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PREFACE

Preface

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Topological matter, in which wave-function topology yields to new states of matter are gathering increasing interest from both fundamental and technological points of view. Research on Topological matter was triggered by the discovery of topological insulators [1] and, later on highlighted by the Nobel Prize in Physics 2016 to Thouless, Haldane and Kosterlitz for '*theoretical discoveries of topological phase transitions and topological phases of matter*' [2]. The interest in topological states begun in 2005 with the theoretical work of Kane and Mele, in which Quantum Spin Hall (QSH) phase could be realized in graphene with high spin–orbit coupling without the assistance of any external magnetic field [3]. This was followed by the theoretical demonstration of Bernevig *et al* [4] foreseeing the emergence of a QSH phase with single pair of helical edge states in thin enough HgTe–CdTe quantum wells. Shortly after, König *et al* [5] provided quite convincingly its experimental evidence. This string of achievements have triggered a flurry of impressive experimental and theoretical work on topological matter, yielding a vast literature, providing fine experiments and elaborated theories in search of materials and systems exhibiting topological properties.

This focus issue on Topological Matter includes some remarkable examples. From the theoretical side, Foa Torres [6] reviews the connection between topological states and non-Hermitian quantum mechanics with a special focus on Floquet systems, which are governed by periodic, time-dependent Hamiltonians. This view is particularly timely given that non-Hermitian Hamiltonians connect to the experimental progress in controlling dissipation in open classical and quantum systems. In a second example, Sanchez-Martínez *et al* [7] use first principle calculations to determine the electronic band structure of the chiral insulators Ag_3AuSe_2 and Ag_3AuTe_2, providing a beautiful connection with dark matter physics. In particular, showing high prospects of using those materials for dark matter detection. A similar approach based on first principle calculations is used by Lopez-Benzanilla *et al* [8], which compute the electronic band structure of two-dimensional (2D) uranium based compounds, showing unexpected topological features in their electronic band structure. Indeed, the interaction of strongly localized U anisotropic f-orbitals with the delocalized network of B p-orbitals in a bilayer honeycombed lattice is found to generate Dirac cones, which are further spin-split. Additionally, this topological phase of 2D UB_4 shows a heat capacity much larger than the heaviest 2D transition-metal dichalcogenides as well as an uncommon acoustic-optical gap resulting from the huge difference in the mass of the constituent atoms, all properties making such possible new 2D phase of great interest.

From the experimental side, this focus issue contains appealing examples. Inhifer *et al* [9] study topological states at the surface of the TI Bi_2Se_3 in metal/hexagonal Boron Nitride/Bi_2Se_3 capacitors, demonstrating the potential of microwave quantum capacitance techniques to probe topological surface states in the presence of parasitic density of states. This work echoes with another study published earlier on the fabrication of a graphene-based GHz frequency capacitor, enabling the design of plasma resonance transistors for microwave detection in the sub-THz domain for wireless communication and sensing [10].

Weyl and Dirac semimetals—another two remarkable examples of three-dimensional topological matter—are studied experimentally by Singh *et al* [11], showing a nontrivial correlation between carrier mobility and magnetroresistance effects in metal–monopnictides compounds, which would deserve further theoretical analysis. Finally, Ziese *et al* [12] present an experimental study of the anomalous Hall effect in $Pr_{0.7}Ca_{0.3}MnO_3/SrRuO_3$ supperlattices. Interfacing these two ferromagnets results in complex magnetic states and showing features of a topological contribution to the Hall effect. This work connects to the quest of manipulating topological effects combining strong spin–orbit coupling and magnetism in the perspective of generating new quantum phases such as the quantum anomalous Hall effect, as discussed earlier in reference [13].

Overall, this focus issue gives an interesting flavor of the diversity of topological matter and emerging physical phenomena in such materials, illustrating also the importance of theoretical studies to guide and support experimental research, whereas new exotic properties are also found to suggest novel applications in the field of quantum technologies.

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