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Reaction-diffusion equation for quark-hadron transition in heavy-ion collisions

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Reaction-diffusion equations with suitable boundary conditions have special propagating solutions which very closely resemble the moving interfaces in a first order transition. We show that the dynamics of chiral order parameter for chiral symmetry breaking transition in heavy-ion collisions, with dissipative dynamics, is governed by one such equation, specifically, the Newell-Whitehead equation. Further, required boundary conditions are automatically satisfied due to the geometry of the collision. The chiral transition is, therefore, completed by a propagating interface, exactly as for a first order transition, even though the transition actually is a crossover for relativistic heavy-ion collisions. Same thing also happens when we consider the initial confinement-deconfinement transition with Polyakov loop order parameter. The resulting equation, again with dissipative dynamics, can then be identified with the reaction-diffusion equation known as the Fitzhugh-Nagumo equation which is used in population genetics. We discuss the implications of these results for heavy-ion collisions. We also discuss possible extensions for the case of early universe.

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