A simple model for clonal-growth plants

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Vegetation patterns have been widely studied in arid ecosystems [1, 2]. These patterns cover regions of kilometers being an impressive example of self-organization. Water scarcity is usually the limiting factor which drives the ecosystem to form these spatial patterns. However, beyond the case of terrestial ecosystems it have been shown that submarine patterns can also appear in clonal plants such as *P. Oceanica* [3], obviously being the responsible mechanism completely different.

Clonal plants form meadows which cover large extensions under the sea. These meadows provide suitable environmental conditions to support a huge biodiversity, creating one of the most important ecosystems in the world. Thus, the present degradation of these habitats becomes an important issue to overcome. From this perspective, a spatial pattern of vegetation can have a dramatic influence on the functionality of the ecosystem. The characterization of these spatial structures and their dynamics is a crucial point for the preservation of these habitats.

The growth of clonal plant meadows is well described by the Advection-Branching-Death (ABD) model [3]. However, the computational cost is high and the analytical results limited, not being the most suitable model to understand generic features of the dynamics of patterns. The reason of this inconvenience is the fact that clonal growth has to be described taking into account the densities of plants growing in all directions. This introduces in the model, which is initially defined on two-dimensional space, the growth angle as an extra variable. However, the dynamics of the patterns is not critically influenced by the direction of growth. This fact allow us to reduce the problem to two spatial dimensions, being the resultant simplified equation much more tractable than the complete model.

Furthermore, the terms which we obtain from the derivation are the result of the intrinsic mechanisms of growth on the ABD model, giving qualitative insight in the understanding of clonal growth. In addition, the derivation establish a relation between the parameters of both models, providing a simple tool that can give quantitative results and that can be compared with the ABD model and real data.
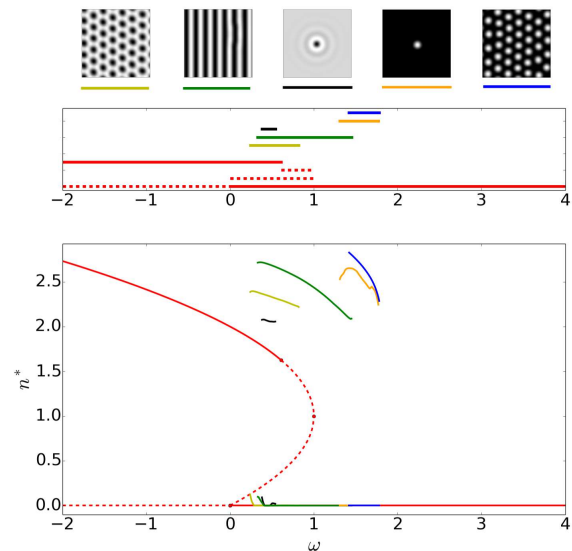

Fig. 1. Bifurcation diagram showing the homogeneous solutions and patterns for the simplified model. The stable (unstable) homogeneous solution is plotted in red (dashed red). The stable part of the five branches associated to each pattern is shown where the maximum and minimum of the density are plotted. From left to right negative hexagons (light green), stripes (green), negative soliton (black), positive soliton (orange), positive hexagons (blue). In the upper plot it is depicted the region of existence only in the control parameter ω, to simplify visualization.

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