Non-equilibrium phase transitions in one-dimensional models with long-range interactions

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An interaction potential is considered long range if it scales at greater distances as $r^{-\alpha}$ with $\alpha < d$, with r the inter-particle distance and d the spatial dimension. They present interesting phenomena such as microcanonical negative heat capacity and temperature jumps at first order phase transition. Examples include gravitational systems, charged plasmas and wave-particle interactions [1]. After an initial violent relaxation [2, 3] the system evolves to a QSS and stay in such regime for times that diverge with number of particles.

Nonequilibrium phase transitions in the Hamiltonian Mean Field model [4] have been studied in the last years, in the context of Lynden-Bell theory (See [5, 6, 7] and references therein), considering initial waterbag states with a given magnetization, and determining the final magnetization after the violent relaxation. More recently we have shown that the corresponding phase diagram is more intricate than had been previously predicted [8], with a cascade of phase transitions associated to reentrant phases occurring when varying the initial magnetization or energy. Here we extend our previous work to the whole region of the energy-magnetization parameter space using a parallel implementation on GPU's of a solver of the Vlasov equation [9], and extend this analysis to the Ring Model [10], a simplified model of self-gravitating particles on a ring, where a similar phenomenology is observed.

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