

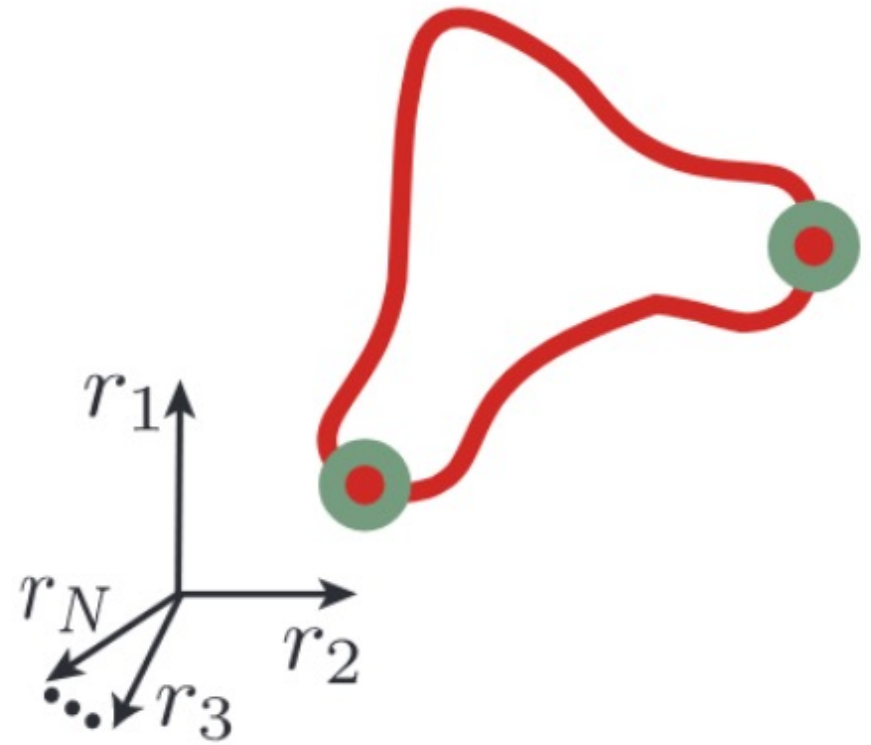
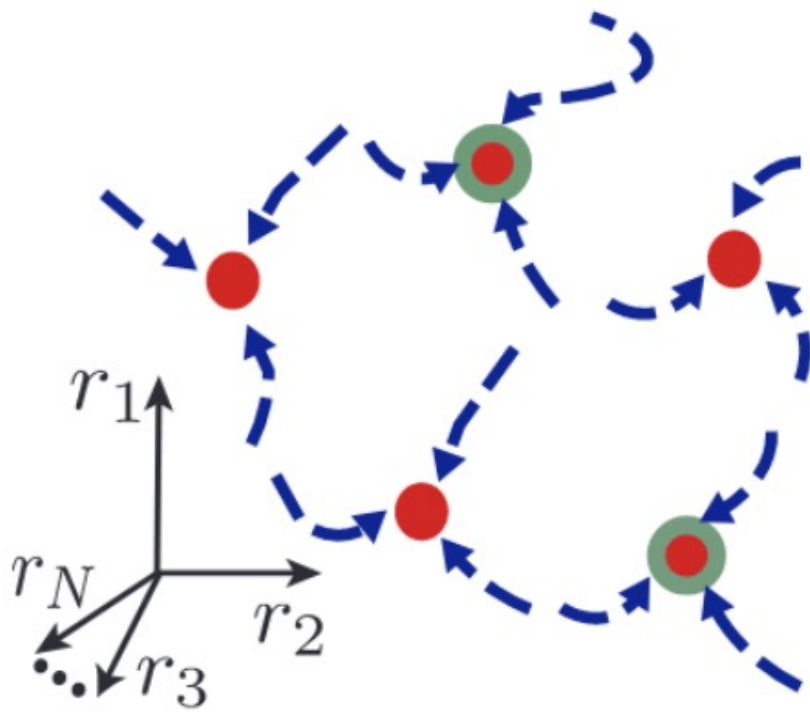
What is an attractor?

