Lattice Boltzmann study of pattern formation in a convective-reaction-diffusion model.

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Reaction-diffusion process taking place in moving media are of considerable importance in combustion, atmospheric chemistry and ecology. Under gravity field, density changes triggered by reaction and diffusion of passive scalar components may lead to convection which, in turn, can significantly affects on the nature and dynamics of patterns formed by theses processes. In this work, we investigate the effects of the buoyancy driven convection on Turing patterns within the Gray-Scott model. We study the coupled Gray-Scott reaction-diffusion model supplemented with convection and the underlying hydrodynamics equations. We observe that modification of the original Gray-Scott model by convection leads to a variety of oscillatory and stable patterns that bears resemblance to vegetation patterns along rain fall gradients [Meron et al., Chaos, Solitons and Fractals, 19, 367 (2004)] and pigmentation patterns in fish [Miyazawa et. al. Nat.Commun.,6,(2010)]. We present linear stability analysis of the ensuing advection-reaction-diffusion (ARD) equation coupled with the hydrodynamic equation and show that, by a suitable choice of the gravity, the solution can be made stationary in time. In this case, lattice Boltzmann simulation of the model shows that the solution is indeed characterized by stationary horizontal stripes perpendicular to the gravitational field. We further show that in the regime characterize with stable hexagonal structures and spots, suitably adjusting the gravitational field can lead to a transition between spots and stripes.