Two New Papers on Josephson Tunnel Junctions with Ferromagnetic Interlayer

February 7, 2008 (H20). Josephson tunnel junctions with ferromagnetic interlayer are currently a subject of vivid interest and intense research. We like to attract our readers' attention to two new papers on this subject, which were recently submitted to *Phys. Rev*. B and are available as electronic preprints (the first paper is already accepted). Both studies involve SIFS (superconductor-insulator-ferromagnet-superconductor) junctions with the interlayer thickness $d_f >> \xi_{f1}$, where ξ_{f1} is the decay length in the conducting ferromagnet.

The theoretical paper by Vasenko, Golubov, Kupriyanov and Weides investigates the SIFS junctions in the dirty limit using the quasi-classical theory and formulates a quantitative model describing the damped oscillations of critical current, I_c, as a function of thickness of the ferromagnetic layer. The negative sign of I_c corresponds to the so-called π state. The derived analytical expression for I_c was used by Vasenko *et al*. to fit recent experimental data and extract the parameters of F, where F was the $Ni_{0.6}Cu_{0.4}$ alloy. The example of such fit is shown in Figure 1.

The authors studied also the superconducting density of states (DOS) induced in F by the proximity effect. They showed that the oscillation pattern of DOS at the Fermi energy in F is nearly ½ of the oscillation period of I_c. Therefore, the DOS oscillations do not reflect the 0 to π transition. The paper is accessible at arXiv:0711.0365v1.

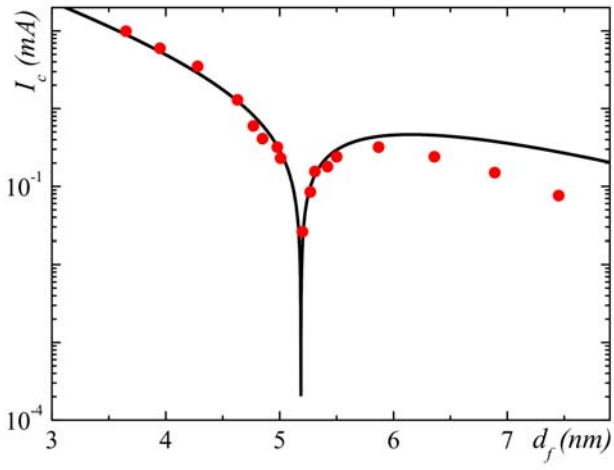

Fig. 1. Fit to the experimental data for the critical current I_c as function of F-layer thickness d_f in a $Nb/Al_2O_3/Ni_{0.6}Cu_{0.4}/Nb$ junction. The fitting parameters are the exchange field and the spin-flip scattering time in the ferromagnet.

The second paper by Pfeiffer *et al*. presents extensive experimental studies on the dynamic and static properties of 0-, π- and 0-π SIFS Josephson junctions of short and intermediate length (static properties of short 0-π junctions are also the subject of the Forum paper ST27). In the underdamped limit these junctions exhibit a rich dynamical behavior such as resonant steps on the current-voltage characteristics. Varying the experimental conditions, zero field steps, Fiske steps and Shapiro steps are observed with a high resolution.

A strong signature of the 0-π Josephson junction is demonstrated by measuring the critical current as a function of two components (B_x, B_y) of an in-plane magnetic

field, see Fig.2. The experimental observation of a *half-integer zero field step* in 0-π SIFS junctions is presented for the first time. The authors have observed *half-integer* Shapiro steps on the current-voltage characteristics of 0-, π- and 0-π Josephson junctions, which does not necessarily imply the presence of the second harmonic in the current-phase relation. The analysis of a short overdamped JJ in the framework of the RSJ model confirms this picture. The dynamic and static properties of 0- and π- SIFS junctions are shown to be qualitatively similar to standard SIS junctions. The paper shows that SIFS 0-, π- and 0-π JJ technology can already be used to fabricate more complex superconducting electronic devices. The paper is available at http://arxiv.org:80/abs/0801.3229v1.

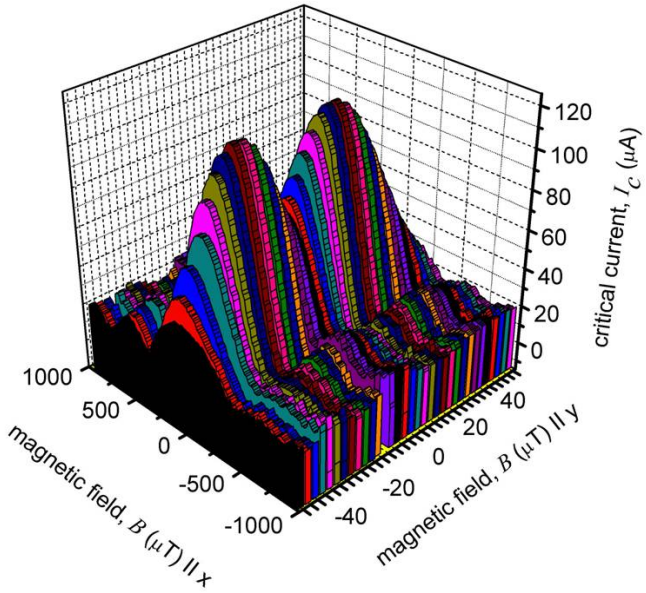

Fig. 2. Experimentally measured dependence of the critical current of a 0-□ sample at T=4.2 K. For B_y=0, the critical current shows a regular Fraunhofer pattern. For B_x=0, a minimum around B_y~ 0 is visible which is a characteristic feature of 0-π JJs.