On the Morphology of Turing Instability under Microscopic Transport

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One of the most important systems able to generate organization through pattern formation is the Turing instability[1], it is liable for morphogenesis in the living organisms, which explains, for example, the colour of pattern on fish skin or on the seashells. Usually in Nature pattern formation does not occurs in isolated reaction system but in presence of external forcing, as the influence of the temperature or density gradients, and even, in presence of certain types of periodical forcing or luminous flows.

In this work we study, theoretically and experimentally, the dynamical response of macroscopic Turing patterns subjected to a mechanical periodic forcing which implies a sinusoidal modulation of gravity. Theoretical predictions indicate that the extra energy due to the forcing, and the reactor characteristics (that prevent flows to occur) modifies the diffusion coefficient at a microscopic level[2], producing changes in the domain where Turing stability appears and also in pattern characteristics[3], as its configuration or wavelength.

In addition, Turing structures appear naturally under different configurations such as stripes and spots as well as mixed states. And the traditional tool to characterize these patterns is the Fourier transformation, which accounts for the spatial wavelength, but it presents difficulties in order to discriminate among the structures just cited previously (see Fig.1). Thus we propose a method based on the Minkowski functional[4] that, in a clearly way, differentiates all spatial configurations, giving a supplementary information about their transitions between each other. This method was successfully tested on a steady and temporally evolving Turing patterns[5].

The authors want to enhance the relevance of the study here presented. Since, on the one hand, it can be applied to other situations where external forcing influences transport in the system through diffusive mechanisms but when no flow or convection is allowed, and in the other hand, as our morphological method results an useful technique to identify the morphology and characterize possible transitions among a great diversity of dynamical spatiotemporal structures.

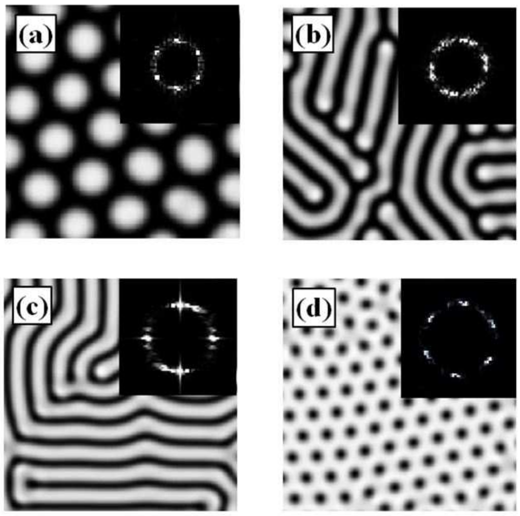

FIG. 1. Numerical simulation of Turing patterns using Oregonator model a) Hexagonal pattern (white spots). b) Direct labyrinth structure (white stripes). c) Reverse labyrinth structure (black stripes). d) Reverse hexagons (black spots).

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