DENIS KOCHAN

Institute of Physics SAS

Project number
IM-2021-26

Project duration
1. 5. 2022 - 30. 4. 2027

"My vision is to build a competitive research group working in the highly-evolving field of superconducting spintronics, that would enrich, fortify and complement the existing scientific portfolio of the Institute of Physics of Slovak Academy of Sciences."

BIOGRAPHY

Denis Kochan studied theoretical and mathematical physics at Comenius University in Bratislava (title Mgr. in 2000, and PhD. in 2004). Later, he joined department of theoretical physics and worked there as an assistant till 2010. In 2010 he moved to University of Regensburg and joined the research group of Prof. Dr. J. Fabian, where he worked on topics involving 2D materials, spintronics and superconductivity. Research done in highly competitive and expanding fields of novel 2D materials and spintronics issued in several breakthroughing theoretical results and highly cited publications, what allowed him to get habilitation (Dr.habil. in 2020) and, as well as, the position of Privatdozent (PD in 2020) of the University of Regensburg. In 2021 Denis Kochan applied for a position within the prestigious IMPULZ 2021 Programme, got awarded (project Superspin) and was offered a position at Institute of Physics of Slovak Academy of Sciences in Bratislava, where he builds from May 2022 his own research group within the Research Center for Quantum Information (RCQI). Denis Kochan published around 40 peer-reviewed papers and co-supervised 8 PhD students, his research interests are focused on phenomena of (un)conventional superconductivity.

Superconducting spintronics & emergent phenomena in low-dimensional superconductors

Superconducting spintronics is vastly expanding field that strives to utilize spintronics phenomena and transfer its applications into the realm of superconductivity. While the latter can support dissipation-less charge transport, and also topologically protected (e.g. Majorana) modes, the former can make use of electron spin for encoding and processing information.

For these reasons, one may hope to launch a spin-driven superconducting device that would be, on one hand, very efficient in terms of energy demands, and on the other hand, would offer computational functionalities operating on quantum principles.

The beauty of the above idea rests in its simplicity, but as always, devil is hidden in details. To bring such spintronics vision into an operating platform one would need superconducting materials that promote unconventional pairing of electrons into Cooper pairs. Unfortunately, Nature does not give us “free of charge” unconventional superconductors with all those wonderful properties. However, it offers us, “smaller pieces of material-Lego” that when being proximitized along each other engender “synthetic hybrid systems” owning effective unconventional pairing. Such proximity effects, which are central to my proposal. From the specific point of views, my research ambitions within the IMPULZ 2021 programme count particularly two scientific projects:

A. Spin relaxation phenomena in low-dimensional (un)conventional superconductors,

B. Topological states engineered through proximity effect –``superconductivity on the edge''.

Both are centred around superconductivity in reduced dimensions and proximity effects, but point to different directions and delve into complementary physical aspects. Research Topics A continue on the safe way, where I have acquired a solid expertise and reputation during my stay in Regensburg. The Research Topics B step on a more exotic, but highly rewarding ground, where one can expect surprising experimental findings, and interesting theoretical concepts. It meanders around the hot field blending topology, effective field theory, and exotic states of matter that can be realized at interfaces of two materials with different order parameters (e.g. an ordinary superconductor and topological insulator).

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PUBLICATIONS

Top 5 publications count:

C. Baumgartner, L. Fuchs, A. Costa, S. Reinhardt, S. Gronin, G. Gardner, T. Lindemann, M. Manfra, P. Faria Junior, D. Kochan, J. Fabian, N. Paradiso, C. Strunk;
Supercurrent rectification and magnetochiral effects in symmetric Josephson junctions
Nature Nanotechnology 17 (1), 39 (2022)

D. Kochan, M. Barth, A. Costa, K. Richter, J. Fabian;
Spin Relaxation in s-Wave Superconductors in the Presence of Resonant Spin-Flip Scatterers, Phys. Rev. Lett. 125, 087001 (2020)

D. Kochan, S. Irmer, J. Fabian;
Model spin-orbit coupling Hamiltonians for graphene systems, Phys. Rev. B 95, 165415 (2017)

M. Gmitra, D. Kochan, P. Högl, J. Fabian;
Trivial and inverted Dirac bands, and emergence of quantum spin Hall states in graphene on transition-metal dichalcogenides, Phys. Rev. B 93, 155104 (2016)

D. Kochan, M. Gmitra, J. Fabian;
Spin relaxation mechanism in graphene: resonant scattering by magnetic impurities, Phys. Rev. Lett. 112, 116602 (2014)

https://orcid.org/0000-0003-0613-5996