Qualitative inference

Designing attractors for biological models

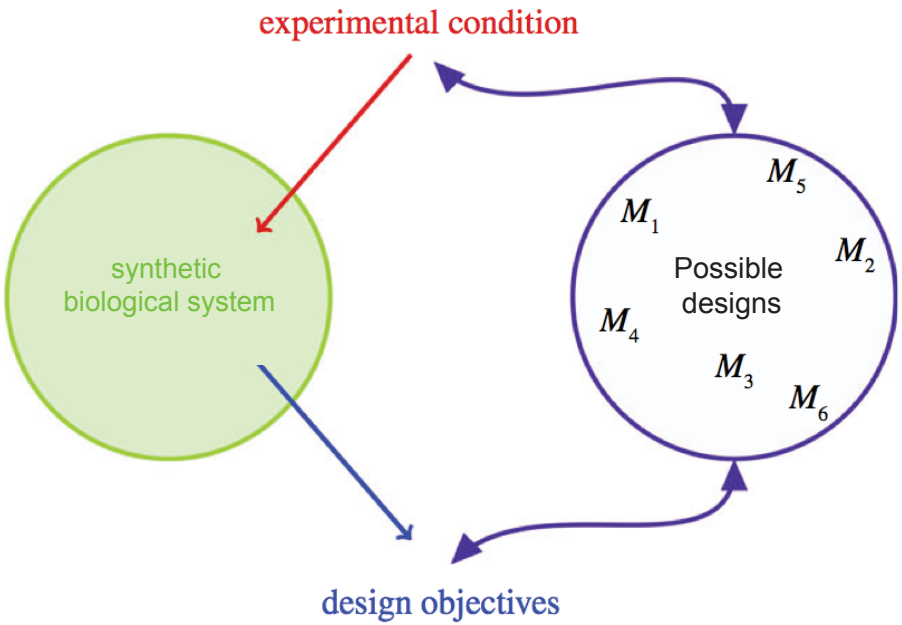
Daniel Silk

IoSSB 2011

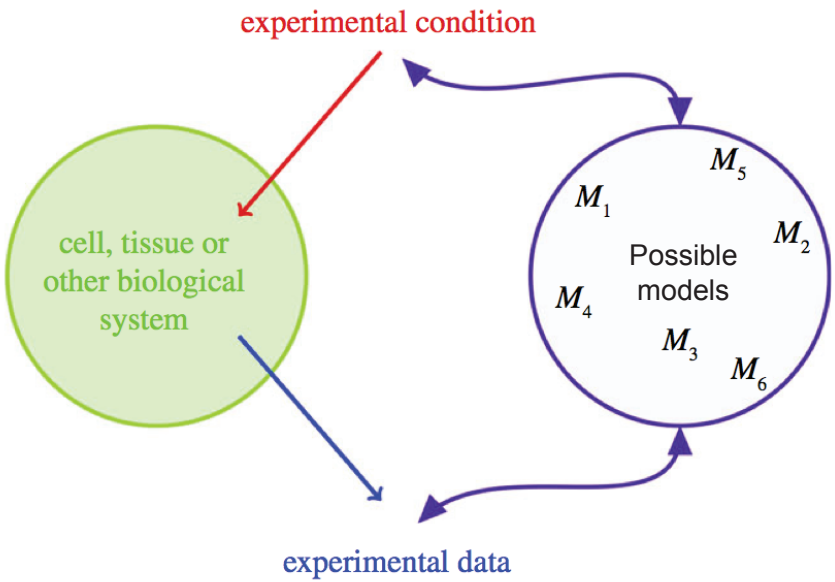
Imperial College London

Desired and expected behaviour

Synthetic biology



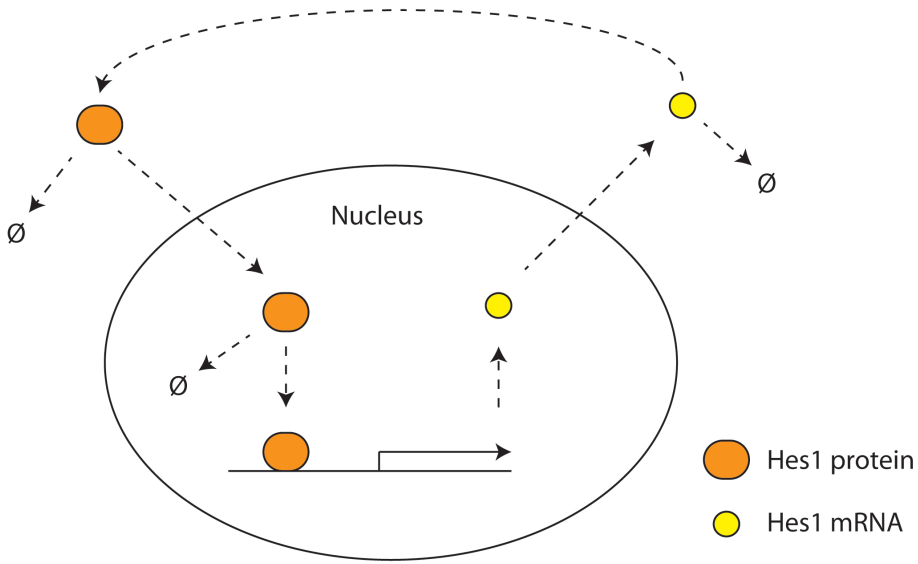
Systems biology

