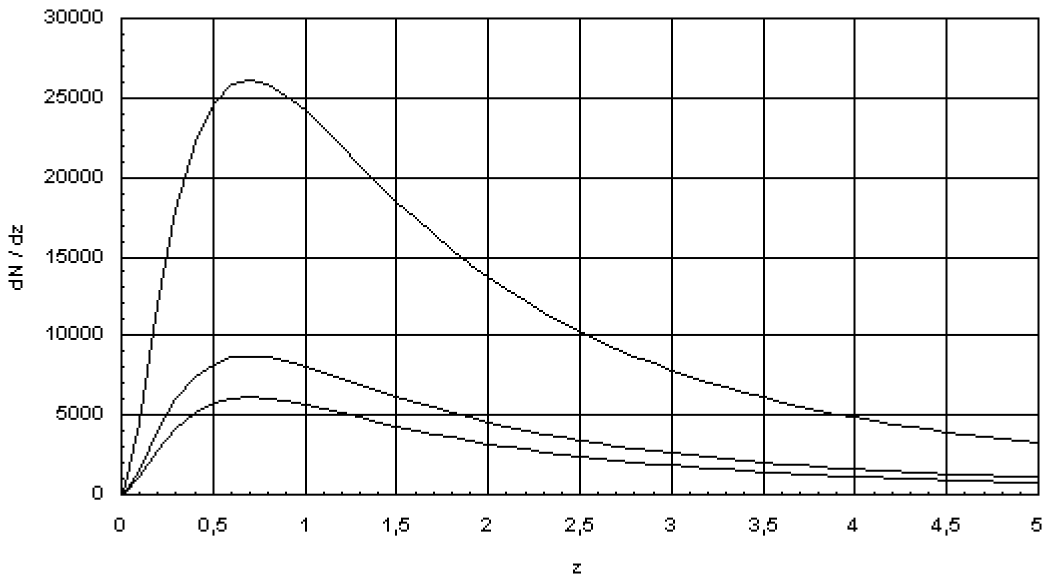

Figure 2.

Differential number dN of cosmic objects in a redshift interval dz depending on the redshift for different N_A. The values of N_A were chosen to be 7 x 10^8, 1 x 10^9 and 3 x 10^9, respectively. For $z \approx 0.7$ we always have a maximum.

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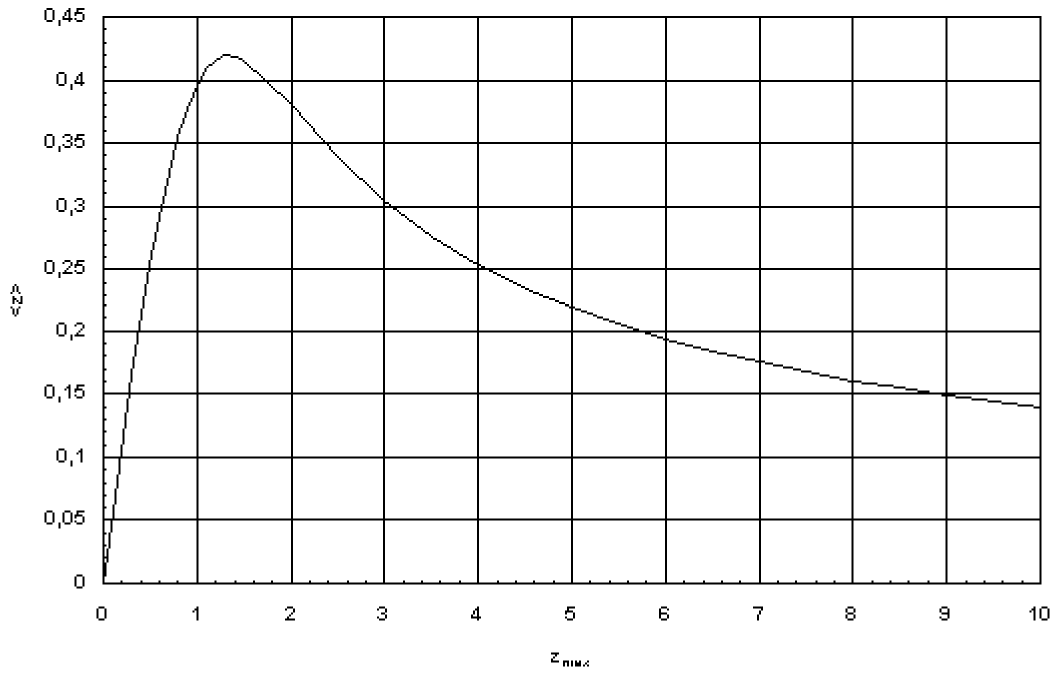

Figure 3.

Mean value <z> of the redshift as a function of a maximum possible redshift z_{max}.

