COMMENTS

Comments are short papers which criticize or correct papers of other authors previously published in the **Physical Review**. *Each Comment should state clearly to which paper it refers and must be accompanied by a brief abstract. The same publication schedule as for regular articles is followed, and page proofs are sent to authors.*

Comment on "Spiral-pattern formation in Rayleigh-Bénard convection"

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In a recent Rapid Communication [Phys. Rev. E **47**, R2987 (1993)] H.-w. Xi, Gunton, and Vinals report on a numerical investigation of an extension of the Swift-Hohenberg equation including mean flow effects as well as non-Boussinesq effects. They claim that the basic mechanism for the formation of spirals are the non-Boussinesq effects. In contrast to H.-w. Xi *et al.*, we had shown in a previous publication [M. Bestehorn *et al.*, Z. Phys. B **88**, 93 (1992)] that models describing a Boussinesq fluid may also spontaneously form spatially extended spirals if nonvariational extensions of the Swift-Hohenberg equation are used.

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With great interest we saw H.-w. Xi, Gunton, and Vinals [1] present numerical results on generalized Swift-Hohenberg (SH) equations. However, several comments are in order.

Xi, Gunton, and Vinals conclude that "the quadratic nonlinearity in the equation is responsible for the symmetry breaking and leads, by itself, to stationary spiral patterns." However, it has been shown in [2,3] for the first time that hexagons are formed in that case, and we also computed transitions from hexagons to more or less parallel rolls. The same has been done in a circular geometry as well, which was first published in [4]. In all these runs we never found any hint about the creation of spirals or even bended rolls. This work was extended in [5] by including the additional heating at the lateral boundary. Furthermore, in [6] as well as in [7] it is mentioned that a stable spiral pattern exists without quadratic nonlinearity. The fact that a stable spiral pattern is unstable by removing the quadratic nonlinearity, as mentioned by Xi, Gunton, and Vinals is not a proof that this nonlinearity is responsible for the existence of the spirals. Rather, the amplitude of the pattern decreases and the boundary conditions, i.e., the sidewall forcing, becomes dominant and forces the pattern to circular symmetry. If, in addition, the sidewall forcing would have been changed to a smaller value, the spiral would remain stable.

A further claim by Xi, Gunton, and Vinals is that "spirals are not obtained with mean flow but without quadratic nonlinearities." This is obviously not the case, as we have shown in a previous publication [8]. If the mean flow is taken into account by the model first proposed by Manneville [9], and investigated in [8] and also by Xi, Gunton, and Vinals we found the spontaneous formation of spirals even for the case of a Boussinesq flow [$g_2=0$ in Eq. (1) of [1]] and without the somewhat artificially chosen sidewall forcing field $f(r)$. An example of the spontaneous formation of a spiral from a random initial condition is shown in Fig. 1. We looked not only at the case of a spiral initial condition as stated erroneously in [1], but also obtained transients from random dot initial states or hexagons to spirals. We explicitly demonstrate this fact in Fig. 1, where the formation of spirals in a model without quadratic nonlinearity is shown. Therefore, we feel that the conclusion of Xi, Gunton, and Vinals that a quadratic nonlinearity is essential for the formation of a spiral is wrong.

Our conclusion concerning spiral pattern formation in Rayleigh-Bénard convection is quite different: It is not the quadratic nonlinearity that leads to the formation of spirals, rather it is nonvariational terms such as terms arising from the modeling of the coupling to mean flow effects are responsible. It seems to us that the spontaneous creation of spirals has to be considered as arising from nonvariational effects, similarly to the creation of defects in roll patterns.

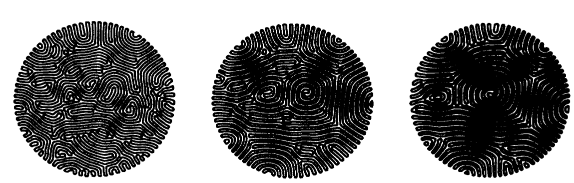
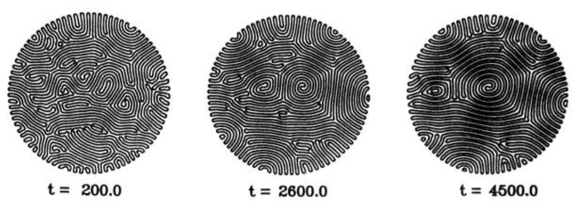


FIG. 1. Spontaneous formation of spirals from a random initial condition without non-Boussinesq effects and without lateral heating. If we fix the values for the temperature field on the sidewall, we obtain rolls parallel to the wall and spirals in the bulk. The essential mechanism for spiral formation is the influence of a large-scale mean flow, caused by the low Prandtl number (for details, see [8]).

[1] Hao-wen Xi, J. D. Gunton, and Jorge Vinals, Phys. Rev. E **47**, R2987 (1993).
[2] M. Bestehorn and H. Haken, Phys. Lett. A **99**, 265 (1983).
[3] H. Haken, *Advanced Synergetics,* 2nd ed. (Springer Berlin, 1987).
[4] R. Friedrich, M. Bestehorn, and H. Haken, Int. J. Mod. Phys. B **4**, 365 (1990).
[5] M. Bestehorn and C. Pérez-García, Physica D **61**, 67 (1992).
[6] M. Fantz, R. Friedrich, M. Bestehorn, and H. Haken, Physica D **61**, 147 (1992).
[7] M. Bestehorn, M. Fantz, R. Friedrich, H. Haken, and C. Pérez-Garcia, Z. Phys. B **88**, 93 (1992).
[8] M. Bestehorn, M. Fantz, R. Friedrich, and H. Haken, Phys. Lett. A **174**, 48 (1993).
[9] P. Manneville, J. Phys. (Paris) **44**, 759 (1983).



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