Preface

Celebrated Tanabe–Sugano papers were published in Journal of the Physical Society of Japan in 1954 [J. Phys. Soc. Jpn. **9**, 753–766 (1954); J. Phys. Soc. Jpn. **9**, 766–779 (1954)]. 3d transition-metal compounds and complexes often exhibit beautiful colors due to optical excitations between many-body states of $3d^n$ configurations (n: number of electrons in the 3d subshell). Usually, the transition-metal 3d electrons are under the cubic ligand field (or crystal field) which splits the five-fold 3d level into doubly degenerate e_g and triply degenerate t_{2g} levels. In these groundbreaking papers, Yukito Tanabe and Satoru Sugano proposed the Tanabe–Sugano diagrams in which many-body-state energies of $3d^n$ configurations are plotted as functions of the cubic ligand field 10Dq. Since then, the Tanabe–Sugano diagrams have contributed to a variety of scientific achievements including the invention of ruby laser, the development of spin-crossover complexes, and the elucidation of the functionality of hemoglobin. Even today, the Tanabe–Sugano diagrams have significant impacts on various fields of science including physics, chemistry, and materials science. The year of 2024 marks the 70th year after the publication. To commemorate this occasion, we have organized a Special Topics entitled "70 Years of the Tanabe–Sugano Diagrams" to discuss the current and future scientific issues related to the Tanabe–Sugano diagrams and ligand field theory.

In this Special Topics, Norimichi Kojima discusses the dynamical phenomena of spin-crossover complexes containing mixed-valence Fe ions and reviews the concerted phenomena involving spin, charge, and photons.

Atsushi Fujimori explores the relationship between ligand field theory and configuration interaction theory and reviews the physics of satellite peaks in photoemission spectra and compounds with negative charge-transfer energy.

Naoya Iwahara examines the dynamical Jahn–Teller effect in 4d/5d transition metals in octahedral environments, focusing on its manifestations in recent resonant inelastic X-ray scattering measurements and cooperative phenomena driven by it.

Masato Mochizuki discusses how various magnetoelectric phenomena in multiferroic perovskite manganites with spiral spin structures can be explained from a simple microscopic model.

Akihiko Ikeda and coauthors investigate the magnetic-field induced spin crossover in $LaCoO_3$ and review their high magnetic field study on the compound including their development on high-magnetic field generating systems.

Ashish Chainani and coauthors apply ligand field theory to element-specific electronic structure studies of rare earth-transition metal ferrimagnets using modern X-ray spectroscopy.

Robert Green and George Sawatzky review variations of charge-transfer energy in a wide range of transition-metal compounds, discussing the role of ligand holes in systems with negative charge-transfer energy.

Editors thank the authors for writing the enlightening articles. It is our great pleasure if this Special Topics will inspire future research related to transition-metal compounds and complexes.

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