Graphene as platform for optospintronics and quantum information

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Graphene, owing to its unique electronic structure and tunable spin–orbit coupling, has emerged as a promising platform for optospintronics and quantum information technologies. In this talk, I will present theoretical studies of optical spin injection, photogalvanic effects, and spin–charge current generation in graphene under the combined influence of Rashba spin–orbit coupling, in-plane magnetic fields, and structured light carrying orbital angular momentum. I will discuss mechanisms enabling highly efficient optical control of spin polarization and photocurrent generation, emphasizing their dependence on the interplay between Zeeman and Rashba splittings as well as light parameters. Furthermore, I will address the role of quantum confinement in nanoribbons, which modifies absorption spectra and enables pseudospin-selective excitations. Finally, I will show how periodic driving within the Floquet formalism leads to exotic non-equilibrium phases, including time-crystalline behavior and topological Lifshitz transitions. Altogether, these results highlight graphene's potential as a versatile platform for optically driven spintronics and the realization of quantum-information functionalities.

References

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