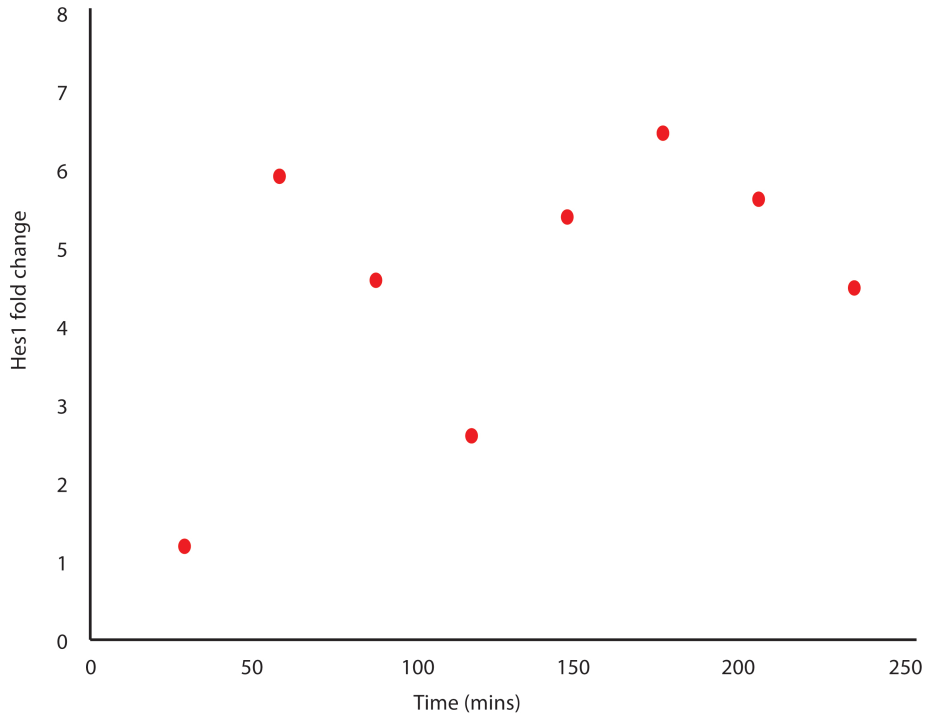


Adapted from C.P. Barnes†, D. Silk† & M.P.H Stumpf. Bayesian design strategies for synthetic biology. Interface focus. (2011)

Motivation - Systems biology

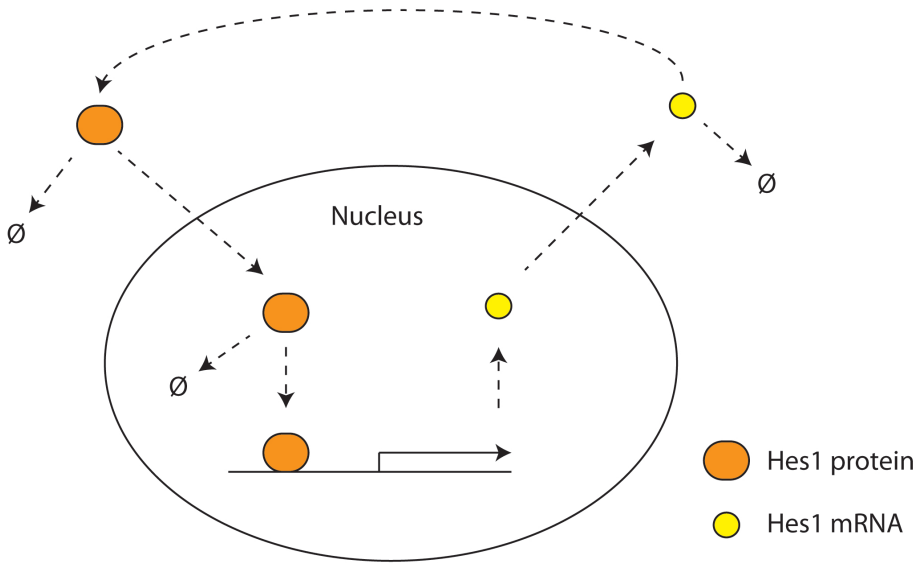
- Oscillating expression of Hes1 plays a central role in regulating vertebrate embryo segmentation.

