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Determination of Ω_Λ and H_0 from photometric data of radiogalaxies

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From photometric observations of elliptical galaxies, among which are both radio galaxies and radio-quiet objects, an investigation was carried out of the relationship 'redshift – age of the stellar system' ($\Delta z/\Delta t$). By means of this relationship cosmological parameters $H(z)$ and Ω_Λ are estimated. Ages of stellar systems are determined within the framework of evolution models of synthetic spectra PEGASE and GISSEL. This approach can be considered as time study of objects of the early Universe independent of other cosmological models. Construction of a pooled sample is described, containing 220 objects from different populations of elliptical galaxies, for which an analysis of the upper limit of the age of formation of a stellar system was performed. These data were used to estimate the boundaries of determination of the cosmological parameters H_0 and Λ–term: $H_0 = 72 \pm 10$ and $\Omega_\Lambda = 0.8 \pm 0.1$ in the model GISSEL and $H_0 = 53 \pm 10$, and $\Omega_\Lambda = 0.8 \pm 0.1$ in the model PEGASE.

Key words: cosmological parameters – radio continuum: galaxies – galaxies: photometry

1. Introduction

An essential point in determining cosmological parameters is the independence of the procedure of the classical methods, which have come to be classical, such as deep three-dimensional surveys of galaxies and clusters, 1a–type supernovae (see, for instance, Leibundgut 2001) or relic radiation (for instance Efstathiou et al., 2002).

One of the independent techniques is based on the datings associated with the age of galaxies (for instance, Saini et al., 2000). The first attempts to estimate Ω_Λ with the use of ages stellar systems were made a few years ago (see, for instance, Parijskij, 2001) proposed by Jimenez and Loeb (2002). It is based on the datings connected with variations of ages of galaxies determined by the spectroscopic technique.

Such an approach makes it possible to construct an independent chronological scale applicable to the early stages of evolution of the Universe. This approach is based on measurements of differences of the ages *Deltat* between two passively evolving galaxies which form at the same time but separated by a small interval *Deltaz*. Then one can determine the finite difference $(\Delta z/\Delta t) \approx dz/dt$. All the galaxies in the procedure proposed by Jimenez and Loeb must have alike metallicities and low rates of star formation (i.e. red colors), while the mean age of the system must be considerably larger than the difference of ages of galaxies Δt. By applying this differential method, Jimenez and Loeb (2002) suggest H(z) and $\omega_Q(z)$ to be measured directly from the first and second derivatives $(\Delta z/\Delta t)$ $(\Delta^2 z/\Delta t^2)$:

$$H(z) = -\frac{1}{(1+z)}\frac{dz}{dt}\,, \qquad (1)$$

$$H_0^{-2}\frac{d^2 z}{dt^2} = \frac{[H_0^{-1}(dz/dt)]^2}{(1+z)}\left[\frac{5}{2}+\frac{3}{2}\omega_Q(z)\right] - \frac{3}{2}\Omega_m(0)(1+z)^4\omega_Q(z)\,. \qquad (2)$$

By proposing this differential method, the authors show that it is necessary both to increase the sample of galaxies and to improve the signal/noise ratio.

We have used a similar method but with another type of dating of the age, namely, from photometric data and choosing optimum consistency of the distribution of energy in the spectrum (SED), depending on age, by the observed fluxes. This procedure, which has already become standard, operates with sufficient stability for a pure sample of elliptical galaxies (see, for instance, Verkhodanov et al., 1999), though it may give an error in the age up to 2 Gyr.

The methods using color and spectral ages of galaxies are based on chronometrying the rates of expansion of the Universe from physical processes not associated with cosmology: from the rates of nuclear reactions in stars, the knowledge of which for standard stars of the solar type are accurate enough and in the last decade have obtained numerous direct and indirect confirmations, including the latest achievements of acoustic tomography of the entrails of the Sun. For this reason, the proposed method of chronometrying the evolution of the Universe resembles those of chronometrying on Earth from the data of radioactive decay and in any case is independent of others.

Note that giant elliptical galaxies with high radio luminosity and with the old stellar population are the most suitable objects for estimating the age of stellar systems. The present-day models predict fast enough (during 1 billion years) formation of such systems at $z \sim 4$ (Pipino & Mantencci 2004), which enables application of photometric methods to their investigation. The efficiency of selecting such galaxies with the aid of radio astronomy methods, beginning from moderate redshifts ($z > 0.5$) is confirmed by several groups (Pedani 2003). A combined diagram of Hubble "K–z" for radio galaxies and field galaxies (Jarvis et al. 2001; De Breauk et al. 2002) show that radio galaxies have the highest luminosity at any redshift $0 < z < 5.2$ (Reuland et al., 2003). Besides, radio galaxies have supermassive black holes whose mass is generally proportional to a stellar bulge one ($M_{BH} \sim 0.006 M_{buldge}$, Maggorrian et al. 1998), and this fact is additional evidence of the presence of an already formed stellar population. Note that the estimate of the age of distant galaxies is also of interest in connection with searching for primeval black holes with masses $10^3 - 10^6 M_{\odot}$.

