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Dynamical crossovers, universality and long-range interactions of excitons on carbon nanotubes JEREMY ALLAM, TARIQ SAJJAD, RICHARD SUTTON, SOPHIA SIDDIQUE, ZHONGYANG WANG, KONSTANTIN LITVINENKO, University of Surrey, QUAN-HONG YANG, Tianjin University, TOM BROWN, University of Southampton, WEI LOH, University of Southamp — Simple microscopic interactions in non-equilibrium systems give rise to complex emergent macroscopic phenomena. There has been much theoretical work to understand dynamics of different systems, and equilibrium concepts of scaling, criticality and universality have proved useful. However there is a noted lack of experimental studies. Here we show that exciton reactions on carbon nanotubes display the rich kinetics of the prototypical 1D coalescence reaction A+A->A. An Auger-like exciton interaction[1] and anomalous kinetics[2] have already been reported. Here we demonstrate the existence of four distinct dynamical regimes: (1) early dynamics determined by spatial ordering of excitons due to Pauli repulsion at high concentrations; (2) a classical mean-field region with exciton population n decaying as t^{-1}; (3) a self-organized critical state with anomalous reaction kinetics limited by diffusion and characterized by $n \sim t^{-1/2}$, which we show to be universal with respect to the initial population; and (4) an exponential approach towards an absorbing state corresponding to one exciton per nanotube. The abrupt crossover between regimes indicates a long-range exciton interaction, which introduces a non-scaling dimension that breaks universality at intermediate length-scales.

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[1]Y.-Z. Mae tal, Phys Rev Lett 94, 157402 (2005).
[2]R. A. Rossi et al. Phys Rev B 74, 041405 (2006).

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