Nanoelectronics and spintronics are concerned with writing, transporting, and reading information stored in electronic charge and spin degrees of freedom at the nanoscale. Past few years have shown that two spintronics effects discovered in the 19th century, namely anisotropic magnetoresistance and anomalous Hall effect, can be used also for sensing antiferromagnetism which opened the field of antiferromagnetic spintronics. The more than a century of controversial studies of these effects have shown their relativistic spin-orbit coupling and spin-polarisation symmetry breaking origin. However, a complete understanding of these effects and a fully predictive theory capable of identifying novel suitable antiferromagnetic materials are still lacking.

Here, by extending modern symmetry and topology concepts in condensed matter physics, we have further developed the theory of anisotropic magnetoresistance and spontaneous Hall effect. Our approach is based on magnetic symmetry and topology analysis of antiferromagnetic energy bands, Bloch spectral functions, and Berry curvatures calculated from the state-of-the-art first-principle theory. This guided us to the prediction of two novel, previously unanticipated effects: relativistic metal-insulator transition from antiferromagnetic Dirac fermions, and crystal Hall effect from collinear antiferromagnetism. Signatures of both effects have been already observed, in collaboration with experimentalists, in Mn_2Au and RuO_2 thin films. Our results have contributed to the emergence of the field of topological antiferromagnetic spintronics. The field promises to provide unprecedented insights into many different physics problems, ranging from dissipationless currents to axion dark matter detection.