Review for *Le Scienze*

INTERPRETING BODIES: edited by Elena Castellani, Princeton University Press, 1998, 0-691-01724-7 (cloth) 01725-5 (paperback)

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This book is a fine testimony to how common are the concerns of two communities in two apparently disparate disciplines: on the 'Arts side', philosophy, and on the 'Science side', physics. Over the last two decades, there has been an increasing collaboration between philosophers of science (often with a training in physics) and physicists interested in foundations of physics. Elena Castellani's collection of essays, focussed on the nature of objects in physics, bears witness to this development.

For here we see not only classic articles by some giants of the middle of the twentieth century—Max Born, Werner Heisenberg and Erwin Schroedinger representing physics, and Hans Reichenbach representing philosophy; but also twelve papers by current researchers. The 'balance' is about equal between physics and philosophy: five of these twelve papers are by physicists. But the unity of topics and methods throughout the book mean that the authors' institutional affiliations really are 'invisible' as one reads the work. (Yet while we are counting, it is amusing and satisfying to note the 'international score': Italy wins, with 5 papers to the USA's four—again, testimony to the strength of philosophy, or foundations, of physics within Italy.)

The nature of matter has been a perennial topic of investigation, both empirical and speculative, since ancient times. But at the risk of oversimplifying history, we can say that a temporary consensus was reached with the establishment within physics, during the eighteenth century, of the Newtonian synthesis. According to this consensus, matter is massive, localized and indeed impenetrable; and it endures through time. Indeed, these are the connotations of the word 'body' of Castellani's title, as used in classical mechanics. On the other hand, two large topics remained problematic. First, there was the question whether one should tolerate action at a distance, as in Newton's theory of gravity—or deny it. Second, there was the question whether matter was atomistic or continuous: the most extreme form of this second dichotomy being whether matter was composed of extensionless point-particles moving in a void, or instead filled all space.

The development of physics in the nineteenth century, especially the rise of classical field theories, broke down this consensus. The electromagnetic field took on attributes of matter, such as energy and momentum; and by the end of the century, the 'electromagnetic world-picture' proposed that matter be somehow reduced to fields. The fates of the two problematic topics differed. As to the first, its second option was favoured: there was to be no action at a distance—a viewpoint that was eventually implemented even for gravity, in Einstein's general relativity. But the second topic remained problematic: perhaps matter was somehow 'stuff', not fields, and perhaps it consisted ultimately of point-particles.

Whichever view one took of such controversial matters, certainly one's picture of matter—as informed by classical physics circa 1900—conflicted with an everyday under-

standing of 'bodies', and indeed with several traditional philosophical views about matter. But to this cluster of conflicts, the quantum revolution of the 1920s and 1930s added yet others. As regards the notion of an object, it made two main innovations. First, quantum systems exhibit curious statistics. These statistics seem incompatible with one's usual ideas about identity (ideas made precise in logic and metaphysics)—ideas which apply readily to classical physical objects, including point-particles. Second, in quantum field theory, particles are treated 'merely' as excitations of the quantum field.

These issues, including the contrast with classical ideas, are much discussed in this book's first Part 'Objects and Individuality': especially in the papers by Toraldo di Francia, Hans Reichenbach, Bas van Fraassen, Steven French, Paul Teller, and Marisa Dalla Chiara, Roberto Giuntini and Decio Krause.

How should one respond to this 'disappearance' of matter, or objects, as we understand them in everyday life? One broad strategy is to argue that what is real is what is invariant under appropriate groups of transformations. This strategy has been popular for decades with both physicists and philosophers; though it hardly promises to reinstate the everyday conception of matter! In this book, it is mostly represented in Part Two, 'Objects and Invariance', especially in a paper by Max Born.

Elena Castellani herself discusses a different, and technically better-focussed, use of group theory: to classify elementary particles. The fundamental idea is simple. Since an elementary particle is meant to have no internal structure, it should be possible to put it into any of its states by some combination of translations, rotations and boosts. Eugene Wigner showed in a famous paper in 1939 how to classify relativistic particles in these terms. Castellani discusses from a philosophic viewpoint the Galilean, i.e. non-relativistic, case.

However, none of the views about the nature of quantum objects, developed by the authors in the first two Parts of this book, remove all the interpretative mysteries of quantum theory. Nor of course would these authors claim to do so. In particular, the notorious measurement problem—roughly speaking, the threat that the indeterminacy of properties characteristic of quantum theory's superpositions could occur at the macroscopic level—confronts any attempt to interpret quantum theory. Being a problem about the indeterminacy of properties, this seems unlikely to be resolved by considerations about the nature of objects.

Accordingly, Castellani's Part Three is addressed to 'Objects and Measurement'. Here I would single out two papers by Italian physicists, Ghirardi and Peruzzi. Ghirardi is well-known as a chief architect of theories which solve the measurement problem by postulating a detailed physical model of the 'collapse of the wave-packet'; and to a wider audience, as the author of 'Un'Occhiata alle Carte del Dio' (?Il Saggiatore, Milano, 1996?). Here, Ghiradi describes how such theories can give an objective description of the familiar macroscopic world. On the other hand, Peruzzi is well-known to readers of *Le Scienze* as the author of 'Maxwell' (?Le Scienze, 1999?). He takes a quite different approach from Ghirardi: he analyses how 'particles' in the sense of present-day particle physics are related to actual laboratory measurements.

To sum up: here is a very valuable collection of essays for anyone interested in the interface between physics and philosophy.