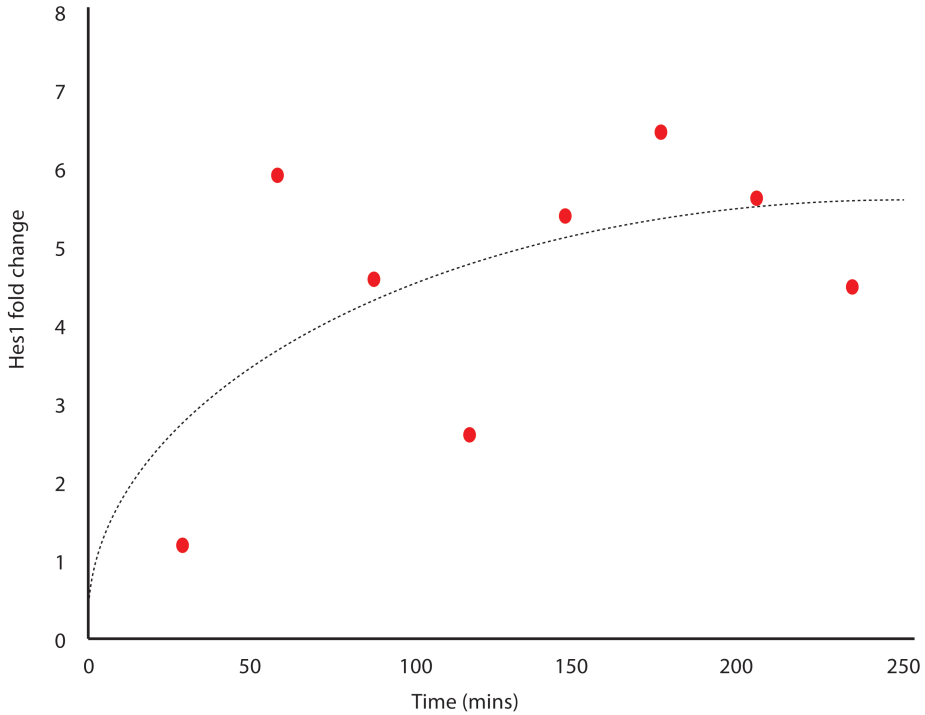




Motivation - Systems biology

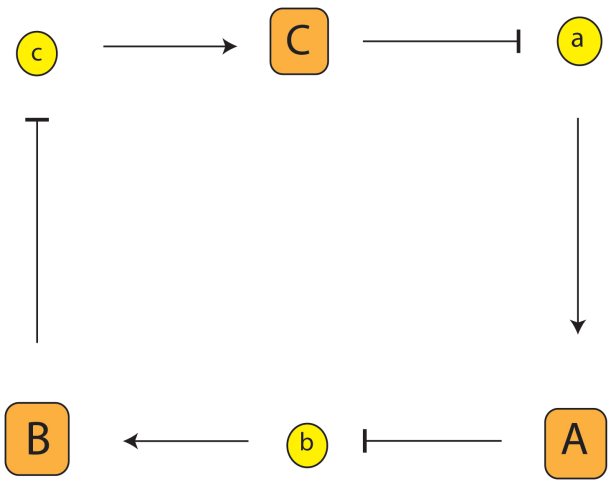
- Traditional qualitative approaches can fail when fitting to complex behaviour.

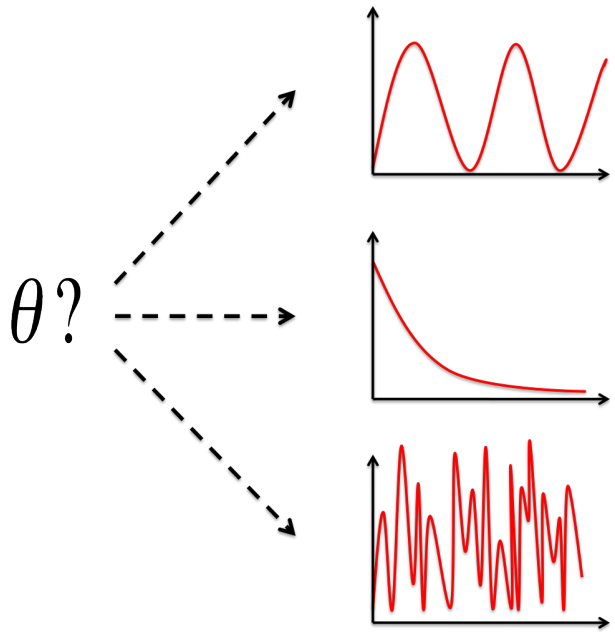




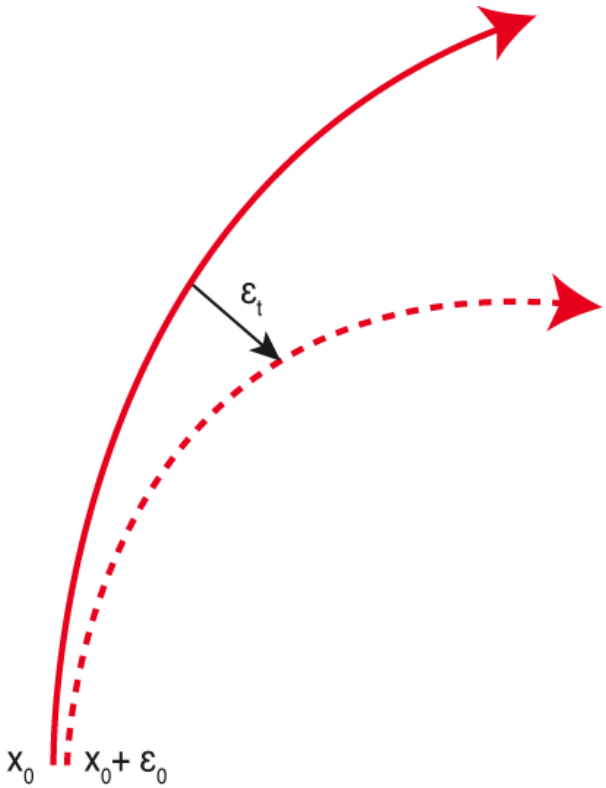
Motivation - Synthetic biology

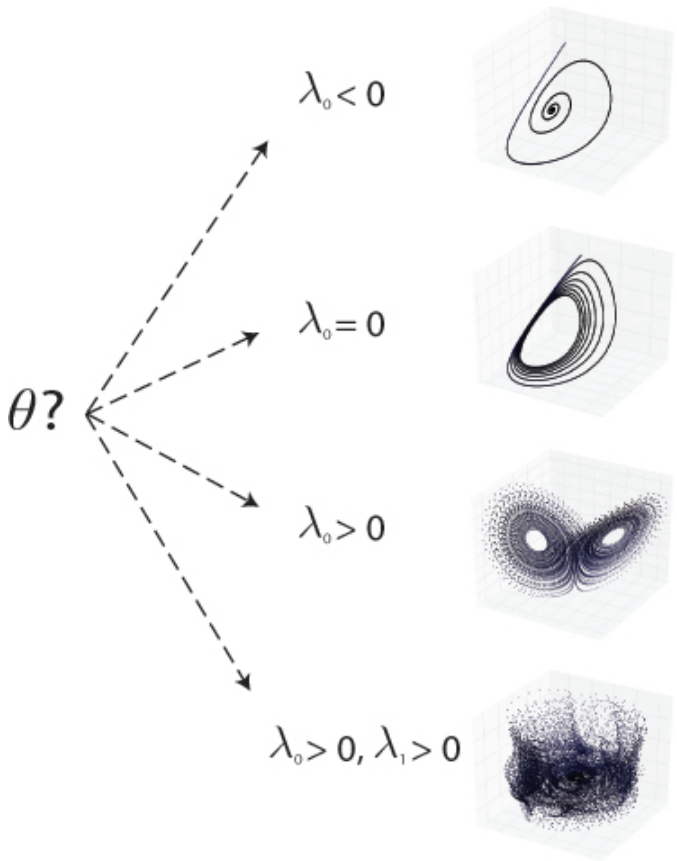
- What structures and parameter combinations give rise to desired types of behaviour?
- In particular, can we design and build a biological circuit that exhibits chaos?





