useful as far as it goes. But it would perhaps have been even more interesting if the author had gone beyond describing the immediate technical responses to particular situations and tackled some of the broader issues, such as the context of radar development in the Royal Navy's general scientific research strategy, the involvement of industry in this process, and the factors that influenced radar development by Britain's principal allies and enemies. This may well have been outside Howse's brief, however, and the Naval Radar Trust is in any case intending to publish another volume purely on the technical development of naval radar.

Howse has managed to bring the Royal Navy's involvement in radar to life, not least in the novel 'tailpieces' at the end of the chapters, where he presents amusing anecdotes (such as the electric razor story). His book is a fitting tribute to all the radar scientists, naval officers and men who devoted their energies to develop these 'electronic eyes', sometimes at the cost of their lives. □

Willem Hackmann is at the Museum of the History of Science, Old Ashmolean Building, Broad Street, Oxford OX1 3AZ, UK.

Other worlds

Constantine Pagonis

The Quantum Theory of Motion: An Account of the de Broglie-Bohm Causal Interpretation of Quantum Mechanics. By Peter R. Holland. Cambridge University Press: 1993. Pp. 598. \$120, £70.

IN 1952, David Bohm did what many thought had been proved impossible: picking up from where Louis de Broglie had left off 25 years earlier, he formulated a "hidden variables" theory of quantum mechanics. In other words, he came up with a "quantum theory of motion", making quantum mechanics a sort of statistical mechanics arising out of our ignorance of the detailed trajectory dynamics.

Bohm's 1952 theory is a (non relativistic) deterministic theory that captures all the predictions of quantum mechanics. Roughly speaking, the picture is of particles whose trajectories are determined by their initial positions and a new type of physical field, the ψ field. The particle positions at any time together with the ψ field determine the values that a measurement would yield at any time for all dynamical quantities associated with the particles. The fact that most quantum predictions are probabilistic reflects our ignorance of the (uncontrollable) initial positions of the particles rather than any irreducibly stochastic behaviour of the system.

In Bohm's theory, measurement interactions do not have special status compared with other types of interactions (there is no 'collapse' of the wavefunction), and complementary experimental situations do not have the effect of making some properties of microscopic systems defined and others undefined: all properties have precise values at all times. That is not to say that Bohm's theory is a classical theory of quantum phenomena: it has a number of novel features that are highly nonclassical (it is a nonlocal and contextual theory, for example). But, however nonclassical, all its features have a solid physical basis.

Reversing Bohr's famous dictum, Bohm might have said: "There is a quantum world". For, unlike the standard interpretation of quantum mechanics, this was a theory of quantum mechanical processes in space and time, not just a theory about experimental results. Physicists could now imagine a quantum world, substituting physics for dogmatic constraints on what questions could be asked. The days of the standard interpretation were surely numbered.

Alas, talk of the mysterious 'collapse' of the wavefunction and of wave-particle duality was not banished to fringe publications exploring the 'connections' between Eastern mysticism and modern physics, but is still found in almost all physics courses taught today. Why this should be is unclear. After reading Peter Holland's book, however, it becomes apparent that the answer must lie in the sociology of twentieth-century physics, for it does not lie in the physics itself.

The Quantum Theory of Motion is a tour de force. After a first chapter on the problem of interpreting quantum mechanics, Holland sets the scene with a review of classical Hamilton-Jacobi theory, which he generalizes, making Bohm's quantum theory of motion and classical mechanics special cases. He then presents the elements of Bohm's theory and proceeds to apply it to all the standard one-body and many-body quantum mechanical problems, developing the theory to account for spin and discussing its extension into the relativistic domain. There is a very useful chapter on the analysis of measurements in quantum mechanics according to Bohm's theory, and special attention is paid throughout to the classical limit of the theory as well as to its novel features.

I strongly recommend *The Quantum Theory of Motion* to the physics community for its clear and thorough presentation of a theory deserving much wider attention. □

Constantine Pagonis is in the Department of History and Philosophy of Science, University of Cambridge, Free School Lane, Cambridge CB2 3RH, UK.

Thoughts and impressions

Sara J. Shettleworth

Through Our Eyes Only? The Search for Animal Consciousness. By Marian Stamp Dawkins. W. H. Freeman: 1993. Pp. 192. £14.95, \$19.95.

DO nonhuman animals have conscious experiences? This question has already been the subject of three books by Donald Griffin (the latest is *Animal Minds*, Chicago University Press, 1992, which was reviewed in *Nature* 360, 118 (1992)). It often arises in philosophical treatments of consciousness and is increasingly discussed by cognitive psychologists. What Marian Dawkins contributes to this debate is not new ideas or examples so much as a short, clear statement, for lay people or beginning students, of the issues involved.

In her previous book, *Animal Suffering* (Chapman and Hall, 1980, now unfortunately out of print), Dawkins displayed a talent for unpacking issues in animal behaviour that are normally surrounded by a great deal of woolly thinking. *Through Our Eyes Only?* continues this tradition. Her aim is to air both sides of the debate about whether animals are conscious by presenting evidence for animal consciousness, arguments against that evidence, more evidence that satisfies stricter criteria and so on. So anyone not reading the book from beginning to end (not an arduous task) is likely to come away with a dangerously incomplete impression.

Dawkins's thesis goes like this: subtleties of perception control of behaviour by complex stimuli and feats of learning and memory are sometimes taken to mean that animals must be conscious. But complex behaviour does not necessarily imply complex processing, nor does complex processing necessarily imply consciousness. For one to conclude that complex cognitive processes underlie apparently complex decision-making, one must eliminate the Clever Hans effect (unintentional cueing by experimenters), have a clear statement of the chance of the observed behaviour under other hypotheses, and — perhaps most difficult — eliminate the possibility that the behaviour is controlled by some combination of simple rules of thumb. Accomplishing all this still does not address the questions of consciousness directly.

Nevertheless, Dawkins claims that in a few cases, such as counting by rats and deception by primates, animals seem to be consciously weighing alternative courses of action. Here, as elsewhere, she explains examples from experimental animal