Coherent spin dynamics probed by optical pump probe Scanning Tunneling Microscopy

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Recent years, the researches of spin dynamics in low dimensional nanoscale systems have grown rapidly and drawn more intentions than the past decades, both theoretically and experimentally. The well-known spin-polarized scanning tunneling microscopy (SP-STM) has been successfully demonstrated to be a powerful technique for characterizing localized spin dynamics and playing important roles in nanoscale science and technology. Alternatively and complementarily, here, we present an optical pump-probe STM (OPP-STM) technique, which is also attested to be a powerful technique to probe spin dynamics with the temporal resolution corresponding to the optical pulse width in principle. In general, spins are optically oriented using circularly polarized laser pulses and their dynamics are probed by STM combined with the OPP method (Fig.1a). In addition to spin relaxation dynamics, spin precessions are also observed for the first time ever, which provide Landé's *g*-factor and the spin lifetimes. Note that all experiments are conducted at 2.5K using Omicron TESLA-STM system.

In this study, a cleaved n-type GaAs sample is used, with a donor concentration of 2×10^{16} cm^{-3} near the value for a metal-insulator transition that ensures a significantly long spin lifetime. One of the experimental data is presented below (Fig 1b), showing that the spin precession under a certain magnetic field. In an external magnetic field, the spin precession occurred at the Larmor frequency, namely, $\omega = g\mu_B B/\hbar$, where g is Landé's *g*-factor, μ_B is the Bohr magneton, and $\hbar$ is the Dirac constant, consequently, magnetic field dependence can also be obtained, thus we can evaluate the *g*-factor (here we have two different *g*-factors) and the spin lifetimes, from the spin precession beats acquired by the OPP-STM. More details will be given and discussed in the presentation.

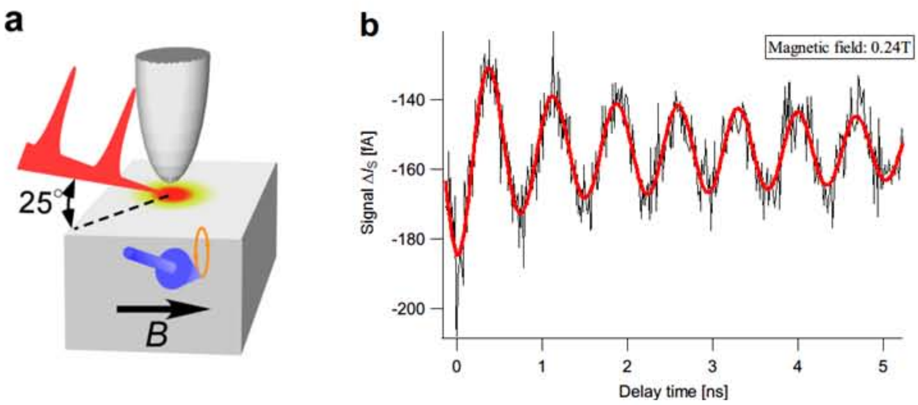

Fig.1. (a) The schematic of the OPP-STM. Two synchronized pulse trains with right-handed and left-handed polarization, are carefully aligned and introduced into the Tip-Sample gap in STM. A n-type GaAs (110) is used with applying a magnetic field parallels to surface at 2.5K, which makes the spin precessions within it. **(b)** Under the coordinates of delay time versus ΔI_S (the signal intensity), the fitted curve shows spin precession using the OPP-STM setup with 0.24T magnetic field applied