# A pattern generating model inspired by plant phyllotaxis: Analysis of requirements and capabilities

Patrik Sahlin[1,*], Bo Söderberg[1], and Henrik Jönsson[1]
1. Department of Theoretical Physics, Lund University, Sweden
*E-mail: sahlin@thep.lu.se

## Abstract

Plant phyllotaxis, the arrangement of leaves and other plant organs, has been an inspiring field of study as these arrangements are closely related to sequences and patterns otherwise found in mathematics and physics. Terms from the Fibonacci series can be found in spiral patterns and the golden angle can often be measured between the radial direction of two consecutive elements. It has been shown that Fibonacci phyllotaxis can be achieved from a combination of a growing apex and a suitable spacing mechanism for primordium initialisation. Here we analyse a model based on polarised auxin transport as a candidate for such a spacing mechanism.

The model is based on the interactions between the plant hormone auxin and the auxin efflux carrier PIN1. In our model auxin is responsible for activation of primordium development. Auxin is transported between cells by a passive diffusion-like transport, but also by an active PIN1-dependent transport. PIN1 is assumed to be polarised according to auxin concentrations in neighbouring cells. These interactions result in a positive feedback where auxin is driven towards peaks of concentrations.

We show that the model is able to generate regular patterns with peaks separated by an average distance dependent on parameter values (see Figure 1). The model has been analysed by linearisation around the homogenous fixed point and the analysis shows a close correlation to numerical simulations.

We have found a close relationship between the PIN1-cycling and the mechanism for active auxin transport. This relationship gives us restrictions on parameter values for regions in parameter space where pattern formation from a homogenous state is possible.

We have also studied, by a sensitivity analysis, how the model depends on parameter values close to experimentally estimated values. Furthermore we have performed a numerical investigation of a larger parameter space where regions generating patterns different from peaks can be found (see Figure 2).

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## References

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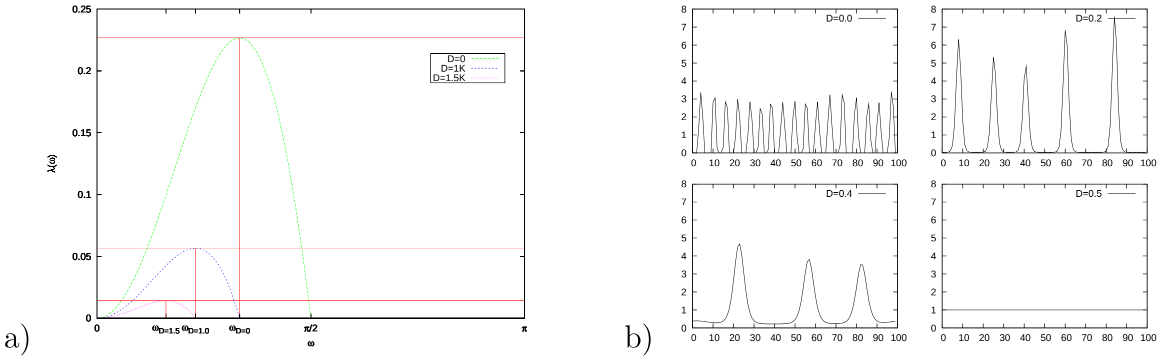

Figure 1: Changing parameter values changes the frequency of the pattern. a) The eigenvalue distribution for the Jacobian matrix. Each eigenvalue and its eigenvector correspond to a frequency. The eigenvector corresponding to the greatest positive eigenvalue will dominate the pattern around the homogenous fixed point. Thus by adjusting the parameters the eigenvalue distribution will change and also the frequency of the pattern. b) Four example simulations with cells located on a one-dimensional lattice with a periodic boundary condition. A selected parameter has been altered between each simulation to demonstrate that the choice of parameter values determines the frequency of the pattern.

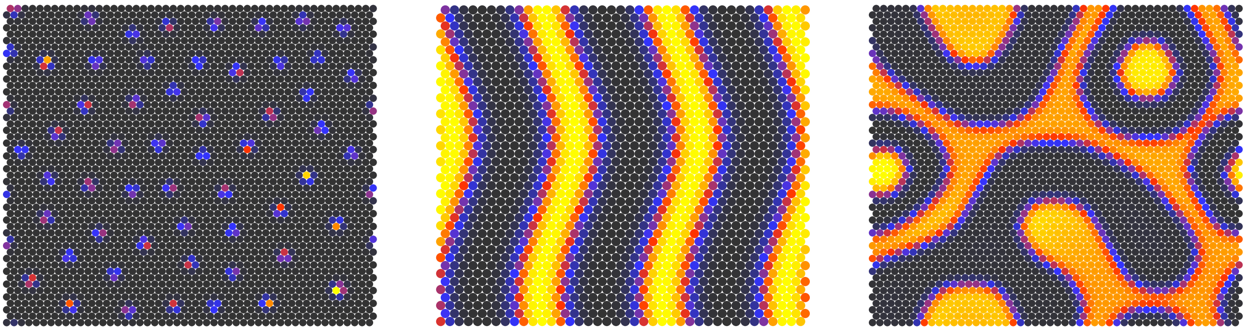

Figure 2: Three example simulations with different transport and feedback mechanisms. The regulated transport model proposed has the capability of generating different kinds of patterns, very similar to a reaction-diffusion mechanism.