“A **dynamical system** is a set of variables together with all the rules that determine their time-evolution.”

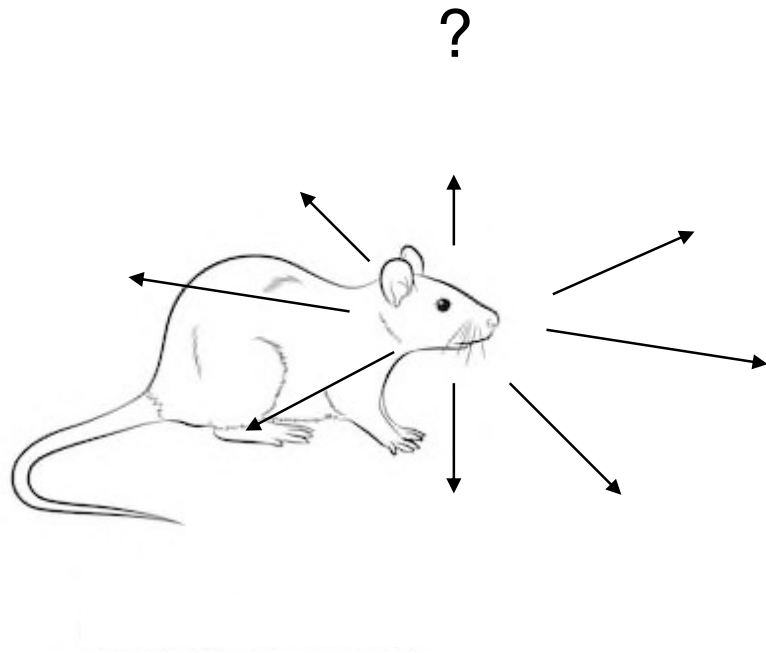
“The instantaneous value of these variables is called the **state** of the system at that moment. The state is a point (vector) in the state space of the dynamical system.”

“An **attractor** is a state within a state space, to which all nearby states eventually flow.”

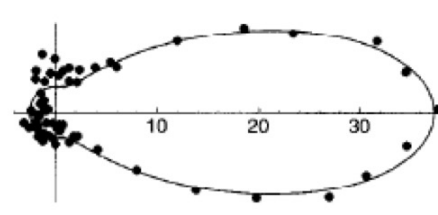
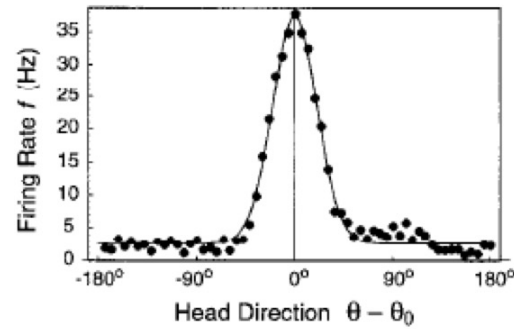
Point vs. ring attractors



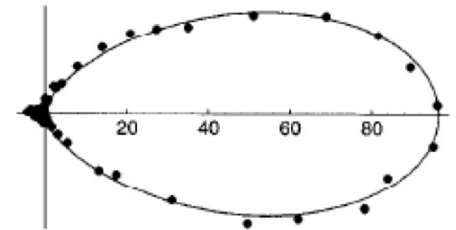
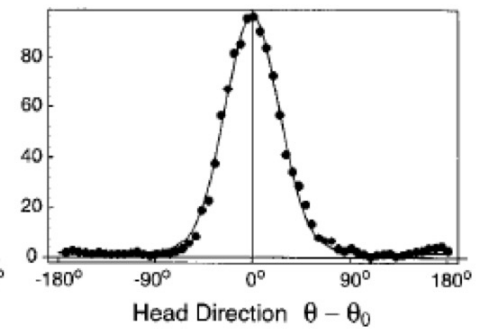
Head-direction cells



