Hydrostatic Pressure Control of the Spin-Orbit Proximity Effect and Spin Relaxation in a Phosphorene-WSe_2 Heterostructure

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Abstract. Mixed-lattice heterostructures offer a versatile platform for engineering novel spin textures. Focusing on the phosphorene-WSe_2 heterostructure, we show how the spin-orbit coupling can be transferred from WS_2, a strong spin-orbit coupling material, to phosphorene and boosted by applying vertical pressure. By changing the optimal interlayer distance between bilayer constituents, which corresponds to the applied pressure in the realistic experimental setup, we show that it is possible to tune the spin-orbit field of phosphorene holes controllably. Fitting of the ab initio calculation data to the effective spin-orbit Hamiltonian model applicable for phosphorene holes around the Γ point reveals that the spin-orbit field can be increased more than two times for the applied pressure up to 17 kbar, consistent with the experimental results of the spin-orbit proximity effect in a graphene/WSe_2 heterostructure. Finally, by calculating the spin relaxation times of phosphorene holes, which represent an experimentally measurable quantity directly affected by the spin-orbit coupling strength, we reveal that the gradual tunability of spin-orbit coupling by the hydrostatic pressure transfers to the tunable decrease of spin relaxation times, suggesting a possibility for a simple determination of hydrostatic pressure effects on the strength of the spin-orbit field in phosphorene-based heterostructures.

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