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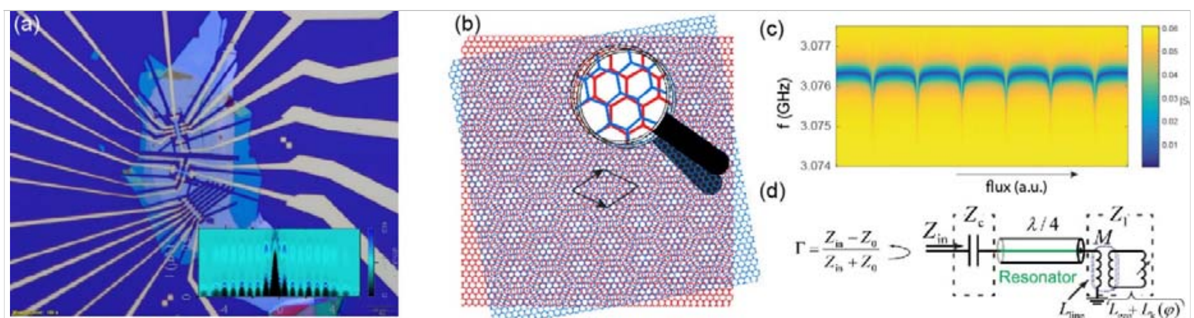
PhD fellowship "Superconductivity in Twisted Bilayer of Graphene"

A fellowship for an **experimental PhD thesis** work is available in the **Nano- and Quantum Electronics** group at the Department of Physics of the University of Basel: www.nanoelectronics.ch

It is one of the most remarkable recent findings, that a **twisted bilayer** at the "magic angle" of 1.2° turns from a semimetal into a **superconductor** (Cao, Y. et al. Nature 556, 43–50 (2018)). Our group has contributed to graphene research since 2011, with major contributions on ultraclean suspended graphene and — since recent— also on encapsulated graphene and other van der Waals materials such as $NbSe_2$ and WTe_2. The former is a well-known superconductor, while the later is a Dirac/Weyl semimetal or in case of a monolayer a topological insulator.

The phenomenal transition of twisted bilayer into a superconducting state is believed to be due to so-called "flat bands", which arise in superlattices, for example, in twisted bilayer. Instead of having a linear "Dirac spectrum", like in monolayer graphene, the electronic bands assume a small curvature, and hence a large mass due to hybridization of the Dirac cones of the two layers. This seem to increase the superconducting coupling strength. In our own research, we have studied superlattices in aligned h-BN encapsulated graphene and found van-Hove singularities in transport studies with superconducting contacts. These are also places where the bands become rather flat.

In this thesis, the PhD applicant will first concentrate on twisted bilayer graphene and study superconducting properties using electron transport measurements at cryogenic temperature down to the milli-Kelvin regime. Josephson junctions shall be fabricated and used in RF and DC-SQUID geometries to measure the critical current, the current-phase relation and emission and absorption properties, see figures below.



(a) Encapsulated graphene Hall-bar devices with the inset showing a "Fraunhofer-pattern" of the critical current of a graphene Josephson junction (JJ). (b) Principle of superlattice with indicated superlattice unit-cell in the center. (c) Measurement of a JJ in an RF-SQUID by microwave reflectometry, the principle of which is shown in figure (d). The frequency shift of the microwave $\lambda/4$ resonator with a bare frequency of ~3GHz is shown as a function of phase tuned by an external flux-coil.

We are looking for a highly motivated student (preferably a physicist) who is keen to explore fundamental aspects of **quantum devices**. You will design and fabricate your own devices using tailored nanowires and state-of-the-art micro- and nanofabrication.

All PhD fellows are expected to work in a team and collaborate with other PhD and postdoctoral fellows, as well as bachelor and master students joining the lab part of their time. Start of the project 1st of Jan. 2020 or earlier. Duration 3-4 years. **Requirement**: you need to have a **profound understanding of quantum and solid state physics** as it is taught in a physics curriculum.

To apply, please email to Christian.Schoenenberger@unibas.ch your short curriculum vitae including names and contact info of referees and scanned copies of grades. Please add a short statement (few lines only) on your motivation and your education / background in quantum physics and solid-state physics.