VARIATIONS OF THE QUASAR RADIO SPECTRA WITH PERIOD $130\,h^{-1}$ Mpc

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It is known that the spatial distribution of galaxies and quasars is structured at a scale $L_S = 130\,h^{-1}$ Mpc. The same scale can be present at a spatial distribution of the physical characteristics of quasars. The search of period $\simeq L_S$ was conducted in the radiospectral indices of quasars in a centimetre range. The Veron-Cetti & Veron catalogue [10] was used as source. In the power spectra of series of spectral indices and proper distances of quasars the peak corresponding to the expected period confidently emerges. 0.23 ± 0.03 estimation of the parameter of density was obtained by the method of smoothing the period in different ranges of z at the varying parameter of density in the flat model of Universe. Interpretation of argument of periodicity, as proper distance, results in a geocentrism. The conformable time is proportional to proper distance and is also a good approximation of the argument of periodicity when the parameter of density equals to 0.23. At the temporal character of the exposed periodicity the centred position of the observer is not required. In such interpretation the exact expression for the argument of periodicity is unknown. The proper distance or the conformable time is introduced by its true values with an accuracy not worse than 1%.

INTRODUCTION

In the sharply-directed deep surveys of the sky Broadhurst *et al.* [1] have found out large-scale coherent periodic distribution of galaxies with an extension $1800\,h^{-1}$ Mpc in a direction of galactic poles. In power spectra of different sets of the galaxies clusters and superclusters the peak corresponding to a characteristic length of large-scale structure by the Universe L_S ([2]; the survey [4]) emerged repeatedly. The usually used value $L_S \simeq 130\,h^{-1}$ Mpc corresponds to its estimation based on the data [1] with $z < 0.3$ at density parameter $\Omega_m \simeq 0.2$ ($\Omega_\Lambda = 0$). At large redshifts the similar scale was detected in the spacing of quasars in the field of $1.8 < z < 2.4$ [8]. Einaste *et al.* [3] have revealed three-dimensional moderately regular net structure with a step of $\simeq 120\,h^{-1}$ Mpc consist of rich clusters and voids. They consider that there should be a process obscure till now producing regular spatial net on big scales. Suppose, that this hypothetical process results in the change of quasars luminosities. Then at a spacing of luminosities of quasars there should also be a periodic structure. Thus, the energy distribution in their spectra, that is spectral indexes should also change. Owing to the large dispersion of luminosities of quasars, the detection of their variations is inconvenient. That is why the analysis of spectral indexes of quasars was carried out. If our suppositions really take place, it is necessary to expect the appearance of a peak in a power spectrum of the relation of spectral indexes on proper distance at the frequency corresponding to L_S.

METHOD

Normalized on a single dispersion the sample power spectra (SPS) of the centered series y_k, x_k we shall designate $S(\omega)$, where $\omega = 2\pi P^{-1}$ is an angular frequency corresponding to the period P. For the decrease of a minor-lobe level SPS were calculated with a window application. The weighing was performed with Hann function $w(x_k)$. The length of implementation is $L = X^2 - X^1$, where X^1 and X^2 are boundary values of a x_k series. While SPS estimating, the sample was divided into s segments with equal number of objects. SPS were calculated for each segment. At the frequencies of interest an averaged periodogram P_ω and its error σ_P were calculated. As the criterion of signal presence at ω frequency the value $p_\omega = (P_\omega - 1)/\sigma_P$ was used. Since SPS are normalized on a single dispersion, mathematical expectation $(P_\omega - 1)$ is equal to zero.

