

formations of eastern England it is not the Weybourne Crag which shows the coldest conditions, but the Bridlington Crag of Yorkshire, which is believed to be later than the Cromer Forest Bed³. It seems to me that we can conclude that Zeuner's analysis suggests that there may have been fluctuations of climate during Crag times, and these may even go back into the Pliocene, but there is insufficient faunal evidence for calling these fluctuations 'glacials' or 'interglacials'. For similar reasons it is difficult to agree with Woldstedt's use⁴ of the term 'Cromer Forest Bed Interglacial'.

As Sainty has pointed out⁵, Clement Reid came to the conclusion after several years of work on the Cromer coast that among the occasional marine shells found in the estuarine parts of the Cromer Forest Bed Series, no new 'arrivals' have been recognized as compared with the Weybourne Crag fauna; and in fact the marine fauna of the Weybourne Crag itself only differs from that of the earlier Norwich Crag in the 'arrival' of one new species (*Tellina balthica*) as compared with the Norwich Crag; this species is a common living British shell to-day, and (in spite of its name) is not typical of specially cold conditions. As no new 'arrivals' of cold indicators have yet been found in the Weybourne Crag, there is no proof from the marine fauna that this deposit represents any colder conditions than the Norwich Crag. In view of the lack of geological evidence for truly glacial conditions in the later Crag beds which were formed before the Cromer Forest Bed Series, it seems to me unwise to refer to the Cromer Forest Bed as an 'Interglacial', at least until we know more about conditions during the formation of the Norwich and Weybourne Crag.

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May 24.

¹ Boswell, P. G. H., *Nature*, **181**, 1087 (1958).

² Reid, C., "Geology of the Country around Cromer", *Mem. Geol. Surv.*, **18** (1882).

³ Woldstedt, P., *Nature*, **165**, 1002 (1950).

⁴ Zeuner, F. E., *Proc. Prehist. Soc.*, N.S., **3**, 148 (1937).

⁵ Baden-Powell, D. F. W., *Proc. Geol. Assoc.*, **66**, 273 (1955).

⁶ Sainty, J. E., *Proc. Prehist. Soc. East Anglia*, **6**, 2, 63 (1929).

"Physics and Metaphysics"

Nature of March 8 contained, over the signature of Prof. L. Rosenfeld, a very lively criticism of the book "Causality and Chance in Modern Physics", published last year by Prof. David Bohm, a book for which I have written the preface. I do not think that the criticisms of Prof. Rosenfeld are justified.

The current probabilistic interpretation of the quantum theory leads in its general lines to exact conclusions. But since it denies every possibility of a precise image of the development of phenomena in space and time, it continues to be surrounded by a certain obscurity. It is not at all certain that it furnishes a complete description of physical reality: scientists as eminent as Planck, Einstein and Schrödinger have always expressed doubts on this subject. The idea of Prof. Bohm that it may be necessary to introduce new 'levels' of physical reality deeper and more hidden than those revealed by current experience therefore seems perfectly defensible to me. For my part, returning after a number of years

to certain ideas that I had considered previously when I was developing the first bases of wave mechanics, I have examined this question in the light of the conceptions of Prof. Bohm and in collaboration with certain young scientists at the Institut Henri Poincaré. In particular, I have asked myself whether it would not be possible to find an interpretation which, while retaining all the results given by probabilistic quantum physics, would permit us to obtain a more clear and more intelligible image of microphysical facts. The problem is certainly not an easy one, but I do not believe it to be so impossible as Prof. Rosenfeld thinks; and a certain number of results already obtained in this direction seem encouraging to me.

In any event, no theoretical interpretation can ever be established with a final and complete definitiveness, and for this reason alone it is always permissible to submit those that have already been accepted to a new examination. At the end of the previous century, the great majority of physicists belonged to the 'energeticist' school, which wanted to develop thermodynamics and its related subjects on purely formal bases, and which rejected, often with great disdain, all atomic and corpuscular representations. However, the interpretation of thermodynamics in terms of statistical mechanics, while taking complete account of the success of classical thermodynamics, has permitted us to go very much further. The existence of 'microphysical levels' of atoms and molecules, which the statistical mechanical interpretation of thermodynamics introduces, has been completely and clearly demonstrated. It is not forbidden to think that something analogous could happen again in the years to come. The introduction of a 'sub-quantum' milieu, deeper than the level of current microphysics, could permit the interpretation of the calculations of the present quantum theory in a clearer way, and might lead us further than the current theory can go.

In addition, the quantum theory in its accepted form seems, in a certain measure, to have exhausted its powers of prevision. After a number of years, becoming more and more formal, it has begun to have as many failures as it has successes. Even its proponents themselves seem now to admit the need to make some efforts to modify its bases. In these conditions, it does not seem to me justified to condemn *a priori* the efforts of those who try to take in a new point of view, and to obtain an image of the physical world more intelligible than that based on the conception of complementarity which remains, in spite of everything, rather obscure.

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THE impossibility of eliminating the relations of complementarity from atomic physics is not a question of opinion but a simple logical point, as devoid of obscurity, as, for example, the impossibility of defining absolute simultaneity. For a detailed discussion of the points raised in M. de Broglie's comments I may refer the reader to my contribution to the book "Louis de Broglie, Physicien et Penseur" (Paris, 1952), a revised version of which appeared in *Science Progress*, **41**, 393 (1953).

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