Spin-valley locking and bulk quantum Hall effect in a Dirac semimetal BaMnSb$_2$

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Spin-valley locking in the band structure of monolayers of MoS$_2$ and other group-VI transition metal dichalcogenides (TMDCs) has attracted enormous interest, since it offers potential for valleytronic and optoelectronic applications. Such an exotic electronic state has sparsely been seen in bulk materials. In this talk, I will give a brief overview on the study of spin valley locking of TMDCs and then talk about our recent finding of spin-valley locking in a bulk Dirac semimetal BaMnSb$_2$ [1]. I will show valley and spin are inherently coupled for both valence and conduction bands in this material. This is revealed by comprehensive studies using first principle calculations, tight-binding and effective model analyses, angle-resolved photoemission spectroscopy, neutron scattering and quantum transport measurements. Moreover, this material also exhibits a stacked quantum Hall effect. The spin-valley degeneracy extracted from the plateau height of quantized Hall resistivity is close to 2. This result, together with the observed Landau level spin splitting, further confirms the spin-valley locking picture. In the extreme quantum limit, we have also observed a two-dimensional chiral metal at the side surface, which represents a novel topological quantum liquid. These findings establish BaMnSb$_2$ as a rare platform for exploring coupled spin and valley physics in bulk single crystals and accessing 3D interacting topological states.

Reference:

[1] Liu et al., arXiv:1907.06318