1995MNRAS.277L...1H

Mon. Not. R. Astron. Soc. **277,** L1–L3 (1995)

The quasi-steady-state cosmology: a note on criticisms by E. L. Wright

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Accepted 1995 August 11. Received 1995 August 2

ABSTRACT

We answer criticisms made by Wright of the quasi-steady-state cosmology (QSSC). It is shown that none of his criticisms is valid, and the QSSC remains a viable cosmological theory.

Key words: cosmic microwave background – cosmology: theory – radio continuum: galaxies.

1 INTRODUCTION

Wright (1995) has criticized a recent paper, in which we have discussed the quasi-steady-state model (Hoyle, Burbidge & Narlikar 1994), on several grounds to which we reply here, taking the relevant sections of Wright's paper in turn.

2 THE CMB POWER PROBLEM

The contents of section 2 of Wright's paper entitled 'The CMB power problem' are not in dispute. This section is concerned with calculating the maximum microwave opacity required in our explanation of the uniformity and origin of the cosmic microwave background (CMB). Wright finds an optical depth per cosmological oscillation of 8. We found 10, so that there is no significant difference. The opacity comes from iron whiskers, and is very largely concentrated near the minima of our cosmological model (QSSC). There is no CMB power problem.

3 MILLIMETRE POINT SOURCES AT HIGH REDSHIFT

In Wright's section 3 entitled 'Millimetre point sources at high redshift', he then applies the optical depth of 8 to observations by McMahon et al. (1994) of high-redshift QSOs. In particular, for the QSO BR 1202 − 0725 with a red magnitude of 18.7 and a redshift of $z = 4.68$, he argues that, if the QSO were being observed through material with an optical depth of 8, the intrinsic luminosity would need to be increased by a factor $2000 \simeq \exp(8)$. The required luminosity is then 5×10^{15} $L_{\odot}$, which leads Wright to claim that this 'essentially' rules out the theory.

Several answers to his criticism can be given. The first is that the intrinsic luminosity of QSOs is simply not known, so that a statement that a given value is too high and thus allows one to rule out a theory is a statement of belief. More important in our view is that the redshift of BR 1202 − 0725 is not wholly cosmological. A great deal of evidence concerning the existence of non-cosmological redshift components is available (cf. Arp 1987; Burbidge et al. 1990 and many references all contained in these works), and two of us (Hoyle & Burbidge 1995) have argued that, for many of the QSOs, the observed redshifts contain an intrinsic component. Only a modest intrinsic contribution is required for BR 1202 − 0725 to reduce the cosmological contribution so much that nothing remains of Wright's argument. For example, an intrinsic redshift component of unity reduces the cosmological components to only 1.84, and at this redshift the microwave absorption is small.

It can also be pointed out that the factor $2000 \simeq \exp(8)$ should have been $(2000)^{1/2} \simeq \exp(4)$, because the opacity through only half a cycle of the model, not a full cycle, is required to reach the source in question. This reduces the claimed 5×10^{15} $L_{\odot}$ for the luminosity of BR 1202 − 0725 to about 10^{14} $L_{\odot}$. Nobody knows whether that is reasonable or not, and statements as to what is ruled in or ruled out are nothing but expressions of the prejudices of the individuals making them. In our model the behaviour of galaxies at and near oscillatory minima could in some regards have been very different from their behaviour in the most recent universe.

4 BLUESHIFTS

The further objection raised by Wright to the QSSC is contained in his fourth section entitled 'Blueshifts'. The calculations given in this fourth section are similar to those given in our paper but they are based on different data. Wright uses a survey of radio sources by Allington-Smith (1982). The analysis is based on 59 sources, about 32 of which would be expected to be radio galaxies. So the argument is about 32 radio galaxies at 1 Jy out of a total of 5000 or more over the whole sky.

Applying the QSSC with the radio luminosity function of our paper (Hoyle et al. 1994) to sources with fluxes between 1 and 2 Jy at 408 MHz, it can be predicted that about eight will be identified with galaxies having apparent *r* magnitudes of ~ +20 to ~ +21, and the remaining 24 should be identified with galaxies of about +25. Since Allington-Smith's attempted identifications went down to an *r* magnitude of about +23, our expectation was that the 24 cases of his would be found as so-called empty fields. Things turned out the other way around, however: about eight empty fields were found and 24 rather clear-cut identifications were made at magnitudes typically around +20.

