Observation of dynamic nuclear polarization in a high-mobility low-density two-dimensional electron system

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Electron-nuclear spin systems in semiconductors have attracted a great deal of interest because of their potential applications for the emerging field of quantum information processing. Both electron and nuclear spin qubits are promising candidate for solid state quantum computation and they are coupled with each other via hyperfine interaction. It is thus necessary to understand the electron-nuclear spin dynamics in semiconductors from a basic point of view.
In this work, we investigated the hyperfine interaction of electron and nuclear spins by using acousto-optical modulator integrated into our time-resolved Kerr rotation setup in a high-mobility low-density two-dimensional electron system. The dependence of the oscillation period versus external magnetic field on the pump helicity revealed the contribution of the Overhauser field. We calculated the magnitude of Overhauser field along the external field $B_N^{'}$: it invert direction when the pump polarization is changed to the opposite with a similar strength. Furthermore, we showed the pump power dependences of $B_N^{'}$ quantitatively. High pump light power reduces $B_N^{'}$ as a result of decreasing time-averaged electron spins due to excessive excitation of holes and unpolarized electron spins, respectively.