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Surprising applications of the zero number: phase transitions, DNA replication, and twist maps

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Bernold Fiedler developed the zero-number in a number of seminal papers as the main tool in describing dynamics of scalar semi-linear parabolic differential equations on bounded domains. We show that this tool can be adapted to study of such equations on unbounded domains, their discrete-space analogues (the Frenkel-Kontorova models), as well as these equations with a random force. The idea is to consider the expectation of the zero number with respect to a measure on the phase space, and its evolution. We show that this tool can be used to describe invariant probability measures of the considered equations, which leads to rigorous results on phase transitions. This could be applied to various physical phenomena modeled with these equations, including Charge Density Waves, Josephson Junction Arrays, and DNA replication. Finally, we outline a line of attack to solving one of the key open conjectures of Hamiltonian dynamics: positive metric entropy of twist maps, by using the same tool.