Lightwave Control of Topological Properties in 2D Materials for Sub-Cycle and Non-Resonant Valley Manipulation

R. E. F. Silva
Á. Jiménez-Galán, O. Smirnova, M. Ivanov
Instituto de Ciencias de Materiales de Madrid, 28049, Madrid, Spain
ruiefdasilva@gmail.com

Modern light generation technology offers extraordinary capabilities for sculpting light pulses, with full control over individual electric field oscillations within each laser cycle [1]. These capabilities are at the core of lightwave electronics on a few-cycle to sub-cycle timescale, aiming at information processing at peta-Hertz rates. At the same time, quantum materials encompass fascinating properties such as the possibility to harness extra electronic degrees of freedom, e.g., the valley pseudospin, that can be optically initialized via resonant circular pulses [2,3,4. Still, initializing, manipulating and reading the valley degree of freedom on timescales shorter than valley depolarization remains a crucial challenge.
I will present an all-optical, non-resonant approach to control the injection of carriers into the valleys by controlling the sub-cycle structure of non-resonant driving fields [5]. For triangular sub-lattices, such as those of hexagonal boron nitride (hBN) or MoS2, the bicircular field, formed by a circular field and its counter-rotating second harmonic, possesses the symmetry of the sub-lattice and is shown to initialize a high degree of valley polarization on a sub-cycle timescale. The valley pseudospin is then read by using either the imprint of the Berry curvature on the high harmonic generation spectrum in non-inversion-symmetric monolayers [5] or by quantifying the appearance of even harmonics due to the breaking of inversion symmetry created by the valley polarization [6].

References

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Figures

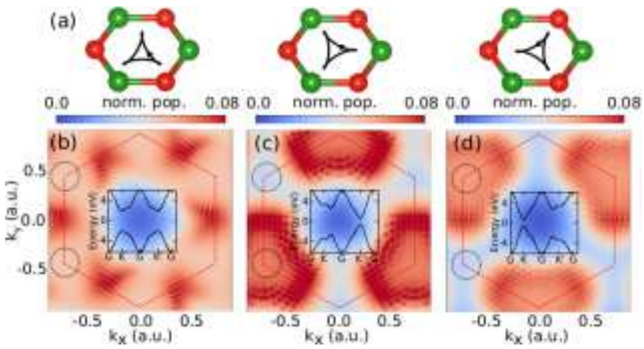

Figure 1: (a) Different orientations of the bicircular field with respect to the lattice, controlled by the phase delay between the two colors. (b-d) Normalized electron population in the lowest conduction band of hBN after applying the bicircular field above with 3 micron of fundamental wavelength.