Formation of radio galaxies at redshifts $z \sim 3 - 5$ provide the already formed stellar populations at $z \sim 2 - 4$ in the ΛCDM models. Thus, when selecting distant radio galaxies, we isolate with sufficient efficiency giant elliptical galaxies which can be used to estimate the age of a stellar population and to investigate the ratio $t(z)$ (Parijskij 2001; Verkhodanov & Parijskij 2003, Starobinsky et al. 2004).

The present paper describes approaches, methods and results concerning cosmological parameters estimates using samples of elliptical galaxies. We will discuss, first, the problems connected with the use of evolutionary synthetic models of spectra of galaxies. Then, using the data on the "Big Trio" project (Parijskij et al. 1996, 2000a, 2000b; Parijskij 2001; Soboleva et al. 2000; Kopylov et al. 1995; Verkhodanov et al. 2002) and other authors (Verkhodanov et al. 1999) we will present results of the first attempts of correction of the standard cosmological model with cold dark matter (SCDM) by means of age estimates of parent galaxies responsible for the origin of powerful radio galaxies at large redshifts. Further we will give a summary of attempts to estimate the relationship between the age of galaxies and their redshifts from the current evolutionary models of the stellar population of elliptical galaxies for a wider interval of redshifts, including close, $z < 1$, objects.

2. Photometric dating

2.1. Evolutionary models of spectra

At the end of the 1980s and in the early 1990s attempts were made to employ color characteristics of radio galaxies to estimate redshifts and ages of stellar systems of parent galaxies. Numerous evolutionary models were proposed, which led to result strongly different from one another in comparing with observational data (Arimoto & Yoshii 1987; Chambers & Charlot 1990; Lilly 1987,1990; Parijskij et al. 1996). Over the past few years the models PEGASE: Project de'Etude des Galaxies par Synthese Evolutive (Fioc & Rocca-Volmerange, 1997) and GISSEL'98: Galaxy Isochrone Syntheses Spectral Evolution Library (Bruzual & Charlot 1993; Bolzonella et al., 2000), in which the defects of previous models were eliminated, have been widely used.

In the "Big Trio" experiment (Parijskij et al. 1996) we also attempted to apply these methods to distant objects of the RC catalog with steep spectra, for which we measured the values in the four filters (BVRI). The procedure of smoothing was used, which made it possible to simulate and predict the flux in the given filter with the given SED with allowance made for the filter response function of this band and also with the effects of the redshift allowed for. These changes in the procedure permitted the results to be more reliable in comparison with the previous paper work.

Preliminarily (Verkhodanov et al. 1999) we investigated applicability of new models to populations of distant ($z > 1$) radio galaxies with the known redshifts, for which we have managed to find in the literature more or less reliable data of multicolor photometry in the optical and near-infrared not less than in three filters. In particular, it is shown that redshifts can be estimated to an accuracy $25 - 30\%$ at $1 < z < 4$, given the measured stellar magnitudes in more than three filters. But if, at least, one brightness estimate in the infrared range is available, than it suffices to use measurements in the tree filters. Estimations were made for two evolutionary models PE-

GASE (Fioc & Rocca-Volmerange 1997), which was constructed for the galaxies of the Hubble sequence both with star formation and passively evolving. One of the advantages of this model consists in the extension to the near-IR (NIR) range of the atlas of the synthetic spectra of Rocca-Volmerange and Guiderdoni 1988). This model reconsiders a library of stellar spectra which is computed with allowance made for parameters of cold stars. The model covers a range from 220Å to 5 microns. According to the authors, the algorithm of the model traces rapid evolutionary phases, such as those of the red supergiant or AGB in the near-IR range. For the computation a wide set of SED curves was used for massive elliptical galaxies in a range of ages 7×10^6 years to 19×10^9 years. We have also used the computations for the elliptical galaxies of the library of synthetic spectra of the model GISSEL'98 (Bolzonella et al. 2000). The spectra are constructed with the aid of the evolutionary models of Bruzual and Charlot (1993,1996). For the calculation of the synthetic spectra of the elliptical galaxies of this library, the following parameters of star formation were assigned: simple star formation (SSP – simple stellar population), the duration of the process of star formation is 1 billion years, while decaying of the burst activity of star formation proceeds by an exponential law. The model used solar metallicity. The initial mass function (IMF) with an upper limit of 125 solar masses has been taken from the paper by Miller and Scalo (1979). As is shown in the paper by Bolzonella et al. (2000), the choice of the IMF does not effect the accuracy of determination of redshifts. The model tracks are calculated in a wavelength range from 200 to 95800Å. For our computations we have used the range assigned by a redshift limit from 0 to 6. The sets of evolutionary models are accessible at the server `http://sed.sao.ru` (Verkhodanov et al., 2000).