As radial coordinate was derived the proper distance $d(\Omega_m, \Omega_\Lambda, z)$, where Ω_m and Ω_Λ are the parameter of density and dimensionless cosmological constant. Usually, at the analysis of cosmological periodicities the SPS for the distribution of quasars on argument $\ln(1+z)$ or $\lg(1+z)$ are calculated. Working with arbitrary

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argument $f(\Omega_m, \Omega_\Lambda, z)$ it is necessary to account for the change of peak frequencies with the change of a view and parameters of a function $f(\Omega_m, \Omega_\Lambda, z)$. Let us introduce the scaled argument

$$d(\Omega_m, \Omega_\Lambda, z) = f(\Omega_m, \Omega_\Lambda, z) D(\Omega_m, \Omega_\Lambda, z_1), \tag{1}$$

where

$$D(\Omega_m, \Omega_\Lambda, z_1) = \ln(1 + z_1)/f(\Omega_m, \Omega_\Lambda, z_1). \tag{2}$$

With such argument peak frequency in SPS changes unsignificantly at variation parameters. The calculations were performed at $\ln(1 + z_1) = 1.5$ ($z_1 = 3.482$).

SPS AND AVERAGED PERIODOGRAMS

The sample was built under the data of the Veron-Cetty & Veron catalogue [10], in which the radioflows s_ν at wavelengths of 6 and 11 cm and their spectral indexes $\alpha (s_\nu \propto \nu^{-\alpha})$ for 1246 quasars are adduced. The relation between mean α and $\ln(1 + z)$ was determined by a least-squares method:

$$\bar{\alpha} = (0.45 \pm 0.09) - (0.18 \pm 0.05) \ln(1 + z). \tag{3}$$

The z_i, α_i values will derive from an initial series. They can be converted to the series $x_i = r_i(\Omega_m, \Omega_\Lambda, z_i)$, $y_i = \alpha_i - \bar{\alpha}$ at given parameters Ω_m, Ω_Λ. Spectral analysis of this series is carried out below.

We suppose that there is a period $P = L_S$ at spectral indexes of quasars. Let us estimate the frequency of a corresponding peak in SPS. The local value L_S is determined by observations of galaxies distribution within the interval $0 < z < z_p$ at definite parameters Ω_m, Ω_Λ. Following [1] at $z_p \simeq 0.3$ and $\Omega_m = 0.2$ ($\Omega_\Lambda = 0$), the value $L_S = 130\, h^{-1}$ Mpc [2]. When parameters Ω_m and Ω_Λ are changed the value L_S will change proportionally to the proper distance $d(\Omega_m, \Omega_\Lambda, z_p)$. When $\Omega_\Lambda = 0$ and $\Omega_m = 0, 0.4$ the values $L_S = 131.9$ and $128.3\, h^{-1}$ Mpc, respectively. Let us consider only flat model $\Omega_\Lambda = 1 - \Omega_m$ when the values $\Omega_m = 0.30$ and 0.23, approximately corresponding to limiting estimates of density parameter [9] at a level 1σ. In a flat model when $\Omega_m = 0.3$ the lengths are notably more: $L_S = 140.2\, h^{-1}$ Mpc. The frequency of an anticipated peak in SPS equals to $\omega = 140$ when $P = L_S$. Having put value $\Omega_m = 0.23$, we shall find $\omega = 151$. The boundary values of the series $X_k = \ln(1 + z_k)$ are equal to $X^1 = 0$ and $X^2 = 1.7$.

