Ferromagnetic Hysteresis

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Abstract. In this talk we shall regard hysteresis as a *rate-independent memory* phenomenon. First we shall address the mathematical representation of hysteresis in general, and illustrate some specific models.

Afterwards we shall deal with processes in space-distributed ferromagnetic or ferrimagnetic materials. This may be described by coupling the Maxwell system (with or without displacement currents) with linear relations among the fields $\vec{E}, \vec{J}, \vec{D}$ (e.g., the linear dielectric relation and Ohm's law), and with a constitutive law with hysteresis between the fields $\vec{H}$ and $\vec{M}$.

The latter dependence will be represented by a vector extension of the so-called *(delayed) relay model,* which in the scalar set-up is characterized by a rectangular hysteresis loop. By suitably composing relays characterized by different thresholds, the large class of *Preisach models* is obtained. (This scalar model was proposed for ferromagnetism by the physicist Ferenc Preisach in 1935; it became so popular that it was and is still applied to other phenomena, too, e.g. filtration through porous media.)

A more mathematical side of this talk will concern the formulation of an appropriate initial- and boundary-value problem for a quasilinear system of partial differential equations. This essentially consists in coupling the Maxwell equations with the linear dielectric and Ohm's law, and by representing the $\vec{M}$ vs. $\vec{H}$ relation via a suitable *weak formulation* of the vector Preisach model. This model will be displayed, but its intricate analysis in the Sobolev spaces will be spared to the audience.

A natural interpretation of the Preisach models refers to a population of relays at a mesoscopic scale. This suggests to provide a (two-scale) mesoscopic-macroscopic representation, that will also be briefly illustrated.

References

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(a copy of a preliminary version of this survey may be requested to the author)