2.2. Procedure of estimating the age and redshift

Prior to the application of model curves we carried out their smoothing by the filters with the application of the following algorithm (Verkhodanov et al., 2002):

$$S_{ik} = \frac{\sum\limits_{j=1}^{n} s_{i-n/2+j} f_{jk}(z)}{\sum\limits_{j=1}^{n} f_{jk}(z)}, \qquad (3)$$

where S_i is the initial model SED curve, S_{ik} is the one smoothed by the k-th, f_k(z) is the curve of transmission of the k-th filter "compressed" $(1+z)$ times when moving along the axies of the point in the filter response function. From the k curves of SED thus formed, we have constructed a two-dimension array (λ–filter) of smoothed synthetic stellar spectra for further computations.

The estimation of ages and redshifts of radio galaxies was made by the method choosing on the smoothing curves of SED of optimum positions of photometric values obtained in different bands in the observations of galaxies. We have used SED curves already computed and stored in tables for different ages. The algorithm of the choice of optimum position of points on the curve consisted (Verkhodanov 1996) in shifting the observational points along the SED curves. In so doing, such a position was found at which the sum of the squares of the departures of the points from the corresponding smoothed curves is minimum, i.e. the minimum of χ^2 was actually computed

$$\chi^2 = \sum_{k=1}^{Nfilters} \left(\frac{F_{obs,k} - p \cdot \mathtt{SED}_k(z)}{\sigma_k} \right), \qquad (4)$$

where F_{obs}, k is the observed stellar magnitude in the k-th filter, $\mathtt{SED}_k(z)$ is the model stellar magnitude for the given spectral distribution in the k-th filter at the given z, p is the free coefficient, σ_k is the measurement error. The redshift was determined from the shift of the position of the observed magnitudes at their best position on the SED curves from the position "rest frame". From the general set of curves we chose such ones on which the sum of the squares of discrepancies for the given observations of radio galaxies prove to be minimum.

We checked the correctness of estimates of ages (and redshifts) by 2 methods. In the first one we took synthetic spectra obtained by means of smoothing by filters the SED curves for different age. This procedure made it possible to simulate CCD observations for 5 filters. Further the points were chosen corresponding to the filters VIJHR, for instance, at the redshift $z = 0.54$ and also the model GISSEL with SEDs for 1015.1 and 5000 Myr. Two tests were applied for each age to estimate the value: with fixed $z = 0.54$ and unfixed redshift. From the results of testing a conclusion can be drawn that the age and redshift are defined reliably, however, a falling on neighboring curve of ages is possible, which gives an error of 200 Myr, while at unfixed z the result is also affected the discretization in wavelength λ in the SED curves (the error in z is up to 60%).

In the second case capabilities were studied of the method of determination of the redshifts and ages of the stellar population of parent galaxies from the data of multicolor photometry. For this purpose, we have selected about 40 distant galaxies with known redshifts, for which stellar magnitudes in not fewer than four filters (Verkhodanov et al., 1998b, 1999) are presented in the literature. At first, using the selected photometric data with the use of the models PEGASE and GISSEL'98 only ages of the stellar population of parent galaxies at a fixed known redshift were determined. Then a search was made for an optimum model of the SED curve with a simultaneous determination of the redshift and age of the stellar population. After that a comparison of the obtained values was made. By this method we estimated both the age of the galaxy and the redshift within the framework of the given models (see also Verkhodanov et al. 1998a, 1999). It is clear from general considerations that the reliability of the result at large redshifts is strongly affected by the presence of infrared data (up to the K range) because when fitting we overlap the region of rapid jump of the spectrum before the region of SED, and thereby we can reliably, with a well defined maximum on the plausibility curve, determine the position of our data. Indeed, when checking the reliability of the procedure with the aid of the measurements available with keeping of only 3 points, one of which is in the K range, we obtain the same result on the plausibility function as from 4 or 5 points. If the infrared range is not used, then the result turns out to be more uncertain. However, as it is shown in the paper by Verkhodanov et al. (1999), the variant of 4 filters close disposition as in our case of BVRI photometry yielded a good result in the sample of 6 objects. This result coincides with the one obtained when all the filters were used, including the infrared range.

3. Sample of objects

It should be noted that the choice of elliptical galaxies as objects for our investigation is not accidental. They can be considered as the most optimum objects among stellar systems having a homogeneous enough stellar population. Although such objects have (moderate) metallicity gradients (Friaca & Terlevich 1998), the modeling showed (Jimenez, Loeb, 2002) that the variation of metallicity leads to an uncertainty of estimates of the age within 0.1 Gyr, which lies inside uncertainties of estimates.

