Analytische und Geometrische Strukturen
RAUM.ZEIT.MATERIE
SFB 647

Graphene Day

TIME:
16 Jan 2013, 15:00 - 17:00

LOCATION:
HU, Institut für Mathematik
Rudower Chaussee 25, rm 1.410
12489 Berlin

PROGRAM:

15:00 - 16:00 **Prof. Dr. Mikhail Katsnelson (Radboud University, Nijmegen)**

Graphene: CERN on the desk
Graphene, a recently (2004) discovered two-dimensional allotrope of carbon (this discovery was awarded by Nobel Prize in physics 2010), has initiated a huge activity in physics, chemistry and materials science, mainly, for three reasons. First, a peculiar character of charge carriers in this material makes it a CERN on the desk allowing us to simulate subtle and hardly achievable e☐ffects of high energy physics. Second, it is the simplest possible membrane, an ideal testbed for statistical physics in two dimensions. Last not least, being the ☐first truly two-dimensional material (just one atom thick) it promises brilliant perspectives for the next generation of electronics which uses mainly only surface of materials. I will tell about the first aspect of the graphene physics, some unexpected relations between materials science and quantum ☐field theory and high-energy physics.
Electrons and holes in this material have properties similar to ultrarelativistic particles (two-dimensional analog of massless Dirac fermions). This leads to some unusual and even counterintuitive phenomena, such as fi☐nite conductivity in the limit of zero charge carrier concentration (quantum transport by evanescent waves) or transmission of electrons through high and broad potential barriers with a high probability (Klein tunneling). This allows us to study

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subtle e□ffects of relativistic quantum mechanics and quantum fi eld theory in condensed-matter experiments, without accelerators and colliders. Some
of these eff□ects were considered as practically unreachable. Apart from the Klein tunneling, this is, for example, a vacuum reconstruction near supercritical charges predicted many years ago for collisions of ultra-heavy ions. Another interesting class of quantum-relativistic phenomena is related with corrugations of graphene, which are unavoidable for any two-dimensional systems at fi□nite temperature. As a result, one has not just massless Dirac fermions but massless Dirac fermions in curved space. Gauge fi elds, of the central concepts
of modern physics, are quite real in graphene and one can manipulate them just applying mechanical stress.

16:00 - 17:00 **Dr. Timur Tudorovskiy (Radboud University, Nijmegen)**

Semiclassical theory of potential scattering for massless Dirac fermions

Two-dimensional massless Dirac fermions are eff□ective charge carriers in graphene and topological insulators. The potential scattering for these particles drastically di□ffers from the conventional one. The most pronounced example, illustrating the di□fference, is the Klein paradox, i.e. the total transmission of the Dirac fermion normally incident on any one-dimensional potential barrier.

We present a systematic semiclassical theory of potential scattering for massless Dirac fermions under the assumption that the potential depends on a single Cartesian variable. We
distinguish three di□fferent regimes of scattering. To fi□nd the reflection and transmission coe□ffcients in these regimes, we apply the Wentzel-Kramers-Brillouin (WKB), or semiclassical, approximation. We use the method of comparison equations to extend our prediction to nearly normal incidence, where the conventional WKB method should be modi□fied due to the degeneracy of turning points. We compare our results to numerical calculations and □find good agreement.

The talk is based on our recent work: K. J. A. Reijnders, T. Tudorovskiy, M. I. Katsnelson,
arXiv:1206.2869v2 [cond-mat.mes-hall].

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