June 20 (Fri.) 11:00 – 12:00

Photo-induced Tomonaga-Luttinger-like liquid in a one-dimensional Mott insulator

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We theoretically study the non-equilibrium quantum phase transition in strongly correlated electron systems when strong AC electric fields are applied to the Mott insulator. The time-dependent density matrix renormalization group method is used to calculate the nonlinear optical conductivity for the half-filled one-dimensional Hubbard model, where we have found an emergence of metallic states that have a linear dispersion within the energy gap. This indicates that the photo-doped carriers behave collectively as in the Tomonaga-Luttinger liquid. A non-equilibrium phase diagram for the photo-induced insulator-to-metal transition is then proposed. We further show that the numerical result is similar to an analytic result for an effective Dirac model, where the Floquet method is employed to incorporate the effect of strong electric fields.