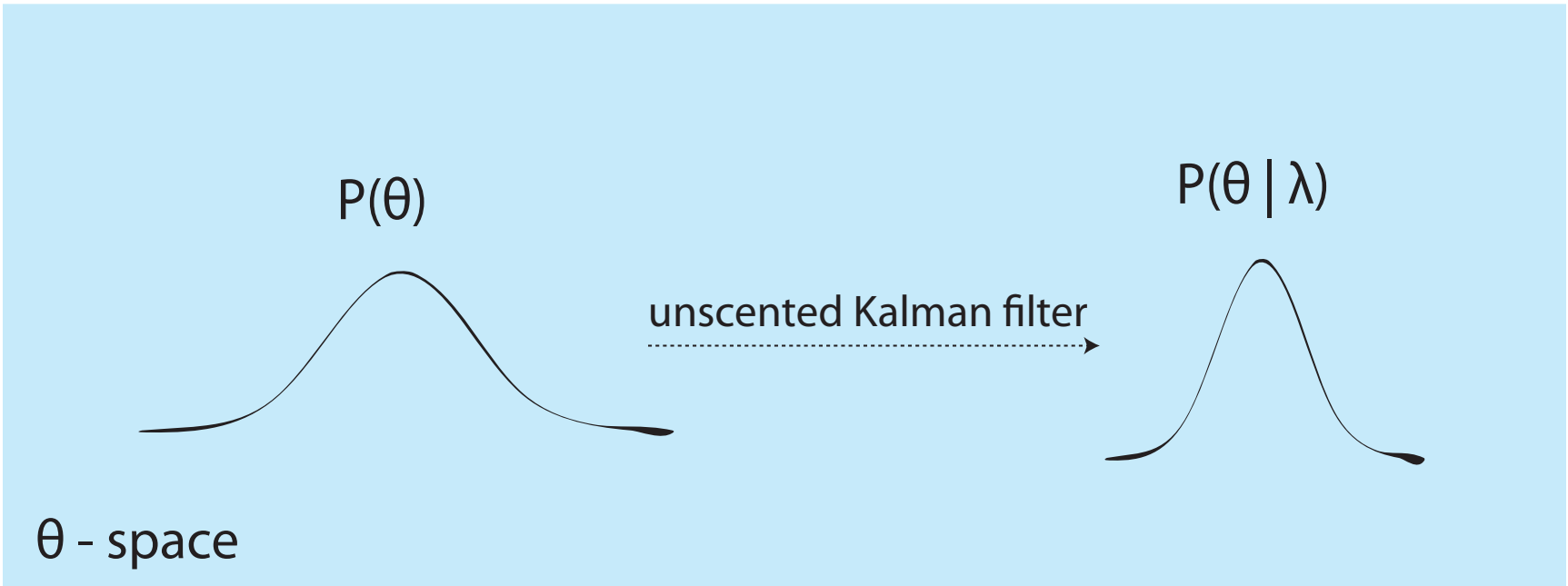
Encoding the desired behaviour



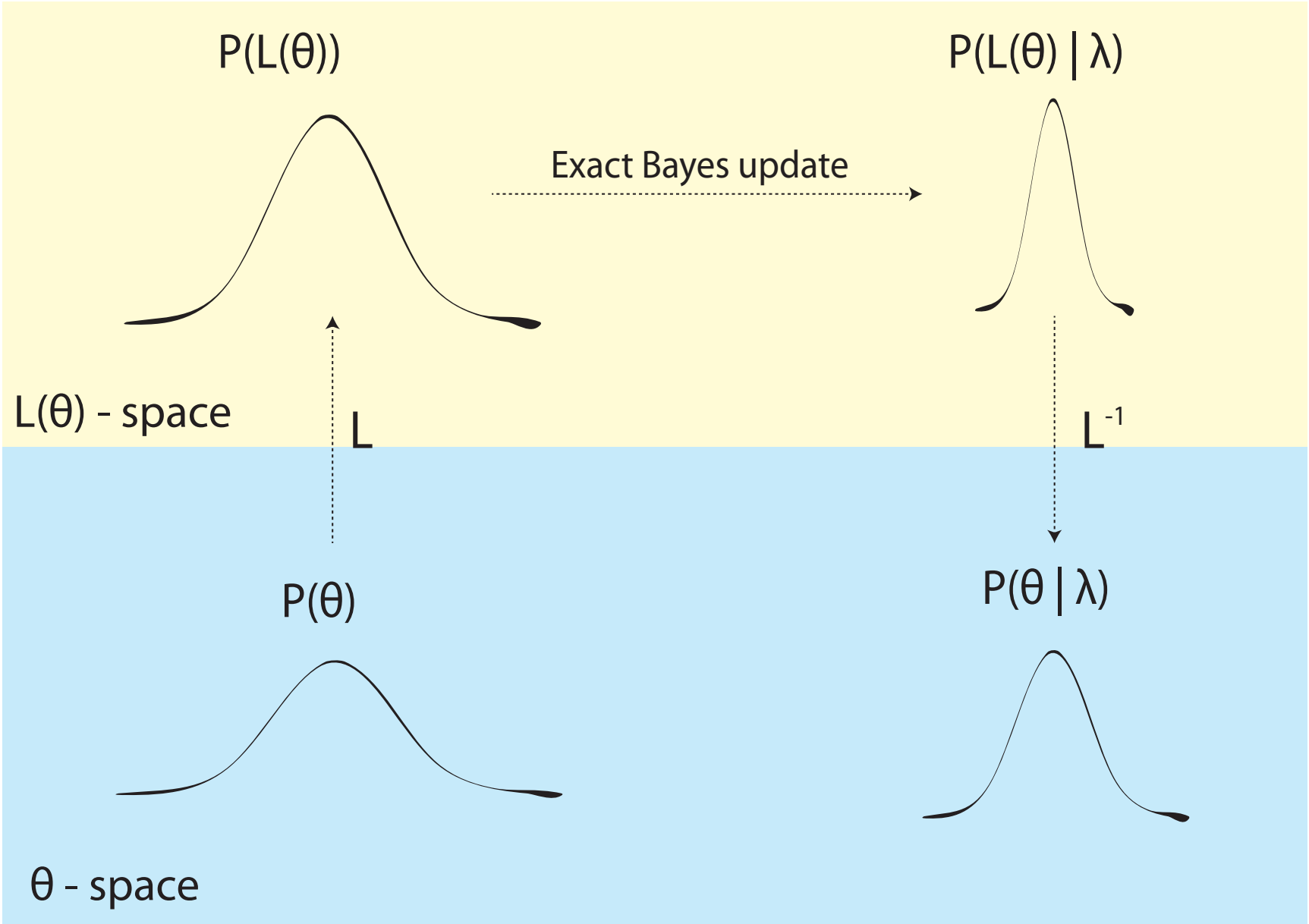


- Lyapunov exponents, $\{\lambda_i\}$ encode the qualitative behaviour of the model.

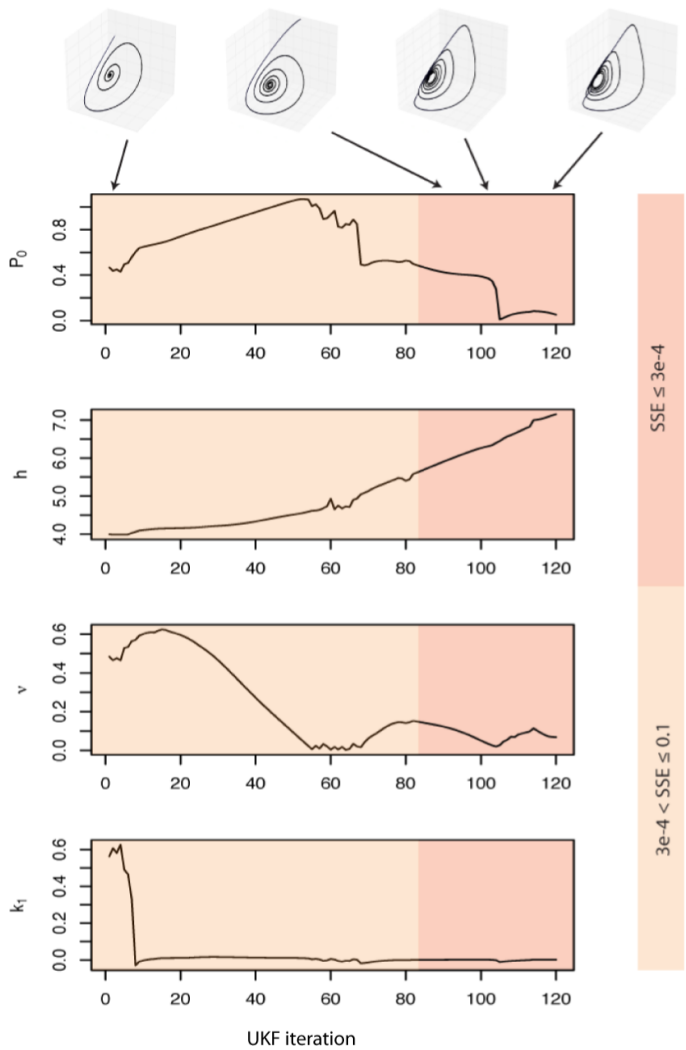
The unscented Kalman filter for qualitative inference