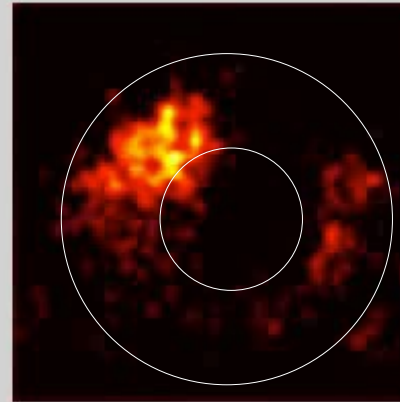
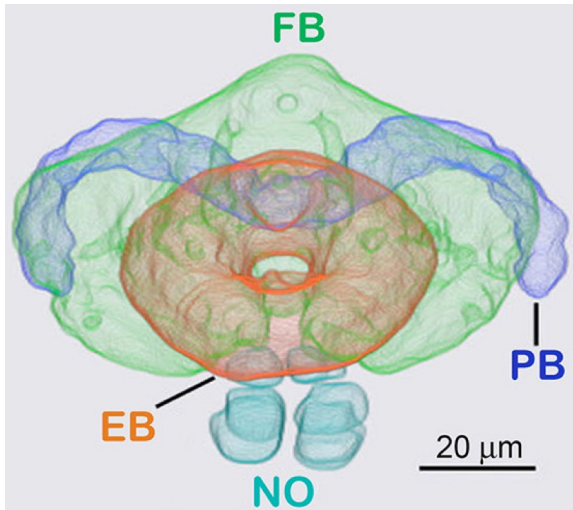
A Anterior Thalamus



B Postsubiculum

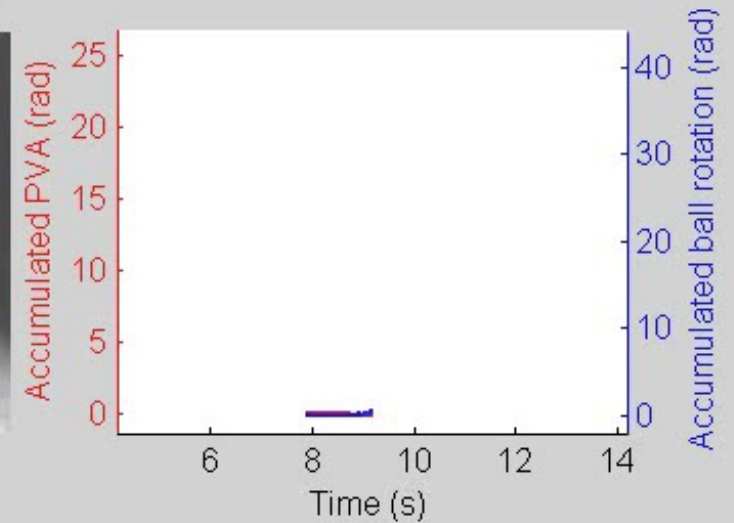


Head-direction cells in ellipsoid body of *Drosophila* (Seelig & Jayaraman 2015)