We agree with Wright that, subject to his premise that the 32 sources are sufficiently representative of the very much larger population to constitute a complete sample of radio galaxies, this is a discrepancy which must be addressed. Wright argues that the discrepancy implies that our prediction, that galaxies from the last maximum of QSSC at magnitude +25 with small blueshifts should be found, is in error. The problem comes from sources appearing at +20 when +25 had been expected. The error, if it can be so described, lies elsewhere. It lies in what we used in our paper for the radio luminosity function. No cosmological theory yet predicts the radio luminosity function, which is always postulated as an addendum to the theory.

We chose a situation in which most sources have intrinsic radio emission at 408 MHz in excess of 10^{29} W Hz^{-1}. However, the Allington-Smith identifications imply that at fluxes of ~ 1 Jy sources with much lower intrinsic emission, ~ 10^{27} W Hz^{-1}, dominate the count. Our reason for studying the case of high intrinsic emission was that, if true, it would have the most interesting implications for radio astronomy, in that radio astronomy would have penetrated further into the Universe according to QSSC than do other branches of astronomy.

We now show, by calculating a new explicit case, that the number count can be explained in QSSC by a differently chosen radio-luminosity function, a procedure that we are free to follow, if the Allington-Smith survey is considered to be representative of all sources in the flux range in question.

The form in which we consider the quasi-steady-state model had a scale function

$$S(t) = \exp\frac{t}{P}\left(1 + 0.75\cos\frac{2\pi t}{Q}\right) \qquad (1)$$

in the metric

$$ds^2 = dt^2 - \frac{S^2(t)}{S^2(t_0)}[dr^2 + r^2(d\theta^2 + \sin^2\theta\, d\phi^2)], \qquad (2)$$

where t_0 is the present moment of time. The characteristic period of oscillation of the second factor of (1) was taken as $Q = 40 \times 10^9$ yr, while $P \gg Q$. The model has a slow expansion because of the factor $\exp(t/P)$ superposed on the oscillations. Numerical values were given in former papers subject to the choice $t_0 = 0.85\,Q$, or $t_0 = 0.85$ when Q is used as the unit of time.

We took the occurrence of radio sources to be always proportional to the coordinate density, while here we modify this extremely simple postulate by requiring the occurrence of powerful sources to be concentrated in the half of each cycle centred around the minima of $S(t)$. This accords with the view that we have expressed on several occasions more recently than in our Monthly Notices paper cited above, namely that violent activity in our model tends to be concen-

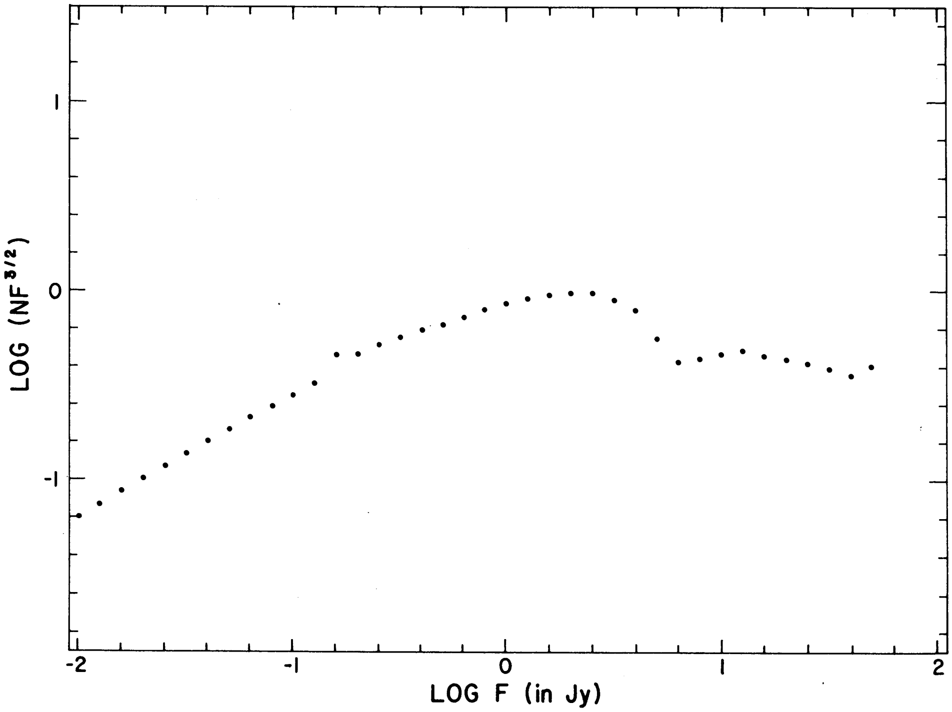

Figure 1. Theoretical curve based on the model described here for the counts of radio sources.

