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Exciton Spin Currents: Theory

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An indirect exciton is a bound pair of an electron and a hole confined in spatially separated semiconductor layers. Long lifetimes of indirect excitons allow them to cool down to low temperatures below the temperature of quantum degeneracy. In coherent exciton gases the spin relaxation mechanisms linked with the scattering of particles are strongly suppressed. Recent experiments evidenced spontaneous coherence and condensation, phase singularities, spatial ordering, and polarization textures in a cold excitons gas [1, 2]. We develop a theoretical model accounting for the spin-orbit interaction of electrons and holes, exchange splitting of exciton states and Zeeman effect. This model describes the polarization patterns observed experimentally, including helical patterns, four-leaf patterns, spiral patterns, and bell patterns, and confirms that the polarization textures at low temperature manifest ballistic propagation of cold excitons over the distances exceeding the exciton Bohr radius by 3 orders of magnitude and the exciton thermal De Broglie wavelength by more than an order of magnitude. The comparison of theory and experiment allows extracting the spin currents carried by electrons and holes bound to excitons. The spins tend to align along the effective spin-orbit field induced due to the Dresselhaus effect (Figure 1).

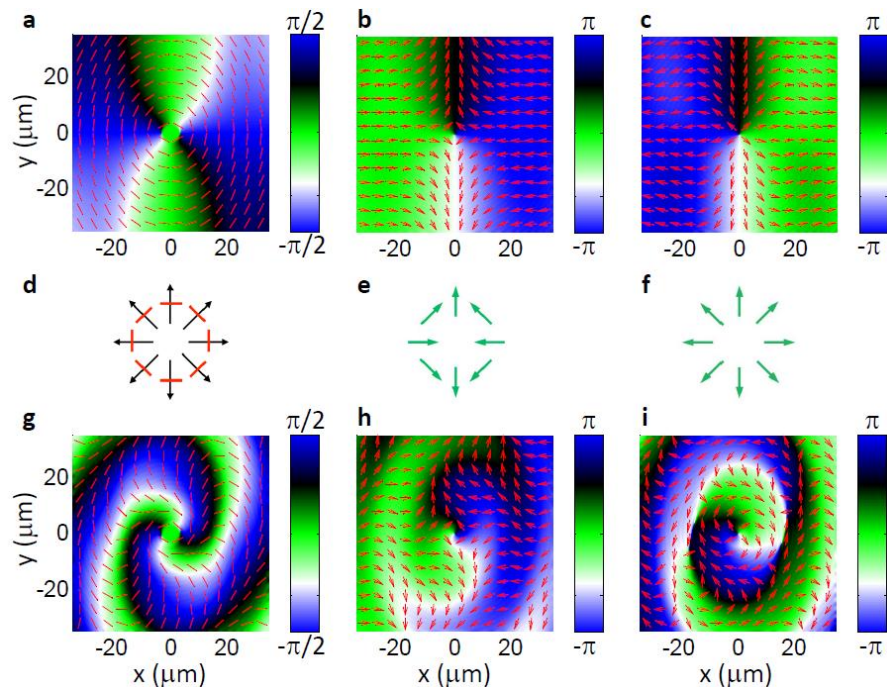


Figure 1. Simulated in-plane exciton polarization (A), electron spin (B) and hole spin (C) patterns around a source of excitons (in the center of each image). (D) Schematic of exciton momentum (black arrows) and linear polarization (red lines) patterns. Schematic of effective magnetic fields given by the Dresselhaus spin-orbit interaction for electrons (E) and holes (F). Exciton polarization (G), electron spin (H) and hole spin (I) patterns in applied magnetic field $B = 7$ T. The lines (arrows) and the color visualize the orientation of the linear polarization (spin).

References

- [1] A.A. High, J.R. Leonard, A.T. Hammack, M.M. Fogler, L.V. Butov, A.V. Kavokin, K.L. Campman, A.C. Gossard, *Nature*, **483**, 584 (2012).
- [2] A.A. High, A.T. Hammack, J.R. Leonard, Sen Yang, L.V. Butov, T. Ostatnicky, M. Vladimirova, A.V. Kavokin, T.C.H. Liew, K.L. Campman, A.C. Gossard, arXiv:1302.3852 (2013).

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