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Book Review: *Brownian Motion: Fluctuations, Dynamics, and Applications*

Brownian Motion: Fluctuations, Dynamics, and Applications. Robert M. Mazo, Clarendon Press, 2002.

There is a reasonable possibility that the first observation of Brownian motion was made by van Leeuwenhoek with his newly-invented microscope. The name Brown is associated with the phenomenon because he was the first to correctly identify Brownian motion as having a physical, rather than a biological, basis. Additionally, Brownian motion is one of the earliest physical phenomena whose properties can only be described in probabilistic terms. Different forms of Brownian motion are also ubiquitous in the physical and biological sciences, which strongly suggests the advantages to a wide audience of understanding qualitative and quantitative aspects of the underlying theory. Robert Mazo's book is a start in this direction. However, in its present form it raises the question of the audience for whom the book is intended, and of how successfully it conveys major elements of this subject.

In my opinion, this would not be a good starting place for a complete novice to master the subject for two reasons. The first of these is that several important subjects simply do not appear in the book, e.g., the notion of local time is never mentioned. The utility of the backward equation in generating moments of the first-passage time in one-dimensional problems does not appear. Analysis based on the local time has recently been applied to solve a number of problems in chemical physics. A second shortcoming is that there is skimpy coverage of mathematical methods for solving diffusion equations. A student completely new to the subject would have no basis for developing an intuition about mathematical and physical properties of Brownian motion. For example, the method of images is mentioned once on p. 185, but is never elaborated upon. The subject of fractional Brownian motion rates no more than half a page. There are several inaccuracies in terminology as well as typographical errors, some of which are serious. As an example the backward equation corresponding to

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the Fokker–Planck equation is incorrect as written. The term "probability distribution" is sometimes used when probability density function is obviously meant. The term "highly non-Markovian" is used. What could this possibly mean? Wiener integrals are discussed, but the author emphasizes that these are not generally used in physics. A very superficial account of the trapping problem is given with only two references to the literature. These do not include the earlier seminal work by Balagurov and Vaks (1974) nor the rigorous mathematical analysis by Donsker and Varadhan (1979).

Having mentioned some of the negative aspects of this monograph, it is only reasonable to mention some of its strong points. The historical introduction is a good one, as well as the later comparison of Smoluchowski's and Einstein' respective approaches to the theory of Brownian motion. Some of the physical arguments are quite enlightening, as, for example, the brief discussion of time scales in justifying the circumstances when the Kramers–Klein equation can be reduced to the Smoluchowski equation. Another very interesting and enlightening topic not found in standard texts is that of the analysis of pneumatic infrared detector first analyzed by Golay. The discussion of rotational Brownian motion is both useful and interesting. It is obvious that the author's real interest in the circle of ideas suggested by Brownian motion relates to some of the more formal aspects of the subject, such as the reduction of the Liouville equation to more manageable form using projection operators. The resulting equations can be analyzed using familiar mathematical tools. His remarks on this subject are generally insightful, undoubtedly because he has contributed to the literature. The subject of molecular dynamics is introduced quite concisely, and the problems related to its use are described very nicely but without going into great detail.

In summary, this monograph contains some interesting material, but would not be suitable as a text. It might, however, provide useful supplementary reading on several topics for a course in statistical mechanics.

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