In the given investigation we use radio galaxies which, as a rule, are identified with giant elliptical galaxies (gE) and are good "lanterns" and representatives of distant stellar systems. The standard point of view of the last decades has been that powerful radio galaxies are associated with old huge stellar system of the gE-type having the red color. The experience of using globular clusters in our Galaxy to estimate the age of the Universe shows that the search for the oldest stellar systems at large redshifts may be useful for chronometrying of the rates of expansion of the Universe at any distances at which powerful radio galaxies still existed. As many groups (Rawlings et al. 1996; van Beugel et al 1999), including the project "Big Trio" (Soboleva et al. 2000) have shown that powerful galaxies appeared at redshifts of about 5. The whole interval $0 < z < 5$ can be potentially investigated even today since the sensitivity of radio and optical telescopes is sufficient for investigation of such powerful radio and optical objects. In contrast to quasars, the radiation of the stellar population can be readily isolated from that of the gaseous component. Note, however, that in radio galaxies uncertainties arise in photometric determination of the age because of different factors (see, for example, Moy & Rocca-Volmerange, 2002), such as ionization and transillumination of the radiation from the nucleus, interaction of clouds and jets etc. Besides, the galaxies at early stages could be interacting, which changes the stellar population. Nevertheless, the radio galaxies remain so far the only simple means of studying elliptical galaxies at large redshifts.

3.1. Data on radio galaxies from the catalog "Cold"

The given sample is composed from FRII-type galaxies found in the RATAN-600 survey "Cold" (Parijskij et al., 1991, 1992) with involvement of data of multicolor photometry for estimating color redshifts and ages of stellar systems of parent galaxies (Parijskij et al. 1996; Verkhodanov et al. 2002). Later, spectral observations at BTA with the device SCORPIO (Afanasiev et al. 2002) were carried out, which confirmed with high accuracy (correlation coefficient 0.92) the photometric estimates.

In the program "Big Trio" BVRI values of about 60 radio galaxies were estimated, and it was discovered that although the color age does not have a large dispersion, the upper limit of the age is a sufficiently reliable function of redshift (the larger z, the less the maximum age). A comparison of this upper limit with the SCDM model showed that age is not at variance with the SCDM model without the cosmological constant Λ, but in the interval $0.7 < z < 2$ there are objects with the color age greater than the age of the Universe at the corresponding redshift. Such a situation, as it is known (see, for instance, Sahni and Starobinsky 2000) is eliminated in the ΛCDM models. Indeed, the age of such a Universe does not differ from the SCDM model either at very small or at very large redshifts, which is seen from the formulae presented in the paper mentioned.

However, in the interval of redshifts $z = 1 - 2$ the difference may reach 1–2 billion years, which is

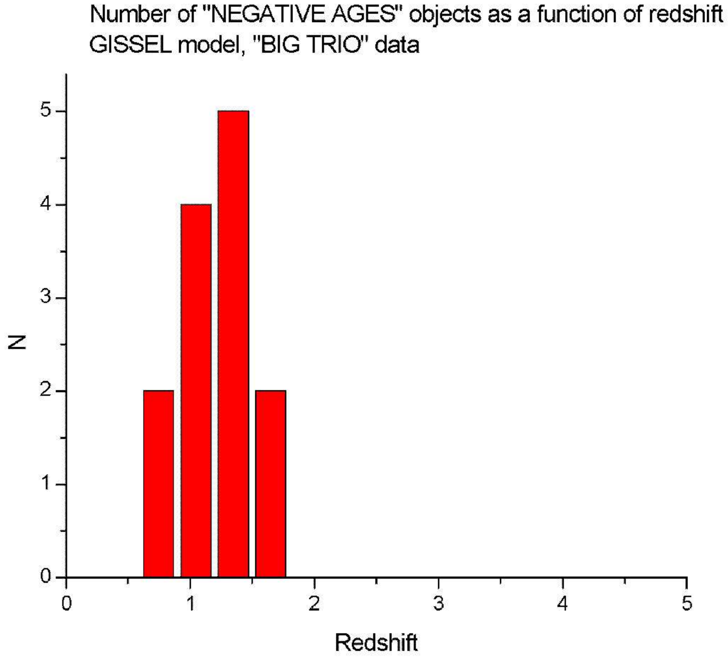

Figure 1: *Histogram of the distribution of galaxies in z with a formal age above that of the Universe.*

close to the possibilities of the experiment. The simple theory $\Lambda \neq 0$ for a spatially flat isotopic cosmological model yields a relationship between the position of a maximum of departures from the SCDM model on the axis of redshifts and the value of cosmological constant. The first attempts to estimate the value of the cosmological constant from the "Big Trio" data were made in 1999 (Parijskij 2001). In connection with the uncertainty in quantitative estimates of the age of galaxies from the measured redshifts, percentage of galaxies whose age formally exceeds that of the Universe in the SCDM model with $\Lambda = 0$ was estimated. Then a histogram of distribution of number of these galaxies as a function of z was constructed (Fig. 1).

From the position of the maximum the proportion of "dark matter" (Ω_Λ) which turned out to be close to the value derived from 1a–type supenovae was estimated: $\Omega_\Lambda = 0.8 - 0.6$ (Fig. 2). This result stimulated our further steps in the usage of age characteristics of the stellar population. Fig. 3 shows all the data collected by the group "Big Trio" in 2001 from steep spectrum radio galaxies. It is seen that there present objects with large z, but at $z < 2$ dispersion of ages is great. But the larger the redshift, the less the age of the oldest object, as it was to be expected in all evolutionary models of the Universe. Having chosen a population of objects the age of which is younger than that of the Universe in the ΛCDM model by more than 2 billion years, obtain a relationship $z(t)$ similar to the one displayed in Fig. 4 The relationship of such a type can already serve as a basis for estimating $R(t)$.

