Materials with possible novel quantum states with *R*MX structure-type: crystal growth and study

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First discovered in 1992, *R*AlGe (*R* = rare earth metal) was initially reported to crystallize in the so-called $ThSi_2$ structure-type with the centrosymmetric space group $I4_1/amd$ (No. 141) [1]. Later, however, it was realized that *R*AlGe instead crystallizes in the LaPtSi-type structure [2,3], with the noncentrosymmetric body-centered space group $I4_1md$ (No. 109). Recent first-principles calculations predicted that members of the *R*AlGe family with *R* = Pr and Ce, crystallizing in the LaPtSi-type structure, are new magnetic Weyl semimetals [4]. This system offers remarkable tunability, since the number and location of the Weyl nodes can be controlled by the choice of rare-earth element and by the Al/Ge content. In addition, the presence of multiple broken symmetries gives rise to a rich phase diagram that can be explored via self-doping or chemical substitution. Therefore, to enable a broad range of experimental studies on this class of materials, there is clear interest in establishing the conditions for the growth of sizable (mm^3) single crystals and in carrying out their basic physical characterization.

In this contribution, I will review our results on the crystal growth and investigation of *R*AlGe materials with possible novel quantum states.

We have reported crystal growth of the *R*AlGe family using both floating-zone and flux-growth techniques, together with their basic characterization [5]. We also investigated the macroscopic and microscopic physical properties of the solid solution of $Ce_{1-x}Pr_xAlGe$ [6] and reported the discovery of topological magnetism in the candidate magnetic Weyl semimetal CeAlGe [7]. Using neutron scattering, we identified the polar magnetic Weyl semimetal candidate CeAlGe as hosting several incommensurate multi-k magnetic phases. These include a topological phase proposed to host antimeron pairs, which is so far unique among polar magnets and magnetic Weyl semimetals. The discovery of diverse multi-k magnetic phases makes this system exceptionally promising for exploring gauge fields of Weyl fermions, and more generally the relationships between magnetically sensitive, topologically nontrivial features in real and reciprocal spaces. It was found, that different crystal growth methods can tune topological magnetism in these materials. We have used diffraction methods to understand the structure-property relations [8].

[1] S. Dhar, S. Pattalwar, R. Vijayaraghavan, J. Magn. Magnetic Mat. (1992). 104-107, 1303.

[2] S. Dhar and S. Pattalwar, J. Magn. Magne.Mat. (1996). 152, 22.

[3] E. Gladyshevskii N. Nakonechna, K. Cenzual, R. Gladyshevskii, J.-L. Jorda, J. All. Comp. (2000). 296, 265.

[4] Guoqing Chang, Bahadur Singh, Su-Yang Xu, et al., Phys. Rev. B (2018). 97, 04114.

[5] P. Puphal, C. Mielke, N. Kumar, Y. Soh, T. Shang, M. Medarde, J. S. White, E. Pomjakushina. Phys. Rev. Mat. (2019). 3, 024204.

[6] P. Puphal, S. Krebber, E. Suard, R. Cubitt, C. Wang, T. Shang, V. Ukleev, J .S. White, E. Pomjakushina, Phys. Revi. B (2020). 101, 214416.

[7] P. Puphal, V. Pomjakushin, N. Kanazawa, V. Ukleev, D. J. Gawryluk, J. Ma, M. Naamneh, N. C. Plumb, L.Keller, R. Cubitt, E. Pomjakushina, J. S. White, Phys. Revi. Lett. (2020). 101, 214416.

[8] S. Shin et al. In preparation.