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Institut für Physik
Physikalisches Kolloquium

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HS N013, Hörsaalgebäude, Reichenhainer Str. 90
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Manipulating ferromagnetic phase transitions through nano-scale materials design

Magnetic multilayers have demonstrated an impressive variety of tunable collective properties, and they represent an established approach to materials design with widespread applications, especially in data storage technologies [1], but also in emerging “green energy” devices [2]. One specific example is the “exchange spring” system, in which low-moment magnetically hard and high-moment magnetically soft layers are coupled to facilitate collective properties that cannot be achieved otherwise and are inherent to the system’s non-uniform magnetic nature [3], a concept that was further advanced by utilizing continuous magnetic anisotropy gradients [4].

In recent years, significant interest has developed in magnetic film systems, in which the exchange coupling strength is ferromagnetic everywhere, but locally varying by means of nano-scale materials design. This interest is associated with the fact that such designed material profiles translate into strongly varying magnetization states down to the 1 – 2 nm length scale, which is somewhat surprising, given that ferromagnetism is a collectively ordered state [5]. Overall, such “exchange-graded” magnetic materials have shown themselves to be a very efficient way of modifying magnetic properties in otherwise rather conventional materials [5]. The most impressive result is hereby the possibility to tune critical exponents, in particular the magnetization onset exponent β in an extremely wide parameter range, which represents a unique way to override the universality usually associated with phase transitions [6]. The same approach also enabled the design of meta-materials that exhibit temperature independent coercive fields for wide temperature ranges [7,8]. Furthermore, an enhancement of magnetocaloric properties was observed [9], and thus, “exchange-graded” materials are an extremely promising way to design the thermal evolution of magnetic properties and adapt it to their utilization in devices.

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