UNIVERSITÄT
LEIPZIG

Fakultät für Physik und
Erdsystemwissenschaften

Prof. Dr. M. Grundmann, Dekan

Fakultäts-Kolloquium
– Antrittsvorlesung des Leibniz-Professors –

Dienstag, 5. Dezember 2023, 16:30 Uhr

Prof. Dr. Sergei P. Kruchinin

Bogolyubov Institute for Theoretical Physics, NASU, Kyiv, Ukraine

Hybrid ferromagnetic-superconductor nanosystems

Recent advances in nanoscience have demonstrated that fundamentally new physical phenomena are found, when systems are reduced in size to dimensions that become comparable to the fundamental microscopic length scales of a material under study. Superconductivity is a macroscopic quantum phenomenon, and therefore it is of particular interest to see how this quantum state is influenced when the samples are reduced to nanometer sizes. Nowadays, developments in nanotechnologies and measurement techniques allow the experimental investigation of the magnetic and thermodynamic superconducting properties of mesoscopic samples in this regime. In this lecture, we will present theoretical models to describe such nanoscale superconducting systems and discuss possible new experimental phenomena we can predict within these theoretical models.

We will consider the theory of interactions between two nanoscale ferromagnetic particles embedded in a superconductor. In the London limit approximation, we show that the interactions between ferromagnetic particles can lead to either parallel or antiparallel spin alignment. The crossover between those is dependent on the ratio of the interparticle spacing and the London penetration depth. We will show that a phase transition between spin orientations can occur as the temperature is varied. Finally, we comment on the extension of these results to arrays of nanoparticles in different geometries.

In view of modern experimental data, we consider also composite nanowires made from both superconducting and ferromagnetic metals in the case of cylindrical geometry, where one metal forms the core of a nanowire, and the second forms an outer cylindrical sheath. Moreover, we analyze also the inverse situation, in which a normal or ferromagnetic core is surrounded by a superconducting sheath. In this case, it is interesting to examine the spectrum of Andreev bound states in the normal or ferromagnetic core.

S. *Kruchinin: Modern aspects of superconductivity: Theory of superconductivity. World Scientific, 308 p. (2021)*

Kleiner Hörsaal,
Linnéstraße 5, 04103 Leipzig

Alle Teilnehmer sind im Anschluss an den Vortrag (ab ca. 17:30 Uhr) zu einem Empfang mit Snacks und Getränken in der Aula eingeladen.