Development of the tunnelling devices with spin-split Al/EuS electrodes for superconducting spintronics and spin qubits applications

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The development of superconducting quantum circuits for quantum computing during the past two decades led to the creation of commercial quantum processors with tens of qubits [1]. With transmon being the superconducting qubit of choice in most architectures, recent quantum processors have proven to be suitable for intermediate-scale quantum computing, where coherence extends over a relatively small number of qubits. Fully-fledged quantum processors, implementing quantum error correction, require improvements in both qubit performance and downsizing. Since the latter is an issue for the transmon, a number of alternative qubits are being intensively developed, including the semiconductor spin qubits [2] and more recently the superconducting Andreev spin qubit [3,4].
In contrast to the original idea of the Andreev spin qubit [5], where spin splitting is achieved due to the spin-orbit interaction, we investigate the use of superconductor — magnetic insulator interfaces for implementing single-qubit operations in spin qubits. We found that Al/EuS bilayers might be used in Andreev spin qubits to complement or even substitute the use of spin-orbit interaction and superconducting phase-phase differences across the weak link [6]. We also present results of a systematic study of Al/EuS interfaces, which led to consistent fabrication of Al/EuS bilayers featuring spin splitting of the superconducting density of states, as observed in the tunnelling spectroscopy shown in Fig 1. These devices were proposed to be used in cryogenic thermoelectric elements and diodes [7,8]. However, the fabrication process can be adapted to the needs of manufacturing of the Andreev spin qubits as well as of the superconducting spintronics in broader terms.

References

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Figures

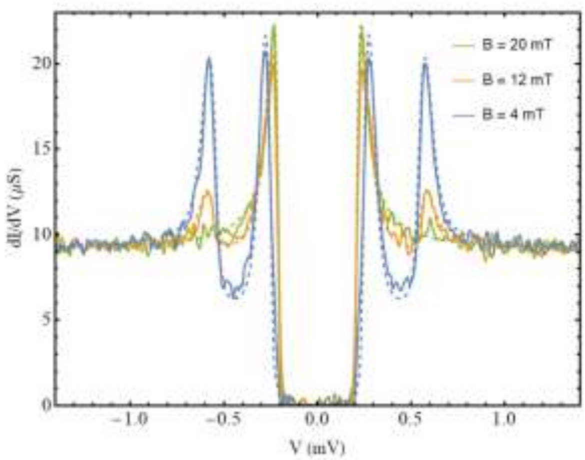

Figure 1: Tunnelling spectra demonstrating spin splitting of density of states in the second Al electrode for the Al/AlOx/Al/EuS heterostructure [7].