3.2. Data on investigated radio galaxies with $z > 1$

As it was stated above, to check the procedure and estimate redshifts and age of stellar systems, we made a sample of radio galaxies FRII with redshifts up to $z = 3.80$ (Verkhodanov et al. 1998b, 1999) using data obtained by other authors.

It should be noted that literature photometric data are very inhomogeneous. They were obtained not only by different authors but also with the help of different instruments with different filters. It was not always that measurements for one and the same object were made with equal apertures etc. For this reason, after the final selection from 300 radio galaxies of the initial sample only 42 remained. The greater part of the sample turned out to be beyond the limits of the sample because they have the properties of quasars, which impedes strongly the use of the procedure SED for standard elliptical galaxies The derived median value of the age for the given sample is 5 Gyr for the model GISSEL and 9 Gyr for the model PEGASE.

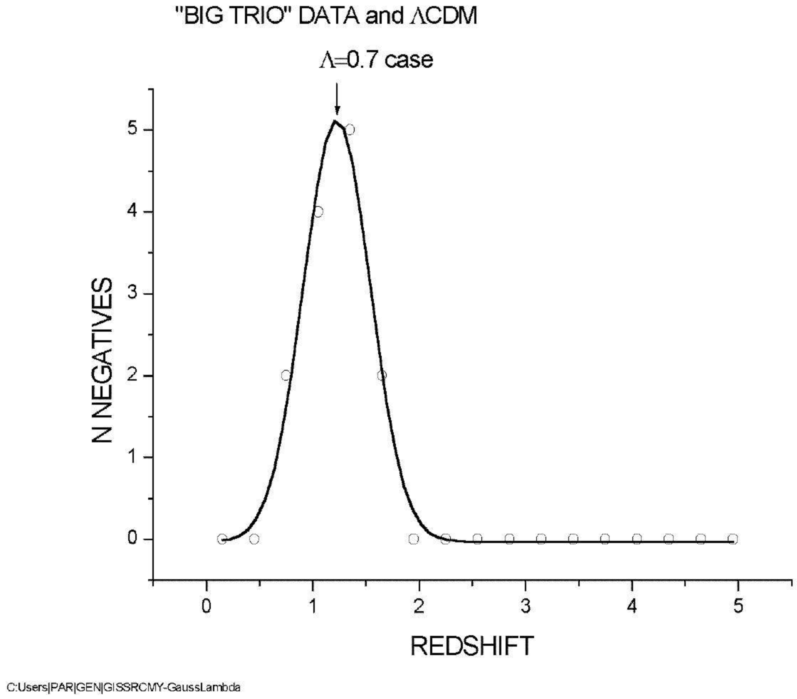

Figure 2: *Estimates of* Ω_Λ *from the objects of the project "Big Trio".*

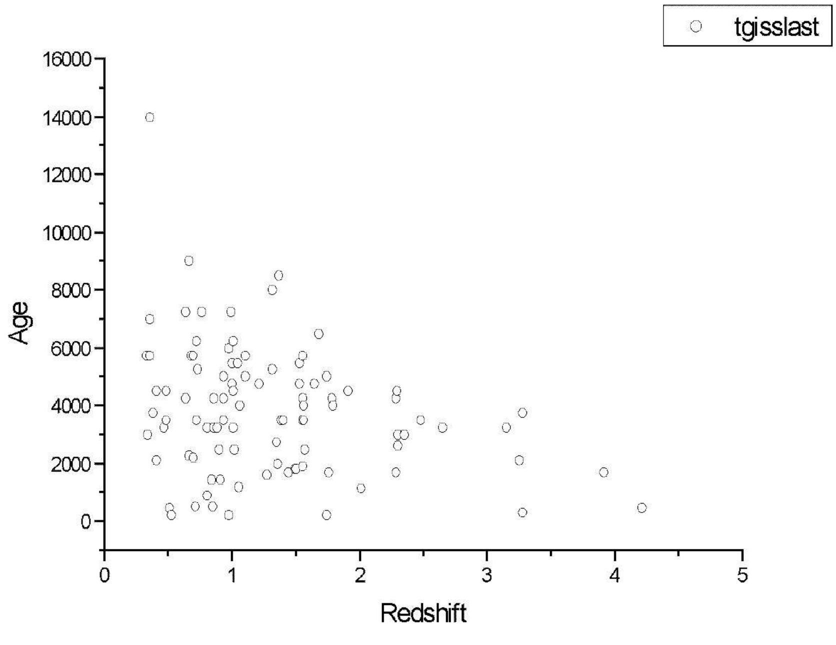

Figure 3: *Relationship* $t(z)$ *for radio galaxies having steep radio spectra with large* z *taken from different published papers. It is seen that at* $z < 2$ *the dispersion of ages is large.*

