Optimal control for quantum metrology

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Rydberg atoms are extremely sensitive to their electromagnetic field environment, which make them a very promising tools for metrology. Rydberg atoms can be described by the model of the hydrogen atom. By applying a small static electric field, it is possible to partially lift the degeneracy between same n levels. The new sublevel forms a regular structure. It is possible to manipulate the state of the atom using a rf field with a well-defined polarization to prepare states with large electric or magnetic dipole. In our experiment, we generate Schrödinger cat states of the Rydberg atom of rubidium by preparing quantum superposition of two trajectories with very different classical property. The relative phase of the superposition is very sensitive to the variations of the probe environment, which allows us to measure electric or magnetic field with a very good sensitivity. However, the preparation fidelity is limited by the actual energy structure of rubidium, which is much more anharmonic than that of hydrogen. I will show how implementing RF pulse shape that have been optimized by the University of Kassel using Optimal Control Theory allowed us to drastically improve the efficiency of our pulses.