SUMMARY AND CONCLUSIONS

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In the cosmological domain, the problems which await solution with the aid of radio telescopes of high resolution and sensitivity are, I believe, the following: identifications with optical sources, the structure of individual sources, 21-cm studies of nearby sources, the distances of sources which are not optically identified, the spectra of Class II sources, their angular diameters and their distribution in space and luminosity function. Clearly the identification problem is one of fixing the position of a radio source accurately enough for a search with the 200-inch telescope to be worthwhile. The field of this telescope is 10′. Bolton and Minkowski have shown how this can be done in their work on 3C295 in the cluster 1440 + 5224. Identifications serve many purposes; for example, they throw light on the optical peculiarities of a galaxy that is a Class II radio source. The apparent magnitude and the redshift of the object can also be measured in the optical domain and its distance estimated. This in turn leads to the absolute radio magnitude (intrinsic power output) and this is needed for the luminosity function.

High resolution enables us to study the positions of radio emission regions in nearby galaxies and their coronas. I refer to the curious pairs of emission centres in such objects as Cygnus A and NGC 5128. An analogous problem concerns clusters of galaxies: is the emission from a cluster really produced by a few exceptional galaxies of the cluster? I need not stress the interest that 21-cm studies of nearby galaxies possesses. But I would like to point out the importance of measuring, if we can, the radio redshift of some moderately distant Class II source like Cygnus A.

The nature of the energy distribution function in the radio spectra of Class II sources has an interest in its own right. The (frequency)^x law, with the spectral index x treated as a constant, is usually employed. But the character of the energy-distribution function may have an additional consequence. Evidence from the case of Cygnus A suggests that the spectral index x may vary with frequency. Should this be confirmed by the study of more Class II sources, there is a possibility of determining the redshift, and hence the distance, of a Class II source that has not been optically identified. We have to assume that the spectral index of the source changes with emission frequency in the same fashion as it does for a pre-selected standard source whose redshift δ_s is known. The observer would measure the flux-density of the standard source and of the one whose redshift, δ, is being sought at two frequencies f_2 and f_1, say. Then it can be proved that, to the first order in the redshifts

$$\log\{S(f_2)/S_s(f_2)\} - \log\{S(f_1)/S_s(f_1)\} = \{x(f_2) - x(f_1)\}(\delta - \delta_s)/E,$$

where S denotes the flux-density, suffix s indicates the standard source and $E = 2{\cdot}303$. Thus the redshift δ can be found.

The determination of the angular diameters of Class II radio sources is also a very important item of information. Are these angular diameters, in a statistical sense at least, effectively the same for all sources? If this is so, then the theory of uniform model universes predicts that the angular diameters will vary with the redshift in a different way from the variation of flux-density (also assumed statistically constant for all sources) with redshift. Hence additional information about the parameters of the model universes would be obtained. You will remember that it was pointed out by Hoyle at the Paris Symposium on Radio Astronomy in 1958, that in certain model universes there could be a minimum to the angular diameter. After this minimum was attained—in the Einstein-de Sitter model at the distance corresponding to a redshift of 1·25—the angular diameter increased again. A couple of years earlier I had pointed out that essentially the same effect existed in another, admittedly rather artificial,

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model universe. In the same model one can also show that, if all Class II radio sources have the same intrinsic power output and the same value, −1, for their spectral index, then there will be a minimum of observed flux-density at a distance corresponding to a redshift of 1·9. These theoretical predictions show how important it is to press statistical investigations of the angular diameters and flux-densities of Class II radio sources to as low values as possible.

Counts of the numbers of Class II radio sources to successive limits of flux-density, made over sufficiently large areas of the celestial sphere, are also of great cosmological significance. Here good resolution is perhaps more important than sensitivity. Each model universe has its own theoretical law for the increase of this number N, with limiting flux-density, S. The ideal procedure would be to carry out the observational survey and then fit the results in turn to the predicted theoretical formulae until the best-fitting uniform model universe was found. Apart from the question of the luminosity function of Class II radio sources, the interpretation of those counts that have been made seems to me to have been confused by the notion that the classical 'minus three-halves' law between N and S is the norm and that without it, uniformity of distribution in space is absent. This is an illusion, as the study of any uniform model universe filled with an expanding distribution of sources will reveal. Indeed, it can be shown that a minus three-halves law of distribution in an expanding universe implies that Class II radio sources must have been more numerous in the past than they are now under the assumption that all of them have the same intrinsic power output. This, however, is an artificial assumption and an escape from it may lie in the luminosity function. This gives, of course, the fraction of the total number of sources, in each unit volume of space, having some particular observed intrinsic power output, or absolute radio magnitude. The investigations of this problem that I have seen all appear to contain the same curious feature. Part of the derivation of the luminosity function is carried out as if the radio sources were at mutual relative rest in the classical Euclidean universe; the remainder is performed as if they were in relative motion in a uniform model universe. Now the majority of Class II sources appear to be remote and their redshifts are therefore not negligible. Thus the use of the hypothesis of mutual relative rest in any part of the investigation is not very satisfactory. Therefore, while the observers are accumulating the data on which to base the luminosity function, the theoreticians have a problem to solve. It is this: How does one establish the luminosity function of a class of objects in an expanding universe, taking account of such matters as the effects of the redshift on distance-moduli and of the fact that the unit volume for remote objects is smaller than for nearby ones? At no point in this theory should one fall back on the traditional results which refer to objects whose relative velocities are all very small compared with that of light.