

PERHAPS the most remarkable paradox of quantum mechanics is that after more than 60 years of highly successful exploitation of the theory, we still cannot agree on how it is to be interpreted. The crux of the matter is the measurement problem: how does it come about that the fitful and elusive quantum world yields a definite answer on any particular occasion of experimental inquiry? As Richard Healey rightly says: "There is today no fully satisfactory way of understanding this theory." His new book is the beginning of an attempt to remedy this sad state of affairs.

At its centre lies a distinction between dynamical states and quantum states (relating to sets of values to be assigned to various dynamical variables, and thus carrying the ontological significance of the theory) and quantum states (which are used to calculate probabilities in the familiar way and which thus articulate the epistemological consequences of the theory). Conventional quantum theory (particularly in the scheme of interpretation broadly called after Niels Bohr's Copenhagen) identifies these two kinds of states. Hidden variable theories

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THE JAGUAR, the king of beasts in the tropical forests of America, has captivated the imagination of native peoples for at least 3000 years and continues to inspire awe. Tracing the role of this animal in the art and belief systems of preColumbian and modern peoples of Middle and South America was the ambitious task Nicholas Saunders set for himself. Writing for the general public, he provides the necessary background information but, unfortunately, includes no maps. He explains carefully how archaeologists study the fragmentary remains of past civilisations and how ethnographic analogies can be enhanced by their interpretations.

Following a brief overview of the rise of civilisations in Mesoamerica (Mexico and Guatemala) and the Andes, Saunders devotes the bulk of his work to two early cultures which rose to prominence about 1000 BC: the Olmec of Mexico's Gulf Coast and Chavin in the Peruvian Andes. He argues that these

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Bohm versus Bohr

The Philosophy of Quantum Mechanics:
An Interactive Interpretation

by Richard Healey, Cambridge, pp 270, £22.50/\$34.50

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(such as that of David Bohm) make the maximal separation between the two. Dynamical states, from this view, carry the full classical information about what is the case. There are a great many of them corresponding to the much more limited information assigned to a single quantum state. Healey seeks to set up a scheme which is somewhere between these two extremes.

A second characteristic of his thought is to refuse to assign a privileged place to observation. (Here, as he acknowledges, he comes quite close to the ideas of Hugh Everett.) Instead, we are given the broad notion of interactions possessing some degree of randomness in their character, from which it is claimed one can select subsets corresponding to the physical acts of preparation and measurement.

Thirdly, Healey claims a holistic character for his theory. He is anxious to do so in order to circumvent difficulties with action-at-a-distance, that arise from the need to get the right results for Alain Aspect's experiments, which violated John

Bell's inequality derived from a purely local formulation. Healey asserts that this holism is due to the fact that "the dynamical state of a compound system does not supervene on the dynamical states of its components." Earlier in the book, he acknowledges that his account does not go beyond that already accessible to conventional quantum theory when it points out that the wave function of a compound system is not simply the product of the wave functions of its components. It is, therefore, far from clear to me that any real advance has been made on this front.

I think Healey's theory might be called the Pretty Obscure Variable Interpretation. Unfortunately the obscurity does not only relate to the underlying stochastic dynamics, whose character he acknowledges he is unable fully to articulate. It extends to the presentation of the material.

A physicist who had come up with an idea of this kind would want to explain it, in the first instance, by setting down as complete an account as possible of its

application to a simple and typical quantum mechanical system. The philosopher Healey starts as though this were his intention also, when he begins to talk about the Stern-Gerlach experiment (measuring particle spins). However instead of equations and diagrams, we are given metaphysical discussion, and the mathematics, when it eventually comes, does so in a flurry of abstract symbolism. This is not the way to help the reader.

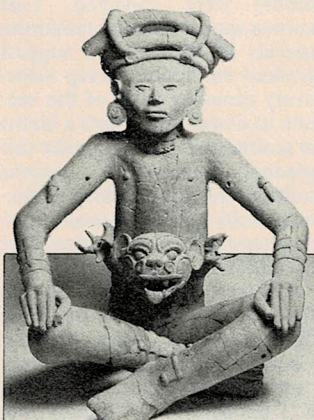
The final chapter frankly describes "open questions." One of them—crucial to the success of the task and in many ways the essence of the measurement problem—is the question of whether what Healey calls M(easurement)-type systems actually behave like classical systems when they attain a macroscopic complexity. He also acknowledges that the application of his ideas to quantum field theory appears "fraught with difficulties." Healey rather dismisses this last point, but since all modern accounts of the nature of matter are quantum field theories, it seems a very significant difficulty to me.

Richard Healey says that "Quantum mechanics is a mine of metaphysical insights, and I hope here at least to have exposed a rich seam." Whether it is gold-bearing remains to be seen. □

Enduring images

People of the Jaguar: The Living Spirit of Ancient America
by Nicholas J. Saunders, Souvenir Press, pp 176, £16.95

Susan Gillespie



Images with power: a jaguar adorns a Mexican statue

peoples created the first great art styles focused on the jaguar, and were ancestral to later civilisations in both areas. The subject then changes to present-day Amazonian tropical forest-

dwellers, where shamans are often associated with jaguars.

Adding modern ethnography to the archaeological data, Saunders equates the shaman as leader of his people, linked to the jaguar at the top of the predatory chain, with the ancient kings of Mesoamerica and the Andes, to explain the high degree of jaguar imagery of the ruling elites.

Saunders' specific theme is thus no less than the search for the origins of preColumbian civilisation as revealed by its most prevalent symbol, the jaguar. Covering such a broad topic in fewer than 200 pages has necessitated a synthetic and "generalising" treatment. Furthermore, in pursuing his objective he pays scant attention to competing ideas and identifications (where Saunders sees jaguars, other scholars recognise the features of caymans, lizards and serpents). He indulges in

hyperbole in presenting the jaguar as a central icon in art and myth, when in fact it is only one of many motifs, and by identifying ambiguous or composite images as jaguars. In a work meant to explain a complicated subject to a general audience, some shortcomings can be expected, and Saunders' attitude towards his material is more impressionistic than scientific. However, readers are misled when a theme is allowed to override the evidence.

A major problem with Saunders' thesis is the reliance on a few and mostly obsolescent references, many of which were themselves syntheses. Interpretations of Olmec archaeology in particular have changed greatly in recent years. The identification of the Olmec were-jaguar image as an actual feline was overturned more than a decade ago, and the assumption of Olmec dominance over less developed neighbouring peoples in the creation and diffusion of an art style is no longer warranted. Similarly, among the motifs at Chavin the jaguar is only one of several animals portrayed. □