Biaxial molecular-colloidal nematic liquid crystals

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Coexistence of order and fluidity enables functioning of biological membranes and liquid crystal displays alike, but only a few of many possible distinct realizations of such ordered fluid states have been demonstrated so far. I will discuss how we disperse micrometer-long inorganic colloidal rods in a nematic fluid host of nanometer-long rod-like organic molecules [1]. These building blocks, while freely diffusing around, interact to spontaneously form an orthorhombic biaxial nematic fluid, in which like-sized rods are roughly parallel and the molecular ordering direction is orthogonal to that of colloidal rods. Using nonlinear optical microscopy and Raman spectroscopy, we study the low-symmetry orientational distributions of both molecular and colloidal rods. We construct a detailed temperature-concentration phase diagram that contains two uniaxial and one biaxial nematic phases, as well as two-phase coexistence regions [1]. Displaying properties of biaxial optical crystals, our hybrid molecular-colloidal fluids can be switched by electric and magnetic fields and promise a host of technological uses ranging from new breeds of displays to metamaterials. I will discuss how similar ideas can be dextended to colloidal inclusions with other shapes and how they enable realization non-othorhombic biaxial nematics and polar ordered fluids with low symmetry and high degrees of orientational order.

1. H. Mundoor, S. Park, B. Senyuk, H. Wensink and I. I. Smalyukh. “Hybrid molecular-colloidal liquid crystals.” *Science* **360**, 768-771 (2018).
2. Q. Liu, P.J. Ackerman, T. C. Lubensky and I. I. Smalyukh. “Biaxial ferromagnetic liquid crystal colloids.” *Proc. Natl. Acad. Sci. U.S.A.* **113**, 10479–10484 (2016).

Short Biography of Prof. Ivan I. Smalyukh. Ivan I. Smalyukh is a full professor at the Department of Physics at CU-Boulder, which he joined in 2007 (promoted from Assistant to Associate Professor in 2014 and from Associate to Full Professor in 2017. He is also a founding fellow of Renewable Sustainable Energy Institute (a joint institute of CU-Boulder and NREL) and Materials Science Engineering Program. He is a senior investigator of the Materials Science and Engineering Center (NSF MRSEC) and directs the Soft Matter Physics Research Group at CU-Boulder with 32 research group members (students, postdocs and visiting scholars). Prior to CU-Boulder, Prof. Smalyukh did his postdoctoral and PhD studies at the University of Illinois at Urbana-Champaign and Kent State University, respectively, as well as was a visiting scholar at the University of Pennsylvania. Prof. Smalyukh also held a visiting professor position at the Newton Institute (University of Cambridge, UK) and at the Max Planck Institute (Stuttgart, Germany), as well as held Paris Sciences Char and CNRS Chair positions at ESPC and University of Paris Sud, respectively (both in France). Prof. Smalyukh's research focuses on soft condensed matter, materials and biological systems, including liquid crystals, colloids, polymers, bacteria, gels, biomaterials and their photonic, electro-optic and energy-related applications. He published ~170 peer-refereed articles, including many in Nature and Science, and has an h-index of 45. He is an elected fellow of the American Physical Society. He received many awards, including the Bessel and Glenn Brown Awards, NASA iTech award and Mid-Career Award of International Liquid Crystal Society, the PECASE Award from the Office of Science and Technology of the White House and the GSoft Award from the American Physical Society.