Quark-hadron duality for $D^0-\overline{D^0}$ mixing in the 't Hooft model

Dr. Hiroyuki Umeeda (Academia Sinica)

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SC427, Science Building III, NYCU

Abstract: Theoretically analyzing the $D^0-\overline{D^0}$ mixing is regarded as a challenging topic due to the difficulty in dealing with charm quark, which has a characteristic mass scale. In particular, the inclusive analysis based on the lowest-dimensional operator product expansion gives the value that is $\mathrm{O}(10^{-4})$ times smaller than the experimental data. One possibility to interpret the mismatch is that quark-hadron duality, an assumption adopted entirely in the heavy quark expansion (HQE), is violated, leading to a sizable correction. Duality violation gives rises to non-perturbative uncertainties that are hard to quantify, and is considered a major obstacle in the HQE.

In this work, we study quark-hadron duality for the heavy meson mixings, on the basis of the 't Hooft model, offering a laboratory of QCD in two-dimensional spacetime. This is a solvable model so that masses and wave functions of mesons can be unambiguously determined within the formalism. We calculate (1) the inclusive rate and (2) sum of the exclusive rates, where the latter is obtained by solving QCD, and compare (1) and (2) in order to investigate local duality and its violation. We show that the realization of local duality is analytically seen in the massless limit of light quarks. Moreover, for massive quarks, the preliminary results on local duality are given numerically by evaluating the decay amplitude for exclusive processes.