CONVECTIVE INSTABILITY INDUCED BY NONLOCALITY

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A convective instability happens when a state of a nonlinear system becomes unstable and a localised perturbation grows while moving but eventually decays at any point. In this regime, a state different from the original one cannot be established unless it is *sustained by noise*. Small regions of convective instabilities have been predicted and observed in hydrodynamics, plasma physics and optics, due to spatial drift terms [1]. Here, instead, we study nonlinear systems with *two-point nonlocal coupling* of the dynamical variable in any spatial point x with the value at the shifted point $x + \Delta x$. We consider a very broad class of nonlinear diffusion equations:

$$(\partial_t - \partial_x^2)\phi(x,t) = f_1(\phi(x,t);\mu) + f_2(\phi(x+\Delta x,t);\mu)$$

where μ is a control parameter and f_1, f_2 are real functions that can be derived with respect to ϕ. Equations of this type arise in nonlinear systems with diffraction-free optical feedback and are an interesting generalisation of more standard nonlinear diffusion equations common in many other fields.
By using a non-perturbative analytical approach we are able to analyse the dispersion relation of all the uniform states and to calculate the convective and absolute thresholds. We find a huge window of convective instability and we confirmed numerically these general predictions in specific nonlocal nonlinear models [2].
We expect that experiments with nonlocal nonlinearity will exhibit a dynamics dominated by noise and boundary effects in a very large region of control parameters. As a matter of fact two-point nonlocality is a general phenomenon in optics, arising in all feedback or cavity devices in which counter-propagating beams overlap partially on a non-linear medium. We will present preliminary results when also diffraction is taken into account.

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[2] F. Papoff et al, Phys. Rev. Lett. **94**, 243903 (2005); R. Zambrini et al, Phys. Rev. E **73**, 016611 (2006).