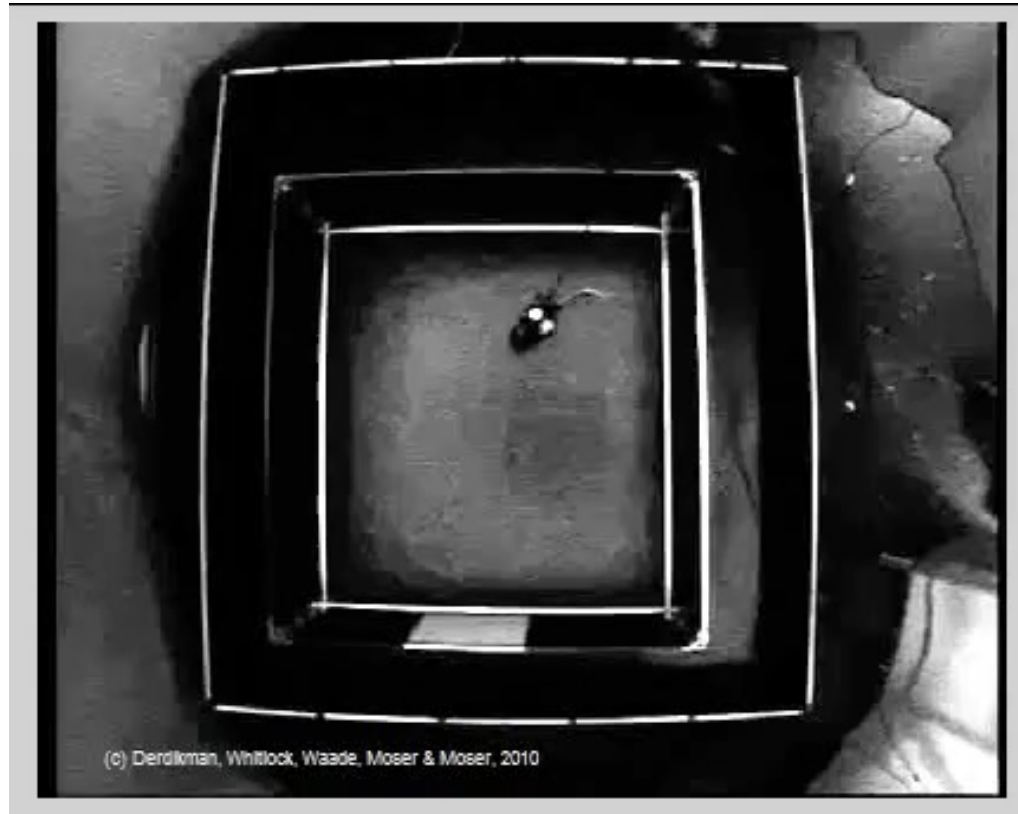


Ellipsoid body activity
(calcium imaging)

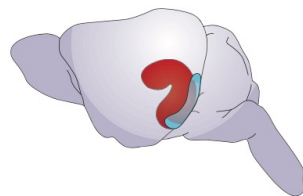
Decoded vs. actual head dir.



