Peebles: That is just the point I was trying to make: one can argue that the apparent clustering in the 4C sources is due to the relatively small fraction of relatively close radio galaxies. We find the effect you mentioned in the 3C catalogue. There does not seem to be enough data to repeat this test in the 4C catalogue.

THE ISOTROPY OF THE UNIVERSE ON SCALES EXCEEDING THE HORIZON

L. Grishchuk

I would like to describe in a few words work which was done by Zeldovich and myself. It gives some restrictions on the amplitude of possible very large-scale density fluctuations mentioned by Peebles. The main question investigated in this work is the following. What can be said, using known observational data and some general hypotheses, about structure of the Universe beyond the region accessible for observation at the present epoch? In fact we consider density fluctuations (as well as rotational perturbations and gravitational waves) with wavelengths larger than the horizon. We use the observational fact that the quadrupole-type anisotropy of the microwave background radiation is absent at the level of $\delta T/T < 10^{-4}$. It is interesting to know if it may happen that, at the present epoch, there exists a significant density of perturbations (say, with the dimensionless amplitude of the order of 10^{-1}) which we do not even suspect because the corresponding wavelength is very long and therefore direct observation of the entire perturbation is not possible. Such a direct observation will be possible only in the remote future when the horizon becomes equal to the corresponding wavelength. To answer the question we make a natural but very important assumption. Namely, we assume that the harmonic perturbations of different wavelengths are not correlated in any particular way. Otherwise, they might fit together in such a way that all perturbations (and, therefore, $\delta T/T$) would be especially small within the horizon while significant perturbations could take place just beyond the horizon. A situation of this kind would imply that an observer at the Earth occupies a unique position in the Universe. We assume, on the contrary, that all observers are equivalent. All of them, even causally unconnected observers, could detect similar restrictions on the anisotropy of the microwave background, $\delta T/T < 10^{-4}$. Nevertheless, the question still exists whether small perturbations unnoticeable by every observer within his horizon can represent different parts of a significant long wavelength limit. The main result of this investigation can be formulated in the following way. The observational data on $\delta T/T$ in combination with the natural hypothesis on the statistical independence of different harmonics leads to the conclusion that in the Universe there are no significant (i.e. with the amplitude exceeding $\delta T/T$) density fluctuations on any spatial scale larger than the horizon. (The paper will be published in *Astr. Zh. U.S.S.R.*, November-December, 1977.)

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DISCUSSION

Zeldovich: First, a historical point: Einstein assumed the Universe was uniform but it was Friedman who proved that uniformity is incompatible with a static model of the Universe. Second, Peebles used $\Delta T/T$ to exclude the very crude, very inhomogeneous island model of the Universe. But Sachs and Wolfe have shown that since $\Delta T/T$ of relic radiation is less than 10^{-3}, this proves that perturbations of density of amplitude 1% on scales, say, 500 Mpc are absent. Using rather natural statistical assumptions, Grishchuk and myself have shown that one can extrapolate this result - density perturbations are small even on scales greater than the horizon. This is curious because we are dealing with regions which in principle cannot be observed!