# Preface

The charge density wave (CDW), which is a charge- and lattice-modulated state induced by the Peierls mechanism via Fermi surface nesting, is a classical and widely investigated subject in condensed-matter physics. It is well established in systems with quasi-one-dimensional electronic structures, for example, organic conductors such as TTF-TCNQ and transition-metal compounds (TMCs) such as $NbSe_3$. However, some TMCs with more isotropic two- or three-dimensional electronic structures exhibit CDW-like transitions although they are devoid of Fermi surface nesting; therefore, their mechanisms remain controversial. Such TMC-based systems typically feature multiband Fermi surfaces that can be decomposed into doubly degenerate $e_g$ orbitals and/or triply degenerate $t_{2g}$ orbitals. In some TMCs, the Fermi surface geometry can be reconstructed via orbital orderings to realize Fermi surface nesting and subsequent CDW transitions. Others host van Hove singularities near the Fermi level at high-symmetry momentum points, and their degeneracy can be lifted by orbital orderings or band Jahn–Teller-like distortions. In addition to the electron–lattice interaction that drives the Peierls transition, Coulomb interactions between d electrons are crucial in realizing orbital ordering and subsequent CDW or charge ordering. The mechanisms of such novel charge-orbital orderings in TMCs involve the relationship between the charge and orbital degrees of freedom via electron–electron and electron–lattice interactions. Furthermore, spin–orbit interactions may contribute significantly to CDW-like transitions in 4d and 5d TMCs.

TMCs with novel charge-orbital ordered states are currently receiving considerable interest because of the extensive development of transition-metal dichalcogenides as post-graphene materials. The present special topic focuses on $CsV_3Sb_5$, $Nb_3Cl_8$, $VTe_2$, $LiVS_2$, $IrTe_2$, and $CsW_2O_6$, which host such novel charge-orbital ordered states. Advanced experimental and computational techniques have enabled us to understand the complicated charge-orbital states, thus allowing us to establish new theoretical concepts;

Zhong, Yin, and Nakayama reviewed the electronic states of the Kagome superconductor $AV_3Sb_5$, which was investigated via angle-resolved photoemission spectroscopy, and discussed the CDW and superconductivity of this material;

Haraguchi and Yoshimura introduced van der Waals magnets and discussed the experiments based on $Nb_3Cl_8$, where a peculiar trimerization was observed, and reviewed the physics of related materials;

Mitsuishi and Ishizaka reviewed an exotic charge-orbital ordered state in $VTe_2$ and described its recent development via angle-resolved photoemission spectroscopy;

Katayama and Kojima discussed trimerization caused by molecular orbital formation and its precursory orders/fluctuations in $LiVS_2$ as well as the related triangular lattice system;

Hwang and Mo described the charge orders and superconducting properties of 1T-$IrTe_2$ and discussed the differences among its bulk, surface, and monolayer forms, thereby highlighting the importance of strong interlayer coupling;

Okamoto described studies pertaining to $\beta$-pyrochlore oxide $CsW_2O_6$, where a self-organization transition caused by multiple factors was mentioned, and discussed its properties based on comparison with other related materials.

The editors thank the authors for writing exciting and enlightening articles pertaining to popular research topics.

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