The Abdus Salam
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for Theoretical Physics

**Conference on Long-Range Interacting Many-Body Systems:
from Atomic to Astrophysical Scales
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Venue: ICTP Leonardo da Vinci Building - Budinich Lecture Hall
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Title:
Temperature inversion in long-range interacting systems, from atomic to astrophysical scales

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Abstract:

Temperature inversions occur in nature, e.g., in the solar corona and in interstellar molecular clouds: somewhat counterintuitively, denser parts of the system are colder than dilute ones. We try to understand which are the minimal ingredients and the basic physical mechanism behind such phenomena. We argue that temperature inversions may spontaneously occur in a generic many-particle classical Hamiltonian system with long-range interactions that is prepared in an inhomogeneous thermal equilibrium state and then brought out of equilibrium by applying an impulsive perturbation or by quenching some parameters of the Hamiltonian. In similar situations, short-range systems would typically relax to another thermal equilibrium, with uniform temperature profile. By contrast, in long-range-interacting systems, the perturbation induces collective oscillations and the interplay between wave-particle interaction and spatial inhomogeneity drives the system to nonequilibrium stationary states that generically exhibit nonuniform temperature profiles with temperature inversion. We demonstrate our findings by means of numerical simulations of simple mean-field toy models as well as of semiclassical models of cold atoms in a cavity and of two-dimensional self-gravitating systems, modeling nearly cylindrically-symmetric filaments in interstellar clouds. In the latter case we observe temperature inversion not only after perturbing a thermal equilibrium state, but also in cold collapses, that are believed to be the way these structures form, thus implying that dissipative processes are not necessary to obtain temperature inversions. In the case of models of condensed matter systems we show that temperature inversions triggered by quenching an external field may in principle be used to cool the system.