The modeling of magnetic materials can be performed at various levels of resolution. The highest level of resolution is the atomic level. At this level, one can use quantum mechanics to understand the basic processes involved. The next step down in resolution is the micromagnetic level, where the magnetization is a continuous function of position. At a still lower level of resolution, one uses the domain level of modeling, where the material is divided into uniformly magnetized domains separated by domain walls of zero thickness. Finally at the lowest resolution, the nonlinear medium level, the magnetization is the average of many domains, and the physical nature of their formation is ignored. In this last level, the medium is characterized by an input/output relationship.

Preisach modeling is a mathematical tool that has been used principally at the nonlinear medium level, but it can also give some insight at all the levels. Its effectiveness in describing magnetic materials is due to its ability to have a behavior when the applied field is increasing which is different from its behavior when the applied field is decreasing. It is thus able to describe minor loops and other complex magnetizing processes. The classical Preisach model is limited by the congruency property and the deletion property, neither of which is possessed by magnetic materials. Although these limitations could be removed using a phenomenological approach, this book relies on physical reasoning as much as possible to make necessary modifications. This practice usually results in simpler models that give physical insight into the processes of interest. Although these modifications have been shown to be robust, the book uses physical reasoning rather than mathematical rigor to justify its derivations.

In Chapter 1, the physics of magnetization processes is briefly summarized. Chapter 2 summarizes the classical Preisach model, which is the basis for the statistical analysis used in modeling hysteresis. However, since it cannot describe
many of the subtleties in the behavior of magnetic materials, modifications based upon physical reasoning are presented in the subsequent chapters. In particular, the concept of reversible magnetization is discussed in Chapter 3. Accurate behavior of the susceptibility is obtained by a magnetization-dependent reversible component, called the DOK model. This is further improved by adding a more complex state-dependent reversible component, called the CMH model. As shown in Chapter 4, the congruency limitation can be removed by means of an output-dependent model, such as the moving model or the product model. Including either accommodation, aftereffect, or both in the model, as shown in Chapter 5, removes the deletion property. Even with all these modifications, the resulting model is still a scalar model, so in Chapter 6, we discuss methods of generalizing it to a vector model.

Some applications are discussed in Chapter 7. First, since the model is essentially a magnetostatic model, this chapter presents two brief extensions to dynamics. These extensions include the effect of eddy currents on the magnetization, the effect of the accommodation model on the pulsed behavior, and the effect of the moving model and the accommodation model on noise. Another extension is the development of a magnetostriction model. Finally, the development of an inverse model, which would be useful in control applications, is discussed.

I hope that this book is useful in showing how the Preisach model can be extended to describe accurately a wide range of magnetic phenomena. Although the discussion is limited to magnetic phenomena, it can give deep insight into the analysis of hysteretic many-body problems. The techniques presented here are general and can be applied to hysteresis problems in disciplines other than magnetism.

Edward Della Torre