3.3. Clusters of galaxies

The subsample of elliptical galaxies from clusters, which was proposed by A. Kopylov (2001) is the most representative from the investigated group of objects (Table 1). We have used for its compilation the data from the paper by Stanford et al. (2002) contain-

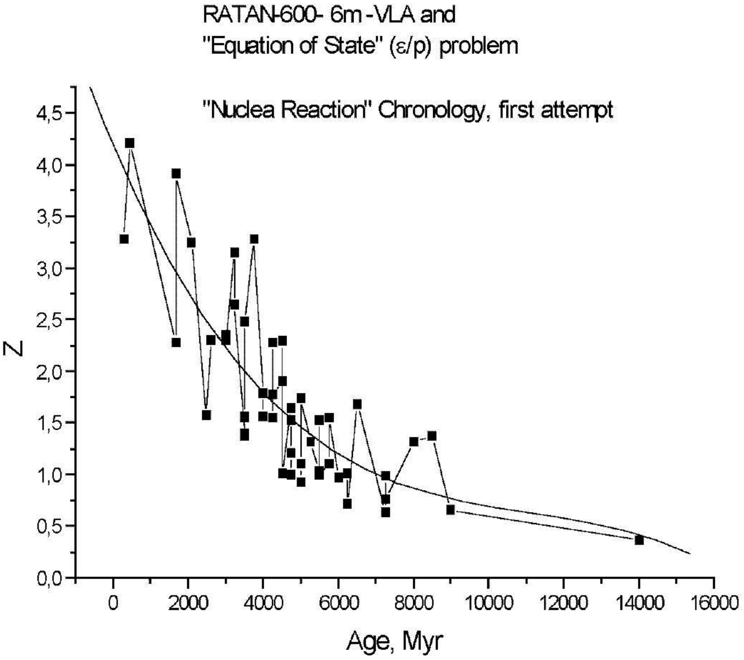

Figure 4: *Relationship* $z(t)$ *of objects with* $t_{star\,form} - t_{Univer} \leq 2$ *billion years*

ing a sample of 45 clusters of galaxies at redshifts $0.1 < z < 1.3$. For all the objects photometric data from the optical and near-infrared region are available. On the average, stellar magnitudes in the bands BIJHK are presented for each galaxy. For our sample we have selected by the color index 5–9 objects, typical elliptical galaxies, from 25 clusters, a total of 175 elliptical galaxies. Table 1 presents the selected clusters with the numbers of galaxies which photometric data are used to estimate the age of stellar systems. The bands in which observations of clusters were carried out, their redshifts and K-values are also presented.

4. Procedure of estimating parameters

Our approach is based on the analysis of the function $t(z)$:

$$t(z) = \int_z^\infty \frac{d\tilde{z}}{(1+\tilde{z})H(\tilde{z})}, \tag{5}$$

constructed from ages of radio galaxies depending on the redshift. As the function $H(z)$ we used the expression

$$H^2 = H_0^2[\Omega_m(1+z)^3 + A + B(1+z) + C(1+z)^2], \tag{6}$$

where $A + B + C = 1 - \Omega_m$.

The fitting of function $t(z)$ to the data analyzed was performed with the aid of variation of four parameters (H_0, Ω_m, A, B). We divided the whole set of redshifts into equal intervals Δz and used the maximum age value in each of the intervals. From the sum of the squares of discrepancies a four-parameter plausibility was constructed. With the values of the parameters $B = C = 0$, i.e. when the simplified model of the function $H(z)$ defined only by two parameters (H_0, Ω_m) and $A = 1 - \Omega_m = \Omega_\Lambda$ was used, there are stable solution of both models of evolution of the stellar population. The results of determination of the parameters are listed in Table 2, in which the parameters of approximation of the curve for the intervals $\Delta z = 0.2$ and 0.3 are given for also in Fig. 5.

4.1. Effects the errors have on the estimates of parameters

This method of determination of H_0 and Ω_Λ is stable enough concerning the input parameters and systematic effect. As the modeling has shown the variation of the initial metallicity caused a change in the age by 0.1 Gyr (Jimenez & Loeb 2002). The change in the initial mass function does not affect the model SED either (Bolzonella et al. 2000).

