Dynamics of pattern selection in a high-density experimental model of phyllotaxis

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Résumé

Phyllotaxis describes the arrangement of leaf-like organs in plants, called primordia, into well-defined patterns. These patterns exhibit clockwise and anti-clockwise spirals, called parastichies, whose numbers are often part of the Fibonacci sequence. This is the case for pine cones, as shown in Figure 1 (left). The ability of plants to reproduce these surprising patterns with high precision and robustness is a central question in phyllotaxis research, as around 91% of plants exhibit Fibonacci spirals (4). This prevalence motivates biologists and physicists to investigate the processes behind the patterns resistance to noise, either by recording and quantifying the development of the organs (1) or by studying the impact of irregular initial conditons on their models (3).
To better understand the underlying mechanisms of phyllotaxis robustness, we conduct experiments inspired by the work of S. Douady and Y. Couder (2), in which ferrofluid droplets injected at the center of a circular bath at a constant frequency create Fibonacci spirals. In our experiment, water droplets are electrically charged at the tip of a conductive needle using a high-voltage amplifier. They are released periodically at the center of a bath filled with silicone oil and interact through long-range repulsive forces that drive them away from one another. These interactions create dense spiraled patterns such as the one shown in Figure 1 (right). This setup enables us to reach higher droplets densities and to explore more complex organization patterns than in previous realizations, in particular with a larger number of spirals. By numerically tracking the droplets positions over time, we quantitatively probe how the spiral structure emerges and evolves, providing dynamic access to the pathways through which structures nucleate and reorganize.

References

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