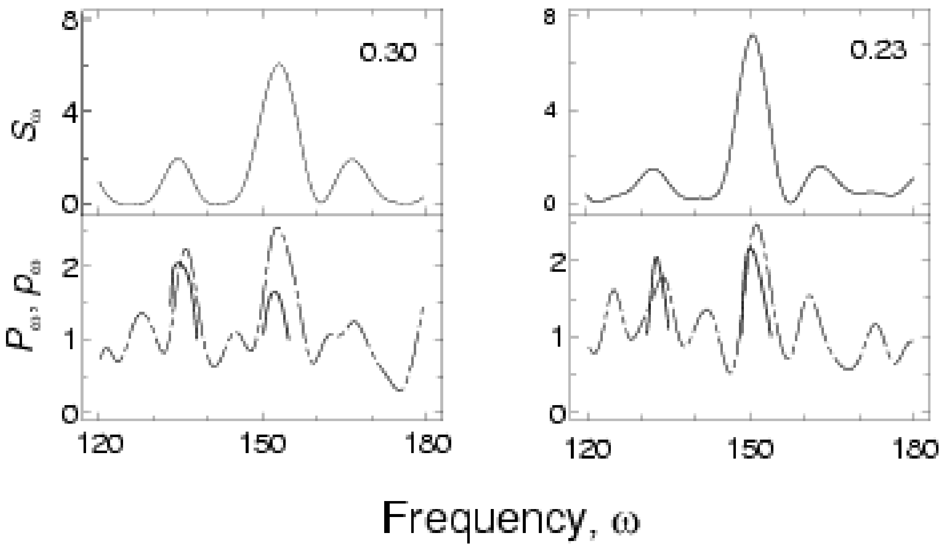

Figure 1. The SPS S_ω of relation spectral indices and scaled distance when the parameter of density $\Omega_m = 0.30$ and $\Omega_m = 0.23$. Averaged SPS on five segments of P_ω periodogram (dot-dashed line), $p_\omega = (P_\omega\text{-}1)/\sigma_P$ for frequencies, where $p_\omega > 1$ (solid line)

In Fig. 1 the part of interest of the SPS of x_i, y_i series is routined when $\Omega_m = 0.30$ and 0.23. There is an expected peak within the range of the anticipated frequencies.

The sample of radioloud quasars is not full. A non-uniformity in distribution of quasars can result in the appearance of false peaks. The spectral window $W(\omega)$ was calculated. As $W(\omega) < 0.01$ at $\omega < 10$, it is impossible to explain the appearance of a peak in SPS by any heterogeneities in the distribution of quasars, in particular by the effects of selection.

While spectral estimation the sample of quasars was divided into s segments with identical quantity of objects $n_s = N/s$. In the sample the quasars are arranged as of right ascension increases. In k-th segment the quasars with numbers $i = k + s(j-1)$ in the basic sample were taken, where j takes the values in the ranges from 1 up to n_s. While such division of the sample the distribution of quasars in each segment on redshifts and on the sky was obtained close to that of in the basic sample. The spectral resolution of the P_ω periodogram is not worse than in the SPS. In Fig. 1 the results of estimation are shown when the sample divided into five segments. Maximum P_ω is seen near the frequencies of SPS peaks. The P_ω value exceeds the background by $2.2\sigma_p$ ($\Omega_m = 0.23$). The estimation performed confirms the presence of periodicity at spectral indices of quasars.

ESTIMATE OF PARAMETER OF DENSITY

Let arbitrary option value Ω_m be equal to Ω^m. At the change of parameter Ω^m the ratio of scales (frequencies of peaks and periods, corresponding to them) at different intervals z and the peak height S_ω will vary. The frequencies of a peak ω in various intervals z at arbitrary value Ω^m will differ. Their dispersion change is depending on Ω^m. When $\Omega^m = \Omega_m$ the value σ_ω should be minimized. The SPS in the range of small z ($X < 0.85$) and large z ($X > 0.85$) are routined. The SPS were calculated with application of Hann weighing function. The frequencies of peaks in two intervals z are close on value when $\Omega_m = 0.21$ and considerably differ at other Ω_m. As follows from this preliminary analysis, the relation of a peak characteristics to parameter of density confidently emerges. It is possible to be use for Ω_m estimates.

