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Colloidal nanocrystals: model systems to investigate compelling questions in the field of electronic topology?

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Nanocrystals in one or more dimensions (e.g. quantum dots, rods, platelets), have been a topic of intense research since their discovery over 40 years ago. Due to quantum confinement effects, the emission spectrum of semiconductor nanocrystals can be accurately tuned by controlling their dimensions. New wet-chemical synthesis techniques and breakthroughs in surface chemistry have enabled precise control over nanocrystal shapes and sizes, thereby significantly advancing the field of excitonic physics and a wide variety of applications.

This success of nanocrystals in optoelectronics raises the question whether these materials could also be model systems in the field of electronic topology? Here, I show our progress with Bi_2Se_3 nanoplates which are a model system for two-dimensional layered systems. (1) We present a new transfer system to get wet-chemically prepared nanocrystals in ultra-high vacuum without the detrimental presence of solvent and capping. Under such clean conditions, STM and STS allows to study the electronic band structure, impurities and crystal defects in all detail. (2) We show that the limited lateral dimensions of Bi_2Se_3 are beneficial (with respect to MBE grown materials) to study the presence (absence) of topological quantum channels at their edges. (3) We present our first steps on the new field of moiré electronics, using stacks of two nanocrystals with their crystal structures rotated under a variable angle. These and other examples show that two-dimensional colloidal nanocrystals can be important and complementary to gas-phase grown crystals for the study of electronic topology.