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Manipulation of Spin-Orbit and Majorana Qubit in Hybrid Quantum Systems

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Abstract:

Combining the long coherence times available in microscopic quantum systems with the strong interactions and integration available in solid state systems is one major goal in the recent study on quantum information. For such purpose, much effort has been taken to propose and realize functional hybrid quantum systems. In this presentation, I will introduce our recent theoretical works on this field. We propose a spin-orbit qubit in a nanowire quantum dot on the surface of a multiferroic insulator with a cycloidal spiralmagnetic order. The spiral exchange field from the multiferroic insulator causes an inhomogeneous Zeeman-like interaction on the electron spin in the quantum dot, producing a spin-orbit qubit. The absence of an external magnetic field benefits the integration of such a spin-orbit qubit into high-quality superconducting resonators. By exploiting the Rashba spin-orbit coupling in the quantum dot via a gate voltage, one can obtain an effective spin-photon coupling with an efficient on-off switching. We also propose a hybrid system composed of a Majorana qubit and a nanomechanical resonator, implemented by a spin-orbit-coupled superconducting nanowire, using a set of static and oscillating ferromagnetic gates. The ferromagnetic gates induce Majorana bound states in the nanowire, which hybridize and constitute a Majorana qubit. Due to the oscillation of one of these gates, the Majorana qubit can be coherently rotated. By tuning the gate voltage to modulate the local spin-orbit coupling, it is possible to reach the resonance of the qubit-oscillatorsystem for relatively strong couplings.

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张鹏，2007年获中国科学技术大学物理专业学士学位，2013年获中国科学技术大学凝聚态物理专业博士学位。2014-2016年在日本理化学研究所（RIKEN）做博士后研究工作，并于2014年获日本学术振兴会外国人特别研究员基金（JSPS Fellowship）。目前在日本乐天（Rakuten）从事数据科学的研究工作。主要的研究方向包括：自旋电子学、量子现象和混合量子器件设计、凝聚态理论。

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