The error in the determination of the age, which may be connected with wrong classification of the galaxy type and, therefore, with the choice of SED,

Table 1: *Selected elliptical galaxies — members of clusters. The table contains the following fields: equatorial coordinates and name of the cluster, numbers of selected galaxies from the cluster according to the published order (Stanford et al. 2002), redshift, used filters, K–limit*

RA+Dec(2000)	Name	ID numbers of galaxies	z	filters	K_{lim}
001631.2+791649	3C 6.1	14,18,33,34,43	0.840	KJIR	19.8
001833.5+162515	Cl 0016+16	8,9,15,17,22,27,35,40,42	0.545	KHJIV	19.1
002354.5+042313	GHO 0021+0406	9,12,15,24,29	0.832	HJIR	20.0
002635.7+170945	Cl 0024+16	3,4,5,8,9,10,16,26,33	0.391	KHJRg	18.8
004910.9−244043	Vidal 14	6,11,14,17,23,31,40,43	0.520	KJIV	18.0
005657.1−274030	J1888.16CL	7,17,23,45	0.560	KHJIV	19.2
011018.5+314719	3C 34	7,8,13,21,23,34,40	0.689	KHJiV	19.1
030619.1+171849	GHO 0303+1706	6,7,13,18,22,24,34,40	0.418	KHJRg	18.8
032001.4+153200	GHO 0317+1521	3,8,9,13,14,23,24	0.583	KJIV	19.2
041246.6−655055	F1557.19TC	20,25,30,37,39	0.510	KHJIV	19.1
045410.9−030057	MS 0451.6-0306	3,11,12,19,25,31,33,40	0.539	KHJiV	19.2
073924.3+702315	3C 184	3,4,8,12,15	0.996	KJI	20.3
084835.9+445337	RDCS 0848+4453	4,6,9,11,13,15	1.273	KHJIR	20.5
085809.9+275052	3C 210	3,6,13,15,16,17	1.169	KJI	20.5
093239.6+790632	3C 220.1	5,8,12,16,17,19,24,25	0.620	KHJIV	19.5
105659.5−033736	MS 1054.5-032	4,7,9,13,14,22,23,25,26,30	0.828	KHJiR	20.3
114022.2+660813	MS 1137.5+6625	3,8,10,11,12,15,16,17,20,21,24	0.782	KHJiR	20.0
132448.9+301138	GHO 1322+3027	2,5,8,10,17,18,20	0.751	KHJiR	20.3
141120.5+521210	3C 295	9,18,24,27,28,31,32,34,35,37	0.461	KHJiV	18.8
151100.0+075150	3C 313	6,12,13,21,33	0.461	KJiV	18.5
160312.2+424525	GHO 1601+4253	4,6,17,18,19,22,43	0.539	KHJiV	19.2
160424.5+430440	GHO 1603+4313	5,15,17,36,40	0.895	KHJiR	20.3
160436.0+432106	GHO 1604+4329	7,10,20,21,28,30,32	0.920	KHJiR	20.1
205621.2−043753	MS 2053.7-0449	35,39,51,89	0.582	KJIV	19.2
220403.9+031248	GHO 2201+0258	10,11,13,14,17,25,29,35,38	0.640	KJIV	19.3

Table 2: *A two-parameter fitting of cosmological parameters by formulae (5) and (6) (at $B = C = 0.0$) for the approximation curves in the interval $\Delta z = 0.2$ and 0.3 for both models of stellar population. In the columns are presented: the used model of the stellar population, the interval Ω_m, Ω_Λ, H_0, the discrepancy ϵ of the relationship $t(z)$, the relative discrepancy ϵ/T_0, where T_0=13.7 Gyr is the age of the Universe.*

model SED	Δz	Ω_m	Ω_Λ	H_0	ϵ [Myr]	ϵ/T_0
GISSEL	0.2	0.2	0.8	77.7	1695	0.12
GISSEL	0.3	0.2	0.8	71.5	1367	0.10
PEGASE	0.2	0.2	0.8	65.4	4101	0.30
PEGASE	0.3	0.2	0.8	53.0	2748	0.20

plays in this case in favor of the approach being described. The models SED corresponding to elliptical galaxies give the oldest stellar population among all the spectra. Thus, if in the galaxy are found star formation regions giving a contribution to photometric data, then the choice of the optimum model is displaced toward a younger stellar population, and the galaxy falls out from our sample.

To check the influence of the sample completeness on the result, we used the bootstrop method consisting in multiplying of the initial sample and in constructing a new one by means of accidental choice of objects. The coefficient of multiplying the sample was taken to be equal to 100, and for each interval Δz the number of objects equal to the initial number was chosen in an accidental manner. 50 tests were thus applied, and in each case the values of the parameters were estimated. As a result, dispersion of