Increasing quantity of intervals more reliable estimates can obtain. In area X from 0 up to 1.7 the ΔX intervals were calculated with the shift in 0.2 both as four intervals with $\Delta X = 1.1$ and as five intervals with $\Delta X = 0.9$. For a set of values Ω_m in each interval the SPS were calculated with weighting function and the frequencies of peak ω_i maximum and their dispersion were determined. Minimum value of σ_ω equals to $\sigma_m = 0.58$ when $\Delta X = 0.9$ and $\sigma_\omega = 0.30$ when $\Delta X = 1.1$. In Fig. 2 the relation of value σ_ω to parameter Ω_m by normalized on these value σ_ω is routined on parameter Ω_m. A parameter estimate equals to $\Omega_m = 0.23 \pm 0.03$ at $\Delta X = 1.1$ and $\Omega_m = 0.22 \pm 0.04$ at $\Delta X = 0.9$ when a level is 2σ. The value σ_m is increased rapidly with decreasing width of the ΔX interval, therefore, the estimate is more reliable when the $\Delta X = 1.1$.

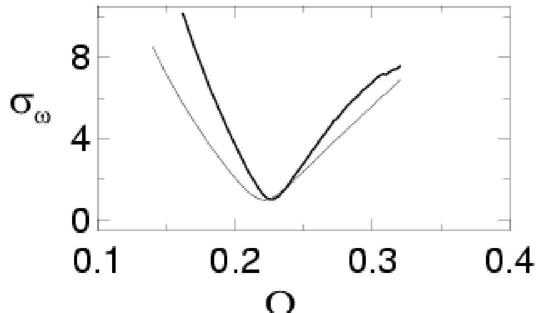

Figure 2. σ_ω peak frequencies in different intervals $\ln(1+z)$ versus parameter Ω_m when the width of interval is 1.1 (*upper curve*) and 0.9. The values σ_ω are normalized by minimum value and are routined on parameter Ω_m

An estimation of density parameter was carried out without using the values L_S and P. The equality of these values is obtained when $\Omega_m = 0.23$.

DISCUSSION OF RESULTS

The exact expression for argument of periodicity is not known. The proper distance $d(\Omega_m, z)$ or scaled distance $r(\Omega_m, z)$ was used as the first approaching of the periodicity argument $r^0(\Omega_m, z)$. Suppose it has the form $r^0(\Omega_m, z) = r(\Omega_m, z)[1 + e(t)]$. For variable t we shall choose the simplest combination $t = r(1.5 - r)$, providing $e = 0$ at $r = 0$ and $r = 1.5$ in decomposing $e = a_1 t + a_2 t^2$. Maximum values S_ω in SPS are achieved at $\Omega_m = 0.21$. With updated argument $r^0(\Omega_m, z)$ should receive the large S_ω. Maximizing a peak $S_\omega(a1, a2)$

the estimates were made: $a1 = 0.001 \pm 0.006$ and $a2 = 0.001 \pm 0.014$. A variable $t < 0.57$ in the whole range r. At a level 1σ the value $|e| < 0.01$, *i.e.*, the scaled distance $r(\Omega_m, z)$ is introduced by its true values $r^0(\Omega_m, z)$ with an accuracy not worse than 1%. The proper distance d and conformal time η are linearly dependent. Therefore, the argument of periodicity is interpreted ambiguously. Our estimate of density parameter is made if we suppose, that periodicity argument is proper distance. The interpretation of the argument, as proper distance, results in geocentrism. The conformal time η is also the argument of periodicity. At temporary nature of the detected periodicity centered position of the observer is not required. Periodic variations in spectral indexes of quasars are probably due to temporary changes of quasars activity. Then, the similar variations should appear both in luminosities of quasars and in their visible spatial density. The periodicities in radioluminosities of quasars were found in works [5, 6]. The periodicities in distribution of quasars depending on proper distances were investigated in work [7]. Thus, the estimate of density parameter $\Omega_m = 0.22 \pm 0.02$ was obtained that is the relation between the argument of periodicity and z was approximately the same, as well as in spectral indexes. Our estimation of density parameter will agree with the value $\Omega_m = 0.27 \pm 0.04$ [9] obtained in the analysis of the WMAP whole results and other astronomical data.

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