5th CDS Seminar

Date: February 20th (Fri.), 2026

Time: 13:30-15:00

Place: Room 913, Department of Physics, Univ. Tokyo

Zoom: https://u-tokyo-ac-jp.zoom.us/j/89400057400?pwd=YkWvzNT26zUEVrbfuGM6aW2ABhwrVC.1

Speaker: Junmo Jeon (Sophia University)

Title: Quantum hyperuniformity and quantum weight

Abstract:

In statistical mechanics, hyperuniformity [1] has been established as a powerful geometric framework to classify spatial distributions of points or classical variables in terms of their long-wavelength density fluctuations. Despite its broad success in classical settings such as point distribution and classical many particle systems [2,3], its applicability to quantum many-body systems—where density fluctuations are known to be strongly influenced by intrinsic quantum effects originating from quantum statistics—has remained largely unexplored.

In this talk, I extend the concept of hyperuniformity to quantum many-body systems by incorporating intrinsic quantum fluctuations and introduce a quantum hyperuniformity classification based on the infrared scaling of the static structure factor [4]. I also identify a quantum-geometric quantity encoded in the ground state, namely the quantum weight [5] by separating classical and quantum contributions to the structure factor.

Applying this quantum hyperuniformity classification to quasiperiodic systems, I show that the infrared scaling of the static structure factor provides a clear criterion for distinguishing gapped and gapless electronic states. I further demonstrate that the classical and quantum contributions play complementary roles, enabling the identification of localized, extended, and critical phases within the hyperuniformity classification framework. Finally, I unveil a universal relationship between the quantum weight and the spectral gap size, allowing quantitative gap information to be extracted from static ground-state correlations alone.

[1] S. Torquato and F.H. Stillinger: Local density fluctuations, hyperuniformity, and order metrics, Phys. Rev. E. **68** 041113 (2003)

[2] S. Torquato: Hyperuniform states of matter, Phys. Rep. **745** 1 (2018)

[3] S. Sakai, R. Arita and T. Ohtsuki: Quantum phase transition between hyperuniform density distributions, Phys. Rev. Res. **4** 033241 (2022)

[4] J. Jeon and S. Sakai: Quantum Hyperuniformity and Quantum Weight, arXiv: 2601.18331 (2026)

[5] Y. Ohishi and L. Fu: Quantum weight: A fundamental property of quantum many-body systems, Phys. Rev. Res. **7** 023158 (2025)