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Extended skyrmion phase in epitaxial FeGe(111) thin films

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Exotic magnetic skyrmions with a new type of topological spin texture have recently been observed in cubic B20 magnets such as MnSi and FeGe [1]. Skyrmions, with a double-twist spin texture carrying a topological charge and a Berry phase in real space, can form long-range ordered structure or behave as solitons [2]. These magnetic skyrmions not only provide a novel route to study the topological nature of magnetic defects but also exhibit spectacular static and dynamic properties such as translational and rotational motion driven by electric current with ultra-low current density. Unfortunately, the skyrmion phase in bulk crystals exists only in a very small region of a few K and a narrow magnetic field range in the phase space. However, theories and some experiments suggest that the skyrmion phase may be greatly expanded in thin films. In this work, we describe the realization of B20 FeGe thin films with greatly expanded skyrmion phase [3]. FeGe has the highest Curie temperature $T_C \approx 280$ K among the B20 skyrmion materials, but FeGe crystals rarely exceed 1 mm. We have succeeded in the epitaxial growth of FeGe(111) thin films on Si(111). We show that the skyrmion states, as revealed by the topological Hall effect and the small angle neutron scattering (SANS), are stabilized in a dramatically larger region in phase space in FeGe films, including the entire temperature range up to T_C, and in a large field range. Furthermore, the properties of the skyrmion phase can be controlled and manipulated by the film thickness. Other aspects of the skyrmion states as revealed by transport and neutron measurements will also be discussed. This work is in collaboration with C. L. Chien and C. Broholm at JHU and L. Debeer-Schmitt and K. Littrell at ORNL.

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