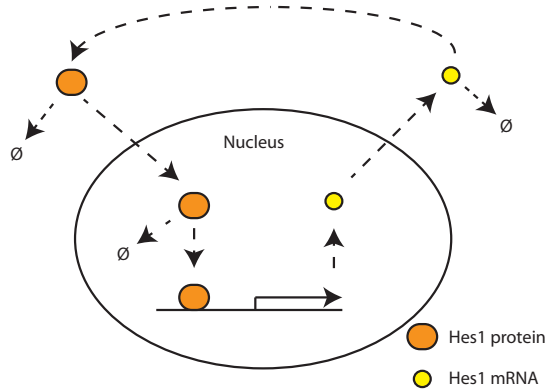


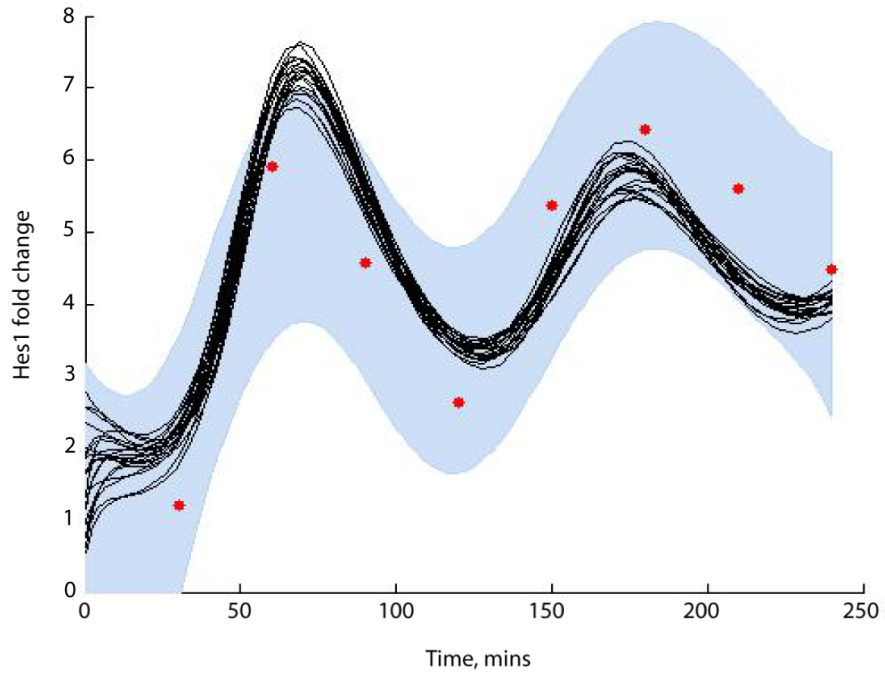
The unscented Kalman filter for qualitative inference



Oscillations in a Hes1 regulatory model

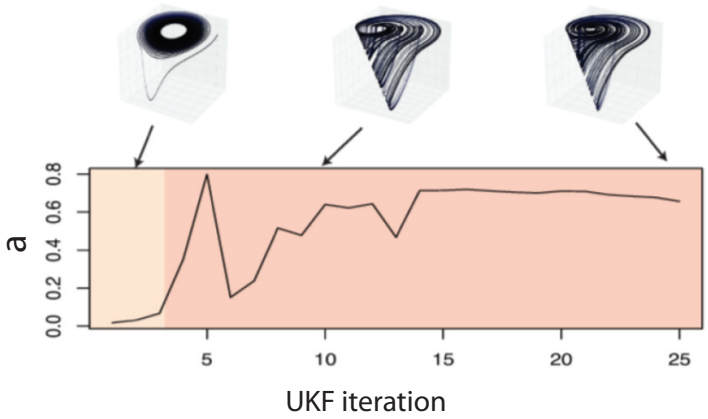


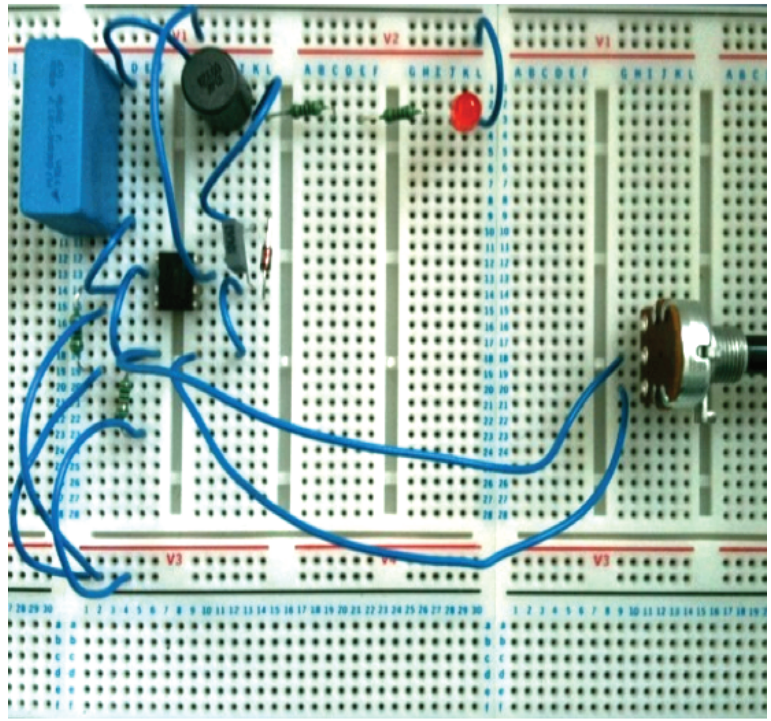


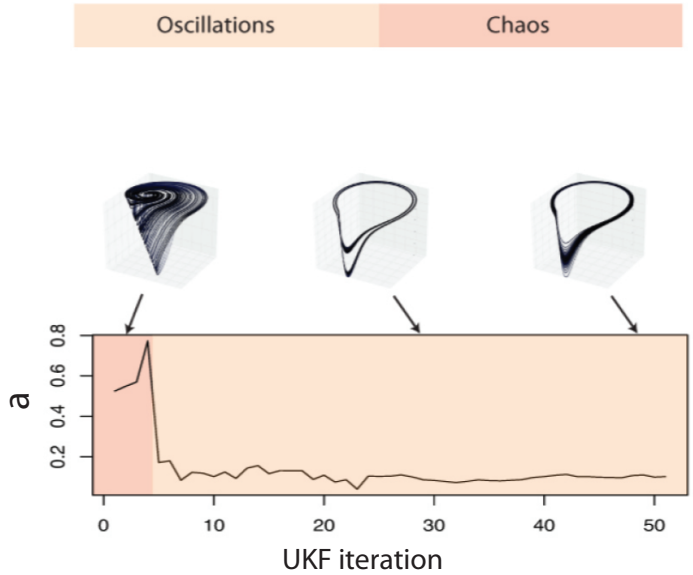


Silk, D. et al. Designing attractive models via automated identification of chaotic and oscillatory dynamical regimes. Nat. Commun. (2011).

