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Title: Electric Field Effects on the Hidden Order of Microstructured URu2Si2

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Electric Field Effects on the Hidden Order of Microstructured URu_2Si_2

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Introduction

Despite being studied for over 30 years there is still continual interest in they heavy-fermion URu_2Si_2 due largely in part to the still disagreed upon origin of the so-called hidden-order (HO) state that arises below T_{HO} = 17.5 K. While both the application of pressure [1] and high magnetic fields [2] have been shown to suppress the HO state, one mechanism that has yet to be explored is the application of an electric field, most likely due to the difficulty of measuring such an effect in a metal. To overcome this challenge we have used focused ion beam (FIB) lithography to obtain the necessary sample geometry to create an electric field across a small section of the sample by applying a voltage. Our results suggest that at low temperatures the application of an electric field is able to suppress the hidden order state.

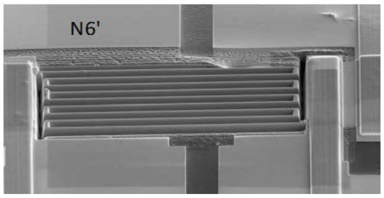

Fig1. Electron beam image of the small microstructured section of URu_2Si_2, studied in this work. There are ten 80 μm x 2 μm cuts through the sample, which results in effective sample length of 800 μm.

Experimental

Voltage sweep measurements focused on 1.8 K in superfluid ^4He at fixed fields up to 15 T in a superconducting magnet at the NHMFL Pulsed Field Facility. Samples were cut using FIB lithography (**Fig.1**) by P. Moll in Dresden.

Results and Discussion

The effects of voltage sweeps up to 350 mV on microstructured URu_2Si_2 in superfluid ^4He at 1.8 K at different fixed magnetic fields was studied in terms of the resulting current and resistance. As shown in **Fig.2**, as the voltage is increased a period of ohmic behavior gives way to a sharp decrease in current that ultimately reaches a near constant value as the voltage increases further. Conversely, as the voltage is decreased, the sharp current jump occurs at a slightly lower voltage. Now as the magnetic field is increased the change in current decreases at the aforementioned voltages and the hysteresis diminishes. More informative is the change in resistance as a function of voltage shown in **Fig.3**. As voltage increases (decreases) a sharp increase (decrease) in resistance is observed at the same voltage, which corresponds to an electric field due to the sample geometry, as the current jumps occurred. Due to the significant magnetoresistance in the HO state, the initial resistance value increases as the magnetic field is increased. However, the resistance value obtained after the threshold electric field is nearly the same for all magnetic field values. The lack of magnetoresistance above the threshold electric field is similar to the lack of magnetoresistance after the suppression of HO with temperature, suggesting that an electric field may be able to suppress the HO state.

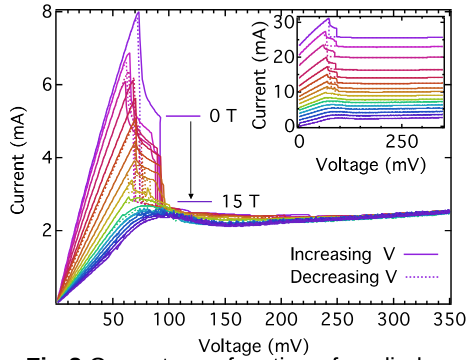

Fig.2 Current as a function of applied voltage. Ohmic behavior gives way to a sharp drop in current at a voltage that corresponds to a threshold electric field that is the same for each magnetic field. (Inset) An offset view of the same data.

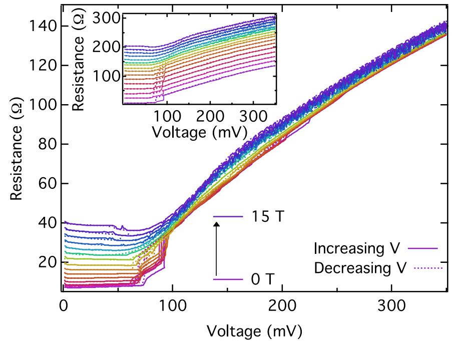

Fig.3 Resistance as a function of applied voltage shows at the same threshold electric field as in Fig1., the magnetoresistance vanishes, such that the resistance is roughly the same for all magnetic fields. (Inset) An offset view of the same data.

Acknowledgements

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[2] Sugiyama, K. *et al*., J. Phys. Soc. Jpn., **59**, 3331-3339 (1990).