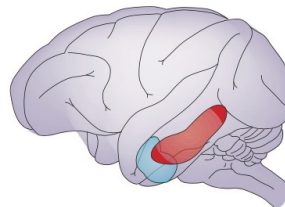
Grid cells in medial entorhinal cortex



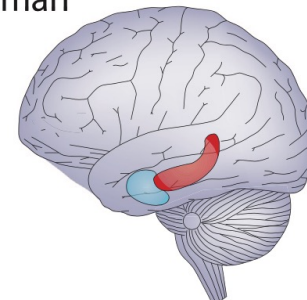
Rat



Monkey



Human



● Hippocampus ● EC

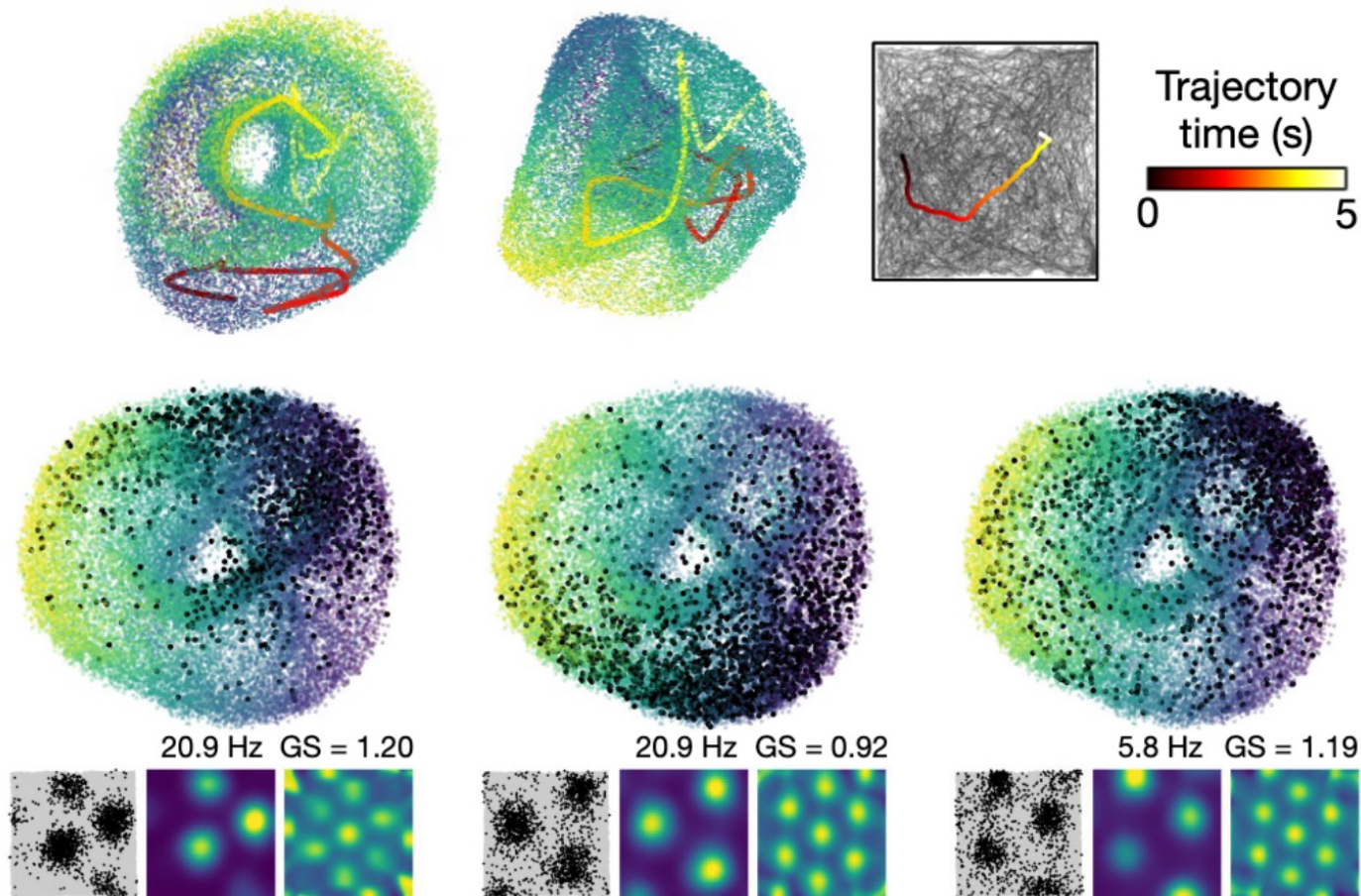
Toroidal topology of population activity in grid cells

