A new quantitative criterion to determine the order of thermomagnetic phase transitions.

J. Y. Law[1], V. Franco[1], L.M. Moreno-Ramírez[1], A. Conde[1], D. Y. Karpenkov[2], I. Radulov[2], K. Skokov[2], O. Gutfleisch[2]

[1]Dpto. Física de la Materia Condensada, ICMSE-CSIC, Universidad de Sevilla, Apdo. 1065. 41080-Sevilla, Spain

[2]Institut für Materialwissenschaft, Technische Universität Darmstadt, Alarich-Weiss-Str. 16, 64287 Darmstadt, Germany

An ideal magnetocaloric material, with a large magnetocaloric effect in the absence of hysteresis, would lay at the borderline between a first-order and a second-order phase transition. Hence, it is important to unambiguously determine the order of the phase transition for both applied magnetocaloric research as well as the characterization of other phase change materials. Although Ehrenfest offered a simple concept to define the order of a phase transition, those known techniques for its determination based on magnetic measurements either provide inappropriate results for specific cases or require extensive data analysis, which is subsequently undermined to subjective evaluation of the qualitative features in the data.

In this work, we show an alternative method to identify the order of phase transition from the study of the field dependence of magnetic entropy change. This technique implements a quantitative fingerprint of first-order thermomagnetic phase transitions: the exponent of the local power law, *n*, is larger than 2 at temperatures and fields close to the phase transition. This model-independent parameter enables the evaluation of the order of the phase transition in a straightforward manner and, at the same time, eliminates any subjective interpretations from previous methods. The proposed technique is applied successfully to several alloy series, which include $La(FeSi)_{13}$-type, Heusler-type alloys and multiphase magnetocaloric composites, and the results from numerical simulations using the Bean and Rodbell model are in agreement with the experimental results, proving the generality of our proposition.

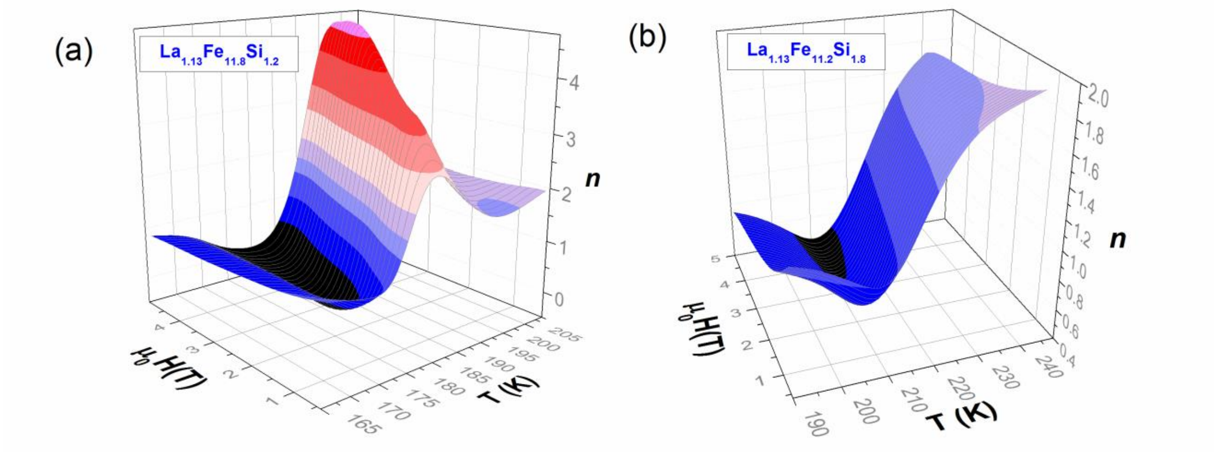

Figure 1. Magnetic field- and temperature-dependence of the exponent *n* for (a) a first-order phase transition and (b) a second-order phase transition.