Controlling Chaos







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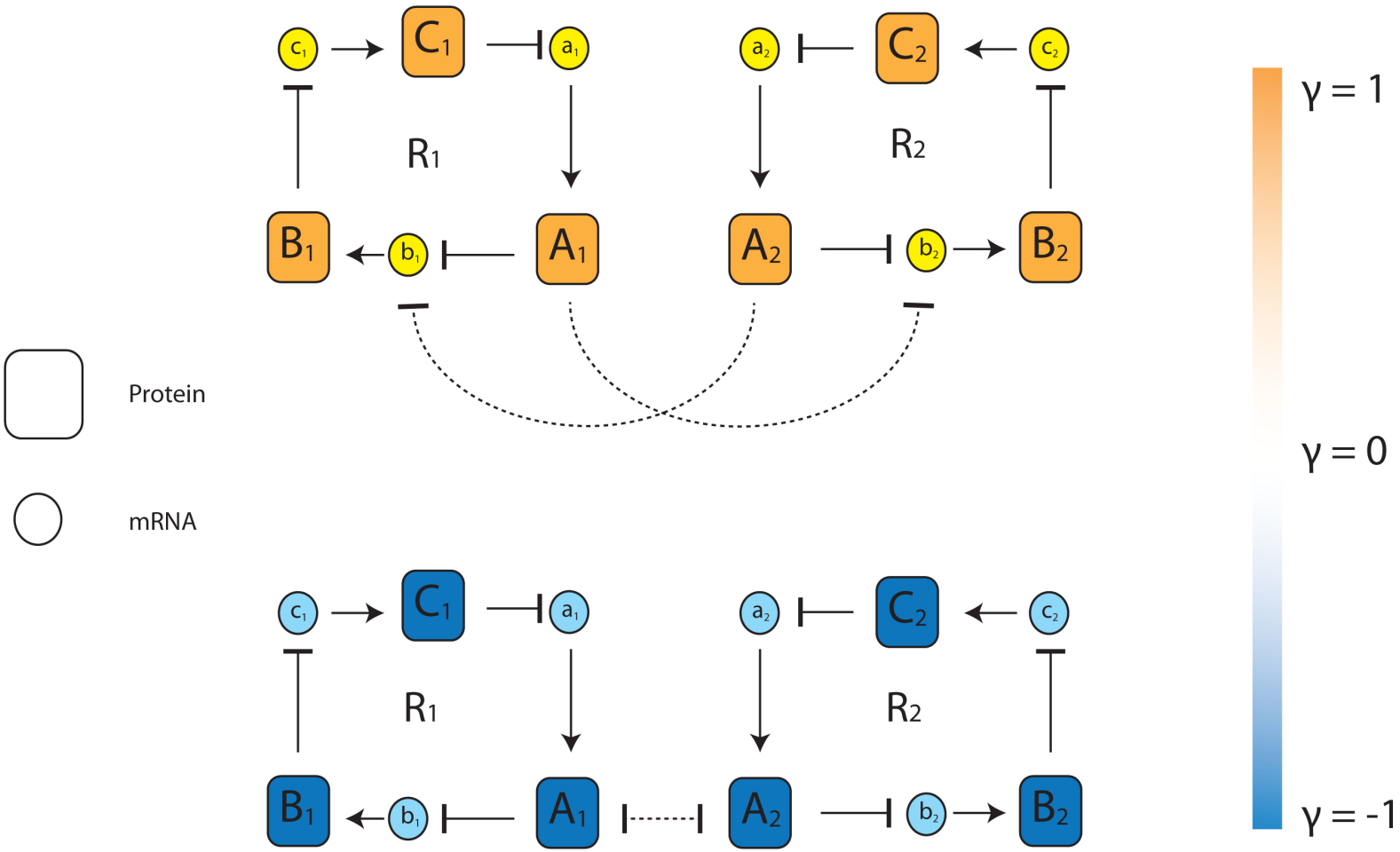
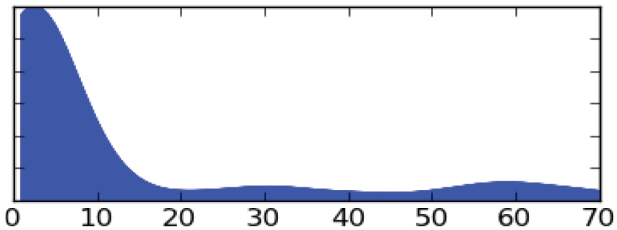
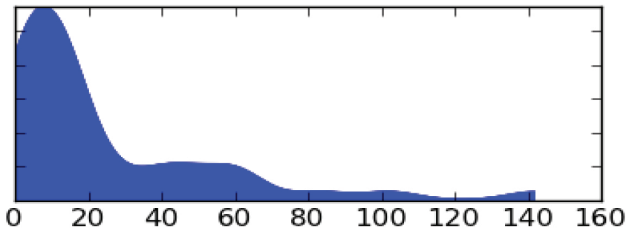
Chaos in coupled repressilators



