MAP-fis Essay Proposal, 2014-2015

(*please write in English*)

Supervisor

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Title

Energy efficient Solid State Magnetic Refrigerators Towards a better environment

Area

(*Materials, Optics, Condensed Theory, High Energy Theory,....*);

Materials, Energy

Summary of Proposal

This project aims to overcome the main factor hindering the commercialization of magnetic refrigerators (MRs) by simulating, optimizing and fabricating the first fully solid state MR device. Magnetic refrigeration, exploiting the magnetocaloric effect (MCE) [1], is an environmentally safe, compact, reliable, and efficient cooling technology. Its cooling efficiency can be much higher (at least 30%) than that of expansion-compression refrigerators [2]. It can have a huge impact on the present ecological and energy problems, lowering the dependence on foreign oil and energy and our carbon footprint. By replacing heat exchange fluid by thermal diodes that are able to manipulate and control the heat-flow direction, one aims to obtain a refrigerator with increased operating frequency and thus efficiency, paving the way for the growth of an emerging technology that can boost energy savings.

Numerical simulations will be first used to provide clear paths towards the fabrication of the envisaged device. The comparison between experimental and numerical results will allow developing a precise model that takes into account real world conditions and can be used to predict large scale devices. Regarding thermal diodes we will follow two main approaches: materials whose thermal conductivity (k) changes with the applied magnetic field (e.g. LaCaMnO3 or magnetic multilayers) and thermoelectric modules (Peltier devices) [3]. We also propose to use metal-insulator-metal structures displaying memrisistive properties [4] as thermal diodes. We will then assemble a macro- and a micro-refrigerator based on Gd and Gd(Si,Ge)4 magneto-caloric materials in bulk and thin film forms.

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References

(*to allow students first look at topic*)

[1] Pecharsky, V.K., Jr., K.A.G.. Giant magnetocaloric effect in Gd5Si2Ge2, Phys Rev Lett 78, 4494-4497 (1997).

[2] Gomez, J.R., Garcia, R.F., Catoira, A.D.M., Gmez, M.R.. Magnetocaloric effect: A review of the thermodynamic cycles in magnetic refrigeration. Renew Sust Energ Rev 17 74-82 (2013).

[3] Urban Tomc, Jaka Tusek, Andrej Kitanovski, Alojz Poredos, A new magnetocaloric refrigeration principle with solid-state thermoelectric thermal diodes, Applied Thermal Engineering 58, 1-10 (2013); Solid state magnetic refrigerator D.J. Silva, B.D. Bordalo, A.M. Pereira, J. Ventura, J.P. Araújo, Applied Energy 93, 570–574 (2012).

[4] Strukov, D. B.; Snider, G. S.; Stewart, D. R.; Williams, S. R., The missing memristor found, Nature 453, 80–83 (2008).