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Switching the chirality of toroidal order in ferroelectric nanostructures by twisting

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Controlling ferroelectric toroidal order in ferroelectric nanostructures, which is central to cashing out its numerous application prospects has triggered intense interests nowadays. Great efforts have been made in pursuit of switching the chirality of ferroelectric toroidal order by an experimentally feasible way in the past decade. However, being quite different with the traditional ferroelectric domain patterns, the controllability of ferroelectric toroidal order is hindered by its topological feature. The strategies of vortex switching reported in the literature recently are to introduce a region of dominant dipoles during nucleation in ferroelectrics via different methods such as making use of the geometry asymmetry, mechanical stress field, defect engineering, inhomogeneous electric field and a sweeping biased tip. Facile manipulation of the toroidal order in ferroelectrics remains challenging. Here, we propose an efficient scheme for controlling the chirality of ferroelectric toroidal order. A trilinear coupling relationship between polarization, toroidization and the twist force is derived based on which two feasible strategies of controlling ferroelectric toroidal order by a combination of homogeneous electric field and torque are suggested and further carried out for ferroelectric toroidal order, Polar-Toroidal Multi-Order State (PTMO) and ferroelectric skyrmion in ferroelectric nanodots and nanowires using first-principles-based effective Hamiltonian simulations and phase-field simulations. Our study demonstrates facile control of toroidal order, PTMO state and ferroelectric skyrmion, providing a good demonstrating of using shear strain engineering to control ferroelectric domain patterns and shedding light on the practical designing ferroelectric devices based on toroidal orders.

Biography

Jianyi Liu completed his BA in Optical Information Science and Technology and PhD in Condensed Matter Physics from Sun Yat-sen University. He worked as a Research Assistant in the University of Hongkong.

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