Trend of Strongly Correlated Electron Research ; Superconductivity and Quantum Fluids

Supercond **Historical Background of Condensed Matter Physics** Semicond. Metal, Insulator

Coventional Superconductors
＝BCS mechanism
SC mediated by lattice vibrations

Effective theory of weakly correlated systems

Landau Fermi Liquid & Electronic Structure Calculation
Basis of Success in Semicondutor Industry in 20C.

Discoveries of various strongly correlated materialsin late 20C. transition metal oxides(cuprates etc.), organic conductors, rare-earth compounds

Strongly correlated materials; essential many−body effects

Discovery of High-Tc Supercond.
copper oxides, iron-based compounds

Emergence of Novel Quantum Fluids
Tomonaga-Luttinger, fractional quantum Hall, BKT phase
Emergence of Topological Materials

Challenge to theory and experiments

Revolutions in Spectroscopy
that eneblaes direct measurenment of strongly correlated quantum dynamics
ARPES, STM / QPI, RIXS
More than three orders improvement in resolution
Qualitatively new data

Innovations in Concepts & Computational Methods
★Concept：New quantum fluid picture
1. Fractional particle, Composite particle; Emergent particles
Unprecedented nature & superior functionality
beyond existing elementary particles
ex： spinon in quantum spin liquids, Majorana particles
2.“Quantum soup”, “unparticle”
Proposals essential for high-Tc SC ex. Planckian fluids
★Quantum many-body calculation, higher accuracy codes
(mVMC (variational MC), tensor network, neural network)
★Multiscale *ab initio* scheme for correlated electrons（MACE)