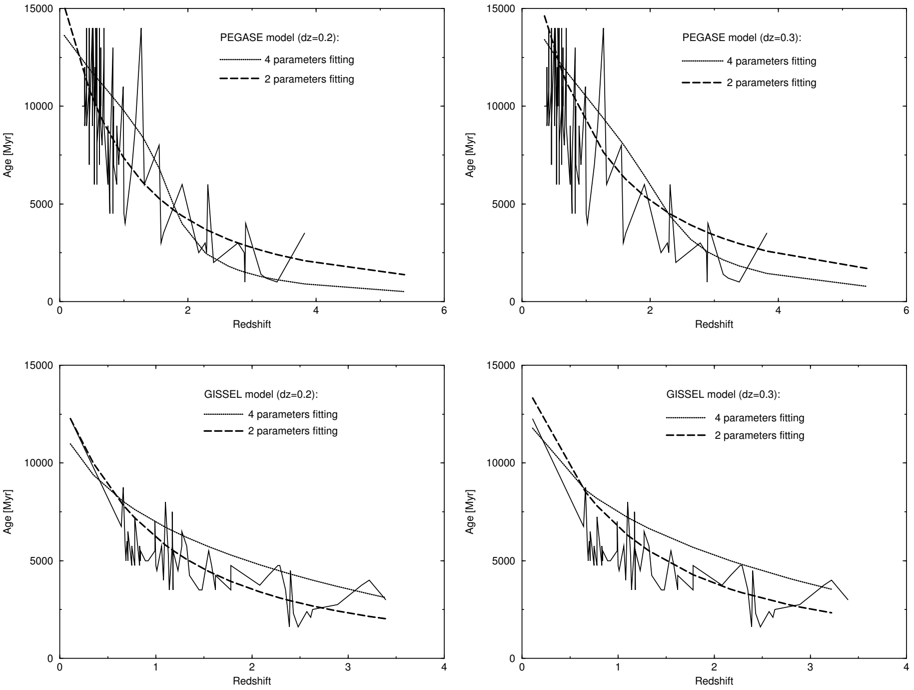

Figure 5: *The relationship* $t(z)$ *for models given in Table 2. Upper figures — estimation for the model PEGASE, low figures — the models GISSEL. Left figures — discretization of* Δz*=0.2, right ones — discretization of* Δz*=0.3. The curves are calculated for parameterization (5,6) using maxima of galaxy ages in the given redshift intervals.*

the estimates $H_0 = 72 \pm 7$ for the model GISSEL and $H_0 = 53 \pm 6$ for the model PEGASE for the interval $\Delta z = 0.5$ were obtained. The values of Ω_Λ remained unchanged, which is explained by the influence of objects at moderate redshifts $z = 0.3 - 1.0$ having a relatively small dispersion of ages. We disregarded the effect of the interval selfabsorption in the galaxy (Sokolov et al. 2001) because of the ambiguity of solutions for a small number of the used input parameters (number of filters) in our case and the necessity for the determination of a large number of unknown parameters.

The possible great contribution to the discrepancy in the approximation of the relationships, which produces the effect of accidental errors, can be considerably reduced by further statistical accumulation of data since the number of known galaxies of type FRII will amount by different estimates to a few thousand in the near future.

5. Discussion of results

The results of our paper confirm, firstly, that we live in an evolving Universe. Secondly, that in contrast to the standard relativistic flat model ΛCDM is situated within the errors of the method. To estimate the quintessence $\omega_Q(z)$, the accuracy is not sufficient yet. For the united data of different populations of elliptical galaxies, for radio galaxies too, an analysis was made of the upper limit of the age of formation of stellar systems. From these data boundaries of determination of the cosmological parameters H_0 and Λ–term were estimated: $H_0 = 53 \pm 10$, and $\Omega_\Lambda = 0.6 \pm 0.1$ in the model PEGASE. Note that the models GISSEL have lower dispersion of ages for each interval, i.e. they give a more stable result and, possibly, as a consequence, more reliable cosmological parameters. The discrepancies of the relationship $t(z)$ decrease and, therefore, the accuracy of estimates of parameters, when changing from the interval $\Delta z = 0.2$ to the interval $\Delta z = 0.3$, improves, which is explained by more reliable determination of the maximum age at a larger interval.

As far as the procedure applied is concerned, it should be noted that one of the main problems is the use of investigations of radio galaxies in which, apart from standard evolution of stars, the photometric measurements may be affected by other factors as well. Nevertheless, new models (for instance, PEGASE2: Le Borgue & Rocca-Volmerange 2002) which allow these factors to be taken into account, are already beginning to appear.

Note also that in principle

1) use of age characteristics of galaxies for independent estimates of cosmological parameters is prospective; example — the estimate of the Λ–term, which can be improved by extending the sample and employing more refined models;

2) the first examinations of the test "Age of radio galaxies — redshift" yielded estimates close to the most accurate measurements of parameters from the WMAP satellite data (Spergel et al., 2003).

3) preliminary selection of candidates must be performed by different ways since none of the known ones is ideal. The relatively powerful radiation (the ratio of radio luminosity to optical) points to the fact that we deal with a giant galaxy with a supermassive black hole in the center, which requires time to be formed. Unfortunately, there is no generally accepted theory of their formation. The proposal to use objects in well understood clusters also seems to be attractive (Kopylov 2001). Because it is exactly from clusters that data for $R(t)$ at small redshifts were obtained. The use of the upper values of the age in the samples at different redshifts seems to be justified. Even one the oldest object in the sample is decisive in the determination of the lower limit of the Universe age at the given redshift, similar to that as the only old star in the Galaxy (or the oldest globular cluster) defines the minimum age of the Universe today. In our opinion the most involved problem is the problem of the theory of evolution of the distribution of energy in the spectrum of galaxies, and here we have considerably various readings.

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