FORC technique: differential analysis versus smoothing

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Two reasons mark the success of FORC technique among researchers in the field of magnetism: one is that it allows extracting otherwise difficult to get information regarding magnetic interactions, and the second is that it can be implemented in many magnetometers available in magnetism laboratories, well understood that such magnetometers must accomplish exigent requirements regarding accuracy, both in the magnetization and magnetic field measurements, as the second order differentiation involved in the FORC diagrams, involves a remarkable increase of the experimental noise influence.

Newcomers to FORC technique frequently confront two problems which may hinder their advances on the topic: (i) one is the complex data processing associated to differentiation and smoothing and often performed by sophisticated mathematical algorithms and (ii) the other is the omnipresent comparison to Preisach plane and interpretation in terms of magnetic hysterons.

Plunging directly into Preisach models and smoothing may lead to missing the intuitive connection to the essence of FORC analysis: its differential nature. FORC filling the area of the major hysteresis loop represent different magnetic paths or processes which essentially differ on the initial magnetic state. The substantial reason why the magnetization evolves differently with the applied field from one FORC to another is precisely the magnetic interaction among the constituents of the system. Hence, crucial information about the magnetic phases as well as the nature and intensity of their interactions is contained within the hysteretical area. Unravelling it involves a careful observation of the first derivative dependence on the starting magnetic state. This idea based on the differential analysis is deprived of any mathematical artifice and directed to the intuitive understanding of the FORC fingerprints. A closer look into any magnetic system necessarily requires physical and computational models which allow simulation of the magnetization curves and FORC diagrams. In this talk, special attention will be paid to the case of multiphase systems containing soft or semi-soft phases and the problems derived from the narrowness of their hysteresis loops. With this starting point, the influence of random noise and the consequences that the smoothing procedures may have on the final appearance of the FORC patterns are analysed.