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Hysteresis Design of Magnetic Materials for Efficient Energy Conversion

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Prof. Victorino Franco

**Condensed Matter Physics Department,
University of Seville (Spain)**

Characterization of the thermal hysteresis of magnetocaloric materials using TFORC

Abstract:

Refrigeration and temperature control involve a significant fraction of the electricity consumption nowadays. Energy efficient, environmental friendly procedures of thermal management will therefore have a direct impact on the sustainability of our way of life. Magnetocaloric refrigeration is considered among the promising technologies to achieve this goal [1]. However, appliances are not in the consumer market yet due to relevant limitations of the active materials.

Magnetocaloric materials with a first order phase transition provide the largest magnetocaloric response, but they exhibit thermal hysteresis, which is one of the key limiting factors that prevent their efficient implementation in magnetic refrigerators. This problem has to be tackled in a twofold way: a) understanding the different sources of thermal hysteresis of technologically relevant materials in order to minimize them, and b) predicting the response of the materials upon an arbitrary sequence of excitations, so that the trajectories of the minor loops in the M(T,H) space is known and their behavior in a magnetic refrigerator can be suitably modeled.

To achieve those, in the recent years, the temperature variant of the first order reversal curves technique (TFORC) has been proposed as a fingerprinting method for the characterization of thermal hysteresis in magnetocaloric materials [2]. This initial approach has been expanded in two complementary directions: the implementation of a faster characterization technique that makes use of an effective temperature approach (T*FORC) [3], and the development of models of the phase transformation that provide a physical meaning to the distinct features observed in experimental TFORC distributions [4,5].

This talk will give an overview of the TFORC technique and highlight its potential for the characterization of hysteretic thermomagnetic phase transitions by applying it to Heusler alloys. We will also suggest procedures to increase the data acquisition rate and to extend this procedure to other caloric materials.

[1] V. Franco, J.S. Blázquez, J.J. Ipus, J.Y. Law, L.M. Moreno-Ramírez, A.Conde, Prog. Mater. Sci. 93 (2018) 112
[2] V. Franco, T. Gottschall, K.P. Skokov, O. Gutfleisch, IEEE Magn. Lett. 7 (2016) 6602904.
[3] V. Franco, J. Appl. Phys. 127 (2020) 133902.
[4] L.M. Moreno-Ramírez, V. Franco, Metals 10 (2020) 1039.
[5] Á. Díaz-García, L.M. Moreno-Ramírez, J.Y. Law, F. Albertini, S. Fabbrici, V. Franco, J. Alloys Compd. 867 (2021) 159184

About the speaker:

Victorino Franco is a professor Condensed Matter Physics Department in the of the University of Seville, Spain. His main research interests cover magnetic materials for energy applications, including soft-magnetic and magnetocaloric materials. He has published more than 190 peer-reviewed technical articles. In 2000, he received the Young Scientist Award from the Royal Physical Society of Spain, followed by the Young Scientist Award of the Royal Order of Chivalry of Seville in 2005. He has served as chair of the Spain Chapter of the IEEE Magnetics Society and chair of the Magnetic Materials Committee of the Minerals, Metals & Materials Society (TMS). He has been the editor and publications chair of several Magnetism and Magnetic Materials (MMM) conferences and will be the general chair of the 2022 Joint MMM-Intermag Conference.