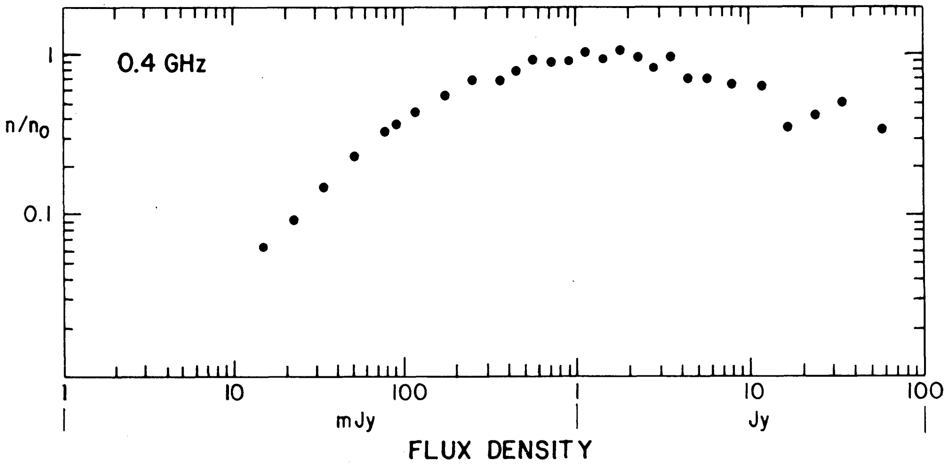

Figure 2. Observed counts of radio sources at 408 MHz redrawn from Kellermann & Wall (1987). The counts are normalized to a uniformly filled static Euclidean universe.

trated around the minima of the oscillatory cycles. According to this view, we expect sources of very high radio luminosity to be more concentrated towards the minima than sources of comparatively low luminosity. Explicitly, we now consider a rather simple situation in which there are just three luminosities:

(I) sources with $L = 10^{26}$ W Hz^{-1};
(II) sources with $L = 10^{27}$ W Hz^{-1};
(III) sources with $L = 10^{29}$ W Hz^{-1}.

A fourth class with $L = 10^{28}$ W Hz^{-1} could be included, and would give extra scope to the model, but, since such a fourth class is not essential, we omit it for simplicity.

Sources of Type I we consider to occur uniformly at all times, as in our former discussion. Sources of Type II are considered to occur uniformly as before for $0.22 \leq t \leq 0.78$ but not for $t > 0.78$, and sources of Type III occur uniformly as before for $0.30 \leq t \leq 0.70$ but not for $t > 0.70$. The relative occurrence rates at times when all three types occur are given by I: II: III = 5000: 1000: 1. Very powerful sources are thus infrequent. The resulting integral source counts as a function of flux F are given by the points of Fig. 1, which may be compared with the observed counts shown in Fig. 2 (fig. 2 of Hoyle et al. 1994). Only sources from the present half-cycle $0.5 \leq t \leq 0.85$ contribute effectively to Fig. 1 and all have redshifts. Integral source counts have been used in Fig. 1, otherwise the approximation of sources of Types II and III being assumed to begin abruptly at $t \leq 0.78$ and $t \leq 0.70$ respectively (rather than as continuous transitions) would lead to artificial distortions.

Only Types I and III contribute down to the level of the 3CR catalogue at $F = 10$ Jy, in a ratio of about 3:1. The Type I sources have low redshifts of ~ 0.03, while the Type III sources have redshifts of ~ 1.4. At $F \simeq 1$ Jy, however, the count is dominated by Type II sources with redshifts of ~ 0.5. These are the cause of the notorious rise of the counts as F decreases from 10 to ~ 1 Jy.

In the last section of his paper, Wright accepts that other cases might exist in QSSC that fit the radio data which 'look very much like big bang models'. However, he then continues to argue that such cases would still face a blueshift difficulty. It is therefore necessary to emphasize that the case calculated above does not have any blueshifts for sources with fluxes greater than 1 Jy.

In conclusion, we reiterate that the QSSC easily survives the criticisms raised by Wright.

ACKNOWLEDGMENT

We thank Dr D. Duari for calculating Fig. 1.

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