Frames of thought

Basileios Drolias

Mach's Principle: From Newton's Bucket to Quantum Gravity. Edited by Julian Barbour and Herbert Pfister. *Birkhauser: 1995. Pp. 536. $64.50, DM 118, SFr98.*

ERNST Mach is famous for his controversial statement of the principle of inertia. He introduced it at the end of the nineteenth century as a way of rationalizing Newtonian physics. Despite rationalizing the Universe with three laws, Newton left behind the concept of 'absolute space', which seemed far removed from human experience. Mach stated his principle in *The Science of Mechanics: A Critical and Historical Account of Its Development*, in which he dealt with the definition of inertial frames. For Newton, an inertial frame was one at rest or moving with constant velocity with respect to absolute space. But according to Mach, inertial systems are defined with respect to all the masses in the Universe. In another formulation, Mach's principle states that inertia is an effect of all the masses in the Universe.

Mach believed that physics should be kept separate from mysticism and should always be concerned with meaningful matters related to experience; his explanation of inertia and his dismissal of absolute space in favour of relativism are expressions of that belief. But it is not clear whether Mach intended his thesis to be a starting point for a new theory of mechanics or just a clarification of the problem of inertial frames. What is certain is that Mach's idea was not very popular among the natural philosophers of his day, at least, that is, until Einstein championed the principle by claiming that it was one of the main influences behind his general theory of relativity. (It was Einstein who named it Mach's principle.) Einstein was more than a follower of Mach; he imposed his own ideas on the principle and persuaded contemporary physicists to become interested mainly in the 'Einstein–Mach' principle or, to put it differently, only Einstein's version of Mach's principle.

Unfortunately, however, Einstein misunderstood the principle as embodied in general relativity. And despite his great admiration for Mach and his idea, Einstein received nothing but harsh criticism of general relativity from Mach. Einstein struggled for years to incorporate Mach's principle into general relativity, convinced that his theory was totally Machian, or should at least be made so. It was this conviction that forced him to introduce the cosmological constant into his equations, albeit without success.

Einstein's strong belief in Mach's principle brought it to the peak of its popularity early this century, even though Einstein would in later life renounce it. Because of the principle's vagueness and Einstein's various formulations of it, it exists today in a multitude of versions, each somehow related more or less to Mach's original idea of defining inertial systems. Not suprisingly, it is remarkably difficult to obtain a clear view of what modern researchers think about the principle and how they apply it to their work.

This book is based on a conference on Mach's principle held in Tübingen in 1993. In addition to the papers presented by the participants and edited transcripts of the discussions that followed, it includes extracts from relevant papers by scientists of the early twentieth century such as Mach, Einstein, Schrödinger, Poincaré and others. The noticeable lack of opposition to Machian ideas might mislead the unwary reader into thinking that they have won an undisputed berth among scientists. Nevertheless, the book succeeds in giving an excellent view of these ideas from perspectives as diverse as those of the historian, the philosopher, the experimentalist and the theorist, and clearly shows how they relate to current research in cosmology, quantum gravity and general relativity.

As with most symposium volumes, the quality and level of the papers is variable, but in general most of them are proficient and fairly advanced, requiring at least a knowledge of general relativity (only the first few historical chapters will be readily accessible to a nontechnical reader). The edited discussions, although fairly dense at times, graphically convey the spirit of the conference. And to avoid misunderstanding and confusion, the authors helpfully say in their papers which particular version of Mach's principle they are talking about.

There has until now been a paucity of detailed treatises on the Machian approach in mechanics. Further, the Machian idea is still not part of the standard framework of interpretation of general relativity, although work on the topic by J. A. Wheeler and J. Isenberg is well worth exploring. The book will not completely plug the gap in the literature but it should provide a stepping stone for a debate that will help gain a better understanding of what Mach described as "a Universe which is given to us only once". □

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Ernst Mach believed that physics should be concerned with meaningful matters related to experience.

All-encompassing

James L. Gould

Magnetic Orientation in Animals. By R. Wiltschko and W. Wiltschko. *Springer: 1995. Pp. 297. DM190, £92, $149.*

THE Wiltschkos are respected pioneers in the study of animal orientation. They provided the first really convincing evidence of magnetic field orientation in migrating birds, and, through a series of clever and well-controlled experiments, have painstakingly pieced together a nearly seamless picture of the elaborate development of orientation ability and strategies in homing pigeons.

They have set out in their newest book — one of the slim, densely packed volumes in Springer's 'zoophysiology' series — to review magnetic compass orientation in animals. The result is a wide-ranging and sometimes over-enthusiastic review of compass orientation. Their blasé treatment of the early and well-justified scepticism about much of this work — the need to average data through three steps in just one of three possible sequences, or to use cages with radial rather than tangential perching monitors, and so on — will worry readers who still harbour doubts about the complete reality of magnetic field orientation.

The general presentation is clear but very concise, and seriously under-illustrated. More is presupposed than many readers may bring to the book — a knowledge of the pattern of polarized light in the sky, for instance, or the Sun's course as a function of latitude and season, or the