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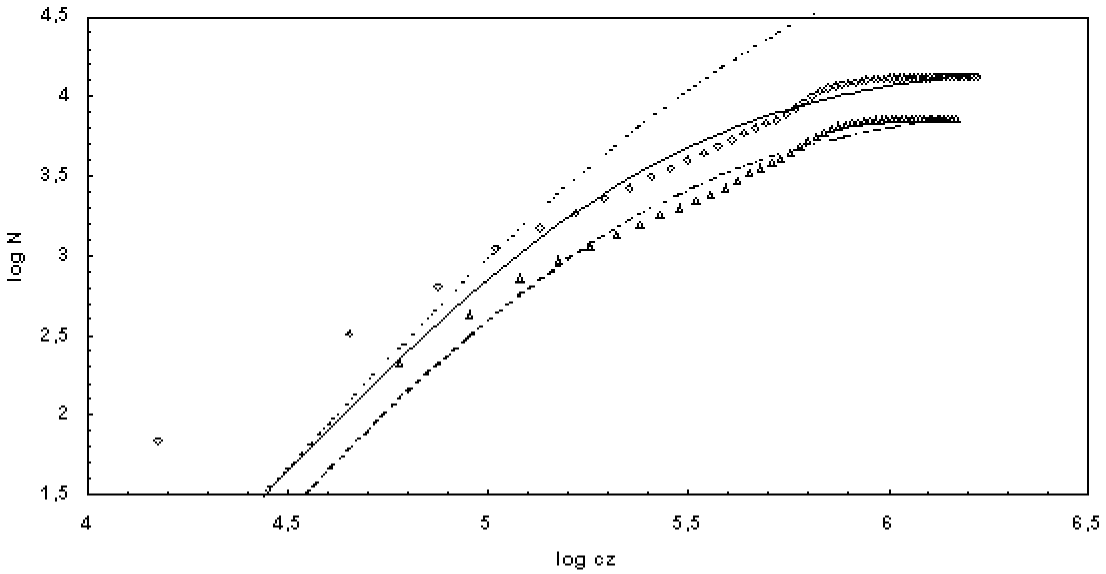

Figure 4.

Comparison of the theory with the number of the quasars that were discovered until the end of 1992 (triangles) and March 2000 (diamonds), respectively according to the catalog No.7158 of the Astronomical Data Center (Hewitt & Burbidge 1993) and Véron-Cetty et al. (2000). The dotted line corresponds to the theoretical derivation that can be found in the literature.

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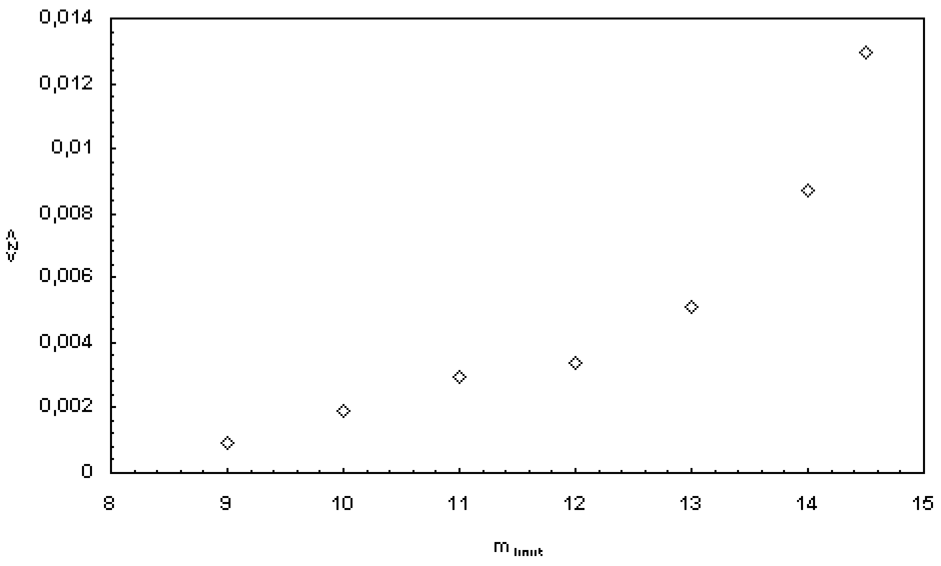

Figure 5.

Mean redshift <z> up to chosen m_{limits} (according to Huchra et al. 1983).

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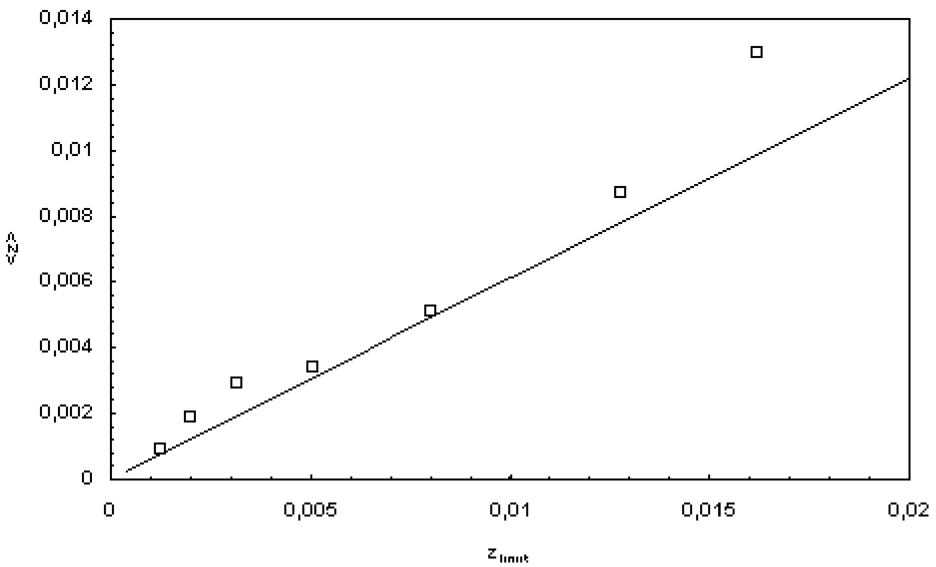

Figure 6.

Mean redshift <z> up to calculated z_{limits} (measuring values according to Huchra et al. 1983).

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