SECTION DE PHYSIQUE

COLLOQUE DE PHYSIQUE

24, QUAI ERNEST-ANSERMET, CH-1211 GENÈVE 4

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Ecole de Physique, Auditoire Stueckelberg

«Josephson field-effect transistors go metal: A groundbreaking route towards concrete superconducting electronics»

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Abstract:

In their original formulation of superconductivity, the London brothers predicted more than eighty years ago the exponential suppression of an electrostatic field inside a superconductor over the so-called London penetration depth, λ_L, in analogy to the Meissner-Ochsenfeld effect. Despite a few experiments indicating hints of perturbation induced by electrostatic fields, no clue has been provided so far on the possibility to manipulate conventional superconductors via field-effect. In this talk, I will report the evidence of full field-effect control of the supercurrent in all-metallic transistors made of different BCS superconducting thin films [1]. At low temperature, our field-effect transistors (FETs) show a monotonic decay of the critical current under increasing electrostatic field up to total quenching for gate voltage values as large as ±40V in titanium-based devices. This bipolar field effect persists up to ~ 85% of the critical temperature (~ 0.41K), and in the presence of sizable magnetic fields. A similar behavior, though less pronounced, was observed in aluminum thin film FETs [1]. A phenomenological theory accounts for our observations, and provides a description compatible with an electric field-induced non-local perturbation propagating deeply inside the superconducting film. In our interpretation, this affects the pairing potential, and quenches the supercurrent.

Moreover, I will show the experimental realization of Ti-based Dayem bridge field-effect transistors (DB – FETs) [2, 3] able to control the Josephson critical current (I_C) of the superconducting channel. Our easy fabrication process DB – FETs show symmetric full suppression of I_C for an applied critical gate voltage as low as V_G^C ~ ±8V at temperatures reaching about the 85% of the record critical temperature 550mK for titanium. Our devices show extremely high values of transconductance (up to 15μA/V) and variations of Josephson kinetic inductance with gate voltage of two orders of magnitude.

Finally, I will show the behavior of mesoscopic superconductor-normal metal-superconductor (SNS) Josephson field-effect transistors [4] which will reveal as well the impact of intense electrostatic fields even on proximity metals. All this seems to suggest that the field effect is *universal*, i.e., it can affect either genuine or proximity *fully-metallic* superconductors.

Besides shedding light on a key issue in physics, these results represent a groundbreaking asset for the realization of an all-metallic superconducting field-effect electronics and leading edge quantum information architectures based on Josephson FETs. Possible electronic and circuital schemes based on this all-metallic technology will be furthermore discussed [3]

Une collation en compagnie du conférencier sera offerte après le colloque.

Prof. Dmitry Abanin

Genève, le 3 avril 2019/nc

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