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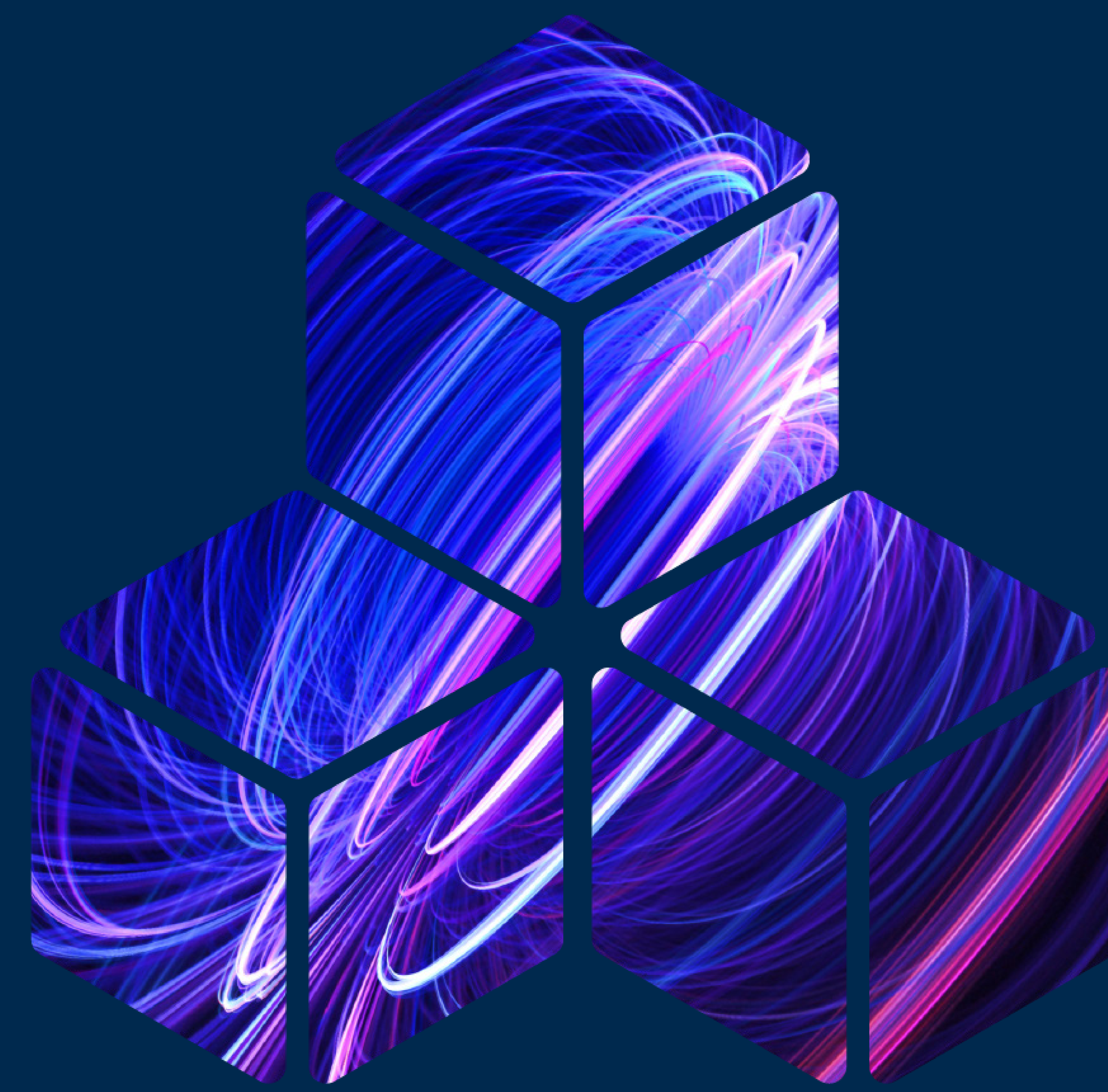

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Antiferromagnetic Tunnel Junctions for Spintronics

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Abstract: Antiferromagnetic spintronics has emerged as a subfield of spintronics, where the Néel vector is exploited to control spin-dependent transport properties. Due to being robust against magnetic perturbations, producing no stray fields, and exhibiting ultrafast dynamics, antiferromagnets can serve as promising functional materials for spintronic applications. Here, we predict the critical functionality of antiferromagnets, namely their ability to produce a strong electrical response to the state of the Néel vector, and, in addition, to generate sizable spin-transfer torques capable to switch the orientation of the Néel vector. These functionalities are achieved using antiferromagnets supporting a non-spin-degenerate Fermi surface in the absence of spin-orbit interaction. Due to their momentum-dependent spin polarization, such antiferromagnets can be used as electrodes in antiferromagnetic tunnel junctions (AFMTJs) to control spin-dependent tunneling. In the transport regime conserving electron's spin and transverse momentum, AFMTJ conductance is largely determined by the spin matching of the conduction channels of the two electrodes. If their relative momentum-dependent spin polarization changes in response to the Néel vector direction, the net conductance of the AFMTJ alters, thus producing a tunneling magnetoresistance (TMR) effect. In addition, we predict the existence of the Néel spin currents, i.e., staggered spin currents flowing through different magnetic sublattices, which can effectively transfer current-carrying spins between two antiferromagnetic electrodes resulting in a spin-transfer torque (STT). The predicted TMR and STT effects are comparable to those in well-known magnetic tunnel junctions based on an MgO barrier layer, thus demonstrating the efficiency of AFMTJs to control and detect the Néel vector in antiferromagnets.

Bio: Evgeny Tsymbal joined the University of Nebraska-Lincoln (UNL) in 2002 as associate professor, was promoted to full professor 2005, and was named Charles Bessey Professor in 2009 and George Holmes University Distinguished Professor in 2013. Prior to his appointment at UNL, he was a senior research scientist at University of Oxford, a research fellow of the Alexander von Humboldt Foundation at the Research Center-Jülich, and a research scientist at the Russian Research Center "Kurchatov Institute." From 2007 to 2021, Tsymbal served as director of an NSF-funded Materials Research Science and Engineering Center, and from 2013 to 2017, he also served as director of the Center for NanoFerroic Devices sponsored jointly by Semiconductor Research Corporation and NIST. Tsymbal's research is focused on predictive modelling of advanced functional materials relevant to nanoelectronics and spintronics. He a is co-author of more than 300 papers, review articles, and book chapters and is a co-editor of the three-volume "Spintronics Handbook: Spin Transport and Magnetism" published in 2019. He is a fellow of the American Physical Society and the Institute of Physics, and a recipient of the UNL's Outstanding Research and Creative Activity Award.

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