of the entire quantum theory. And quantum theory comprises the widest field of experience in natural science.

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[1] Bergstein, T., *Nature*, 222, 1033 (1969).
[2] Melrose, M. P., *Nature*, 223, 874 (1969).

LETTERS TO THE EDITOR

PHYSICAL SCIENCES

Complementarity and Philosophy: A Reply to Criticism

I AM sorry that M. P. Melrose has misunderstood my article "Complementarity and Philosophy"[1] as profoundly as is revealed by his note[2]. The relation between ordinary language and physical languages discussed in the article is not at all of the kind Melrose presents in the note. On this point I can do nothing better than advise Melrose to read my article again.

But further, the present situation in quantum physics is not as Melrose's note supposes. The great number of fundamental particles or particle states discovered in high energy physics and the inability of quantum theory to account for the existence of the particle states show that this branch of physics is in a period of accumulating experimental data, the description of which may eventually result in a new revision of the conceptual framework of physics. But whatever the revision might be, it cannot exclude fundamental physical concepts (principles, laws), but only display their limited range of applicability. This is a logical consequence of their fundamentality, that is, they have afforded a solid foundation for the description of a wide field of experience basic to further developments in experimental technique. And quantum physics has shown incontestably that physical phenomena cannot be separated from the experimental conditions.

Presumably the non-temporary character of fundamental physical concepts (principles, laws) is hard to accept for many philosophers because they confuse temporariness with possible limitations in the range of applicability. In this context it is essential that a limitation in range of applicability is discovered by a remarkable advance in experimental technique, and hence coincides with the split between phenomena observable by the usual means of observation and phenomena which can be observed only by the new technique. As long as it was not possible to obtain evidence of individual atomic objects, there were no complementary phenomena within physical science. All physical phenomena could be described in the conceptual framework of classical physics (note that "phenomenon" is used in Bohr's sense of the word).

Although the discovery of the quantum of action has displayed the limitations of the causality concept in physical description, this concept is still fundamental in physical investigation. Similarly, the complementarity concept may be subjected to certain limitations by future experimental results, but it will remain a fundamental element of physical description. As stressed by Niels Bohr, the exclusion of complementarity from physics is equivalent to the denial of the existence of the universal quantum of action and hence equivalent to the rejection of the entire quantum theory. And quantum theory comprises the widest field of experience in natural science.

Spectra of Extended Extragalactic Radio Sources

THE extended extragalactic radio sources[1] are thought[2,3] to be late stages in the evolution of relativistic plasma and magnetic fields ejected from galactic nuclei or quasi-stellar objects. The processes forming these sources, which may contain two or more components of emission in regions up to ≈ 300 kpc across, are not understood. Observations of their radio emission may, however, provide useful constraints on theories of their development (ref. 4, for example).

Scheuer and Williams[5] and Kellermann *et al.*[6] have recently pointed out that the spectra of the total emission from many of these sources do not deviate appreciably from a power law in which the received flux density $S(\nu)$ varies with observing frequency ν as $S(\nu)=C\nu^{-\alpha}$, where C and α are constants. They argue that if the individual components of such sources had power law spectra with differing values of α the total spectra could not have this form. Their spectral indices α would increase with decreasing frequency, as components with higher values of α would dominate the emission at low frequencies. They conclude that the component spectra must be essentially similar in most of these sources, within the frequency range 38 to 5,000 MHz spanned by their data.

This argument is misleading, however, for the apparent goodness of fit of a power law to the observed total spectra does not in fact place very stringent limits on the range of spectral indices which may be present among the components. Consider, for example, a two-component source in which the components have spectral indices α_1 and α_2. Assume that the source can be observed at frequencies between 38 and 5,000 MHz with instruments which record the total flux density $S(\nu) = S_1(\nu) + S_2(\nu) = C_1\nu^{-\alpha_1} + C_2\nu^{-\alpha_2}$ with negligible error, and that a single power law $S(\nu)= C\nu^{-\alpha}$ is then fitted to the resulting spectrum. Only if $S_1(\nu)=S_2(\nu)$ near 400 MHz could the departure of the total spectrum from a power law be appreciable; α would otherwise be very close to α_1 or α_2. Making this assumption and taking $\alpha_1=0{\cdot}7$, a typical value for an extragalactic source, it is easily shown that $\Delta\alpha=|\alpha_1-\alpha_2|$ must be $\geq 0{\cdot}4$ for the total spectrum to deviate from a simple power law by >10 per cent of the flux density at any frequency between 38 and 5,000 MHz. The 38 and 178 MHz data used in refs. 5 and 6 have random errors typically ± 10 per cent; at the higher frequencies random errors are smaller, but systematic errors may occur because flux densities of some extended sources must be corrected for partial resolution of the sources by the narrow reception patterns of the instruments used. These observational difficulties, and the fact that in many sources $S_1(\nu)$ does not equal $S_2(\nu)$ at 400 MHz (ref. 7), preclude the detection of differences $\Delta\alpha<0{\cdot}5$ between components of most double sources using present observations of their total spectra.

For multicomponent sources the spectral resolution $\Delta\alpha$ of the present data is still poorer. For example, in a three-component source with $S_1(\nu)=S_2(\nu)=S_3(\nu)$ at 400 MHz and $\alpha_1=0{\cdot}4$, $\alpha_2=0{\cdot}7$ and $\alpha_3=1{\cdot}0$, the total spectrum deviates from a power law with $\alpha=0{\cdot}7$ by <10 per cent