# Pattern Transitions in Unstable Viscous Convective Medium

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**Abstract.** Convection in a thin layer of liquid (gas) with temperature dependent viscosity between poorly heat conducting boundaries is studied within framework of the Proctor-Sivashinsky model. This model is examined in order to study both the flow pattern formation and the second-order structural phase transitions as between patterns with translational invariance as well as between structures with broken translational invariance but keeping a long-range order. The spatial spectrum of arising patterns and estimation of their visual defectiveness are analyzed. The relation between the density of pattern defects and spectral characteristics of the pattern is found. We also discuss the noise effects on the formation of pattern defects. The influence of temperature dependence of viscosity on the process of pattern formation and structure transformations is also discussed. It is shown that the temperature dependence of viscosity inhibits structural transition from regular rolls to square cells.

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## 1. Introduction

The mechanisms of pattern transformations and second-order structural-phase transitions between different patterns that result in changes of their symmetry and partly of their characteristic scales have always been of great interest to researchers and developers of technologies.

Considering the various processes in continuous media, we need to take into account the dynamics of perturbations with not only different spatial and temporal scales but also with different spatial orientation [1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11]. The last one is responsible in the common geometric sense for the spatial structure symmetry, which possess not only short-range but also long-range order [12, 13].

The nonlinearity of the medium manifests itself in certain mechanisms of interaction between these perturbations. Different approaches to the description of such interaction

demonstrates all the characteristics of the second order phase transition (the continuity of the sum of squared mode amplitudes over the spectrum $I = \sum_j a_j^2 \equiv \sum_{k_j} |a_{k_j}|^2$or that the same, the continuity of density of this value and discontinuity of its time derivative $\partial I/\partial t$ ). The crucial issue discussed in this paper is the determination of the degree of defectiveness (pattern imperfection) of originating regular structures and also the searching for a correlation between integral spectral characteristics and a fraction of defective cells in the structure. The defectiveness of the structure appears, in particular, in the intermediate transient regimes and is caused by stimulated (due to non-equilibrium) interference of growing modes [32]. In the case of the external influence, the noise is able to support the set of weak spatial modes which were suppressed before and which interfere with dominating modes is also capable to provide the interference pattern corresponding to the imperfect spatial pattern. The understanding of processes which lead to violations of spatial periodicity of the structure, would allow estimating the level of pattern imperfection by their spatial spectrum that can be quite possible measured experimentally. Especially, it should be clarified the influence of external noise on stability of states and structural-phase transitions.

The existence of preferred scale (the distance between the regular spatial perturbations) and the possibility to select the type of symmetry (the regular spatial configuration) motivate the interest to this physical model, particularly for description of processes in solid state physics, where the characteristic distance between elements of spatial structures (atoms, molecules) in their condensed state is almost invariable.

It is also shown below that the intermediate states with broken short-range order, but keeping a long-range order can appear as a result of structural-phase transitions (second order phase transitions) and demonstrate the same formation dynamics, as the regular spatial structures.

The objective of this work is investigation of the mechanisms of pattern formation and mode competition in convective medium. The nature and evolution of structural phase transitions between patterns of different topology are considered in detail. Besides the regular periodic structures, we also analyse the imperfect patterns i.e. the structures with implemented spatial defects.

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