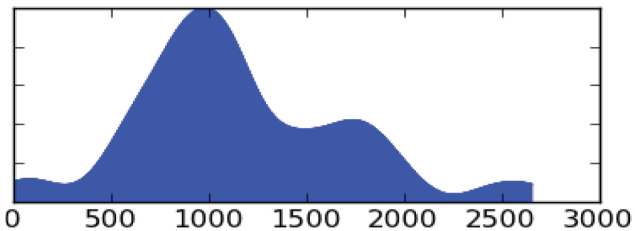
Regions of chaos



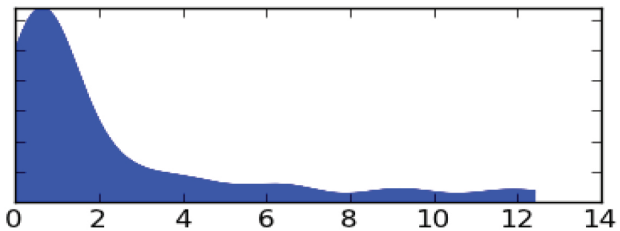
n



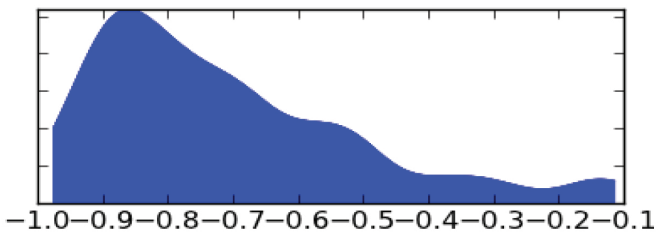
β



α



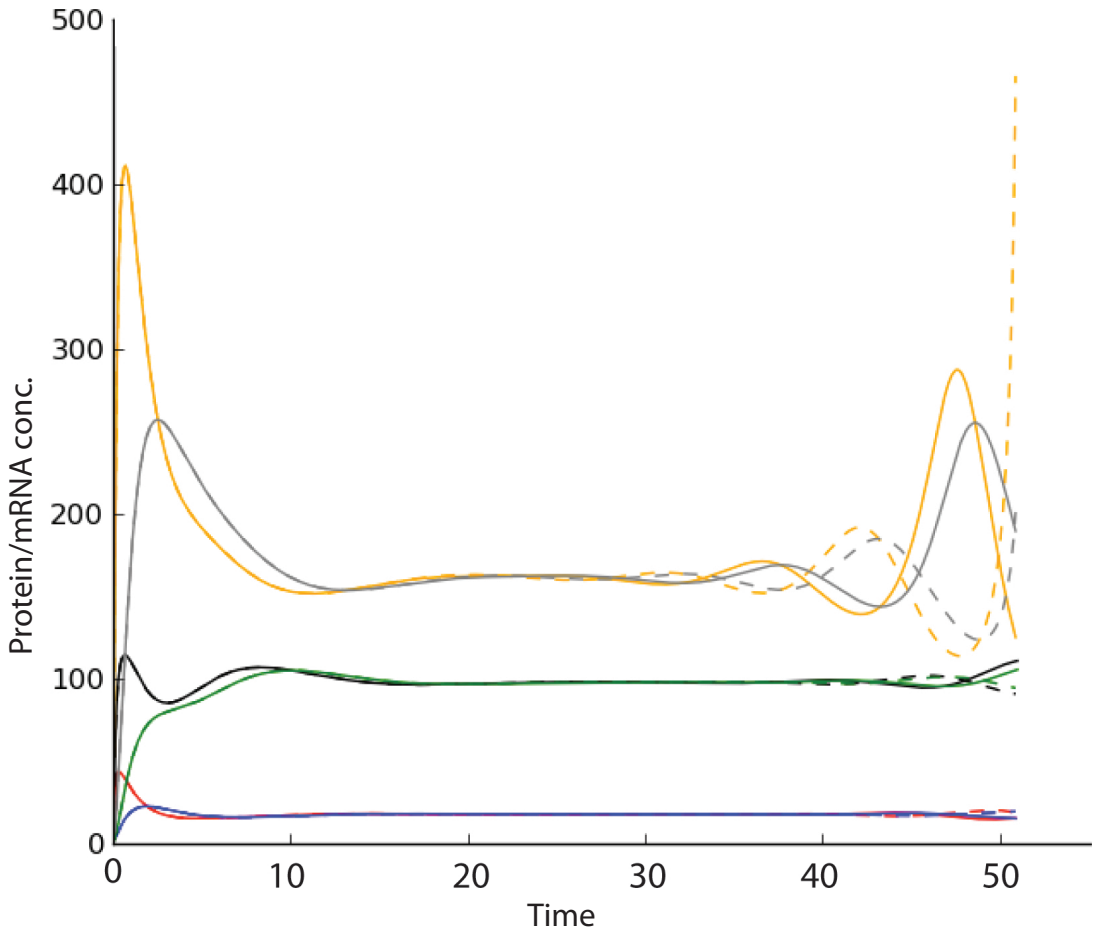
α_0



γ

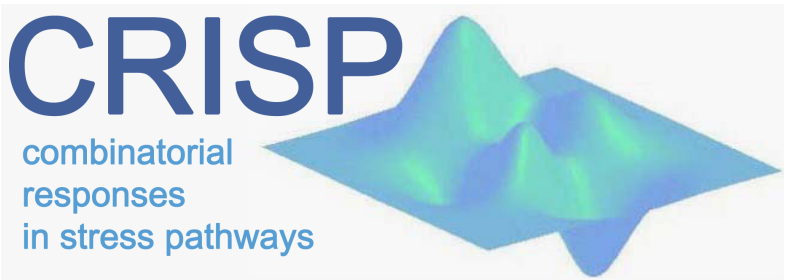
Chaotic behaviour

- The smallest perturbation leads to decoupling of repressilator trajectories.



Acknowledgements

Many thanks to

Michael Stumpf
Paul Kirk
Chris Barnes
Tina Toni
Simon Moon

Margaret Dallman
Anna Rose