<https://doi.org/10.1038/s41586-021-04268-7>

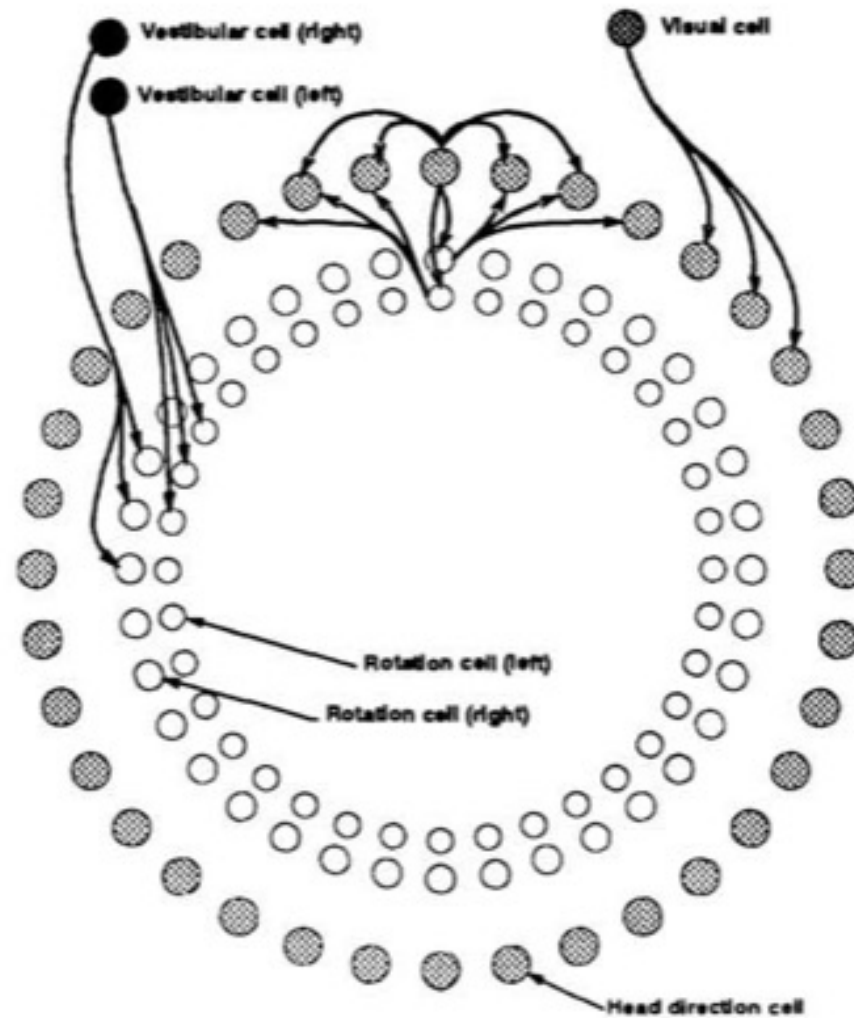
Received: 24 February 2021

Accepted: 19 November 2021

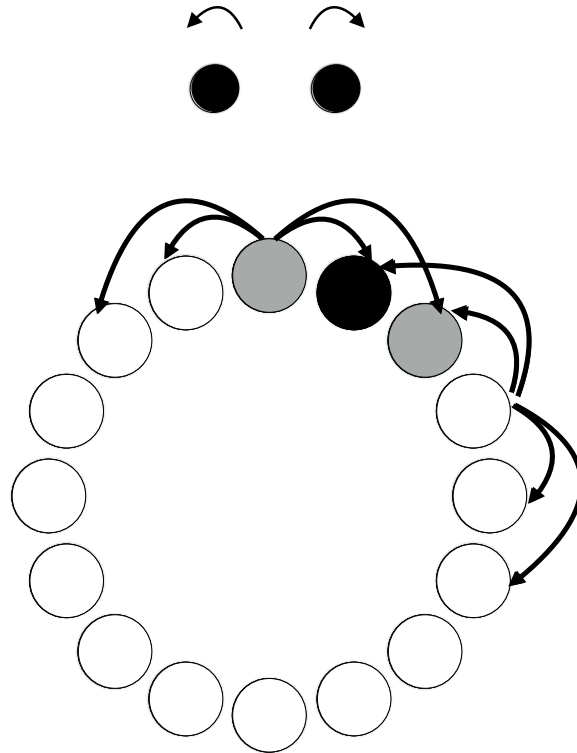
Richard J. Gardner^{1,6}, Erik Hermansen^{2,6}, Marius Pachitariu³, Yoram Burak^{4,5}, Nils A. Baas², Benjamin A. Dunn^{1,2}, May-Britt Moser¹ & Edvard I. Moser¹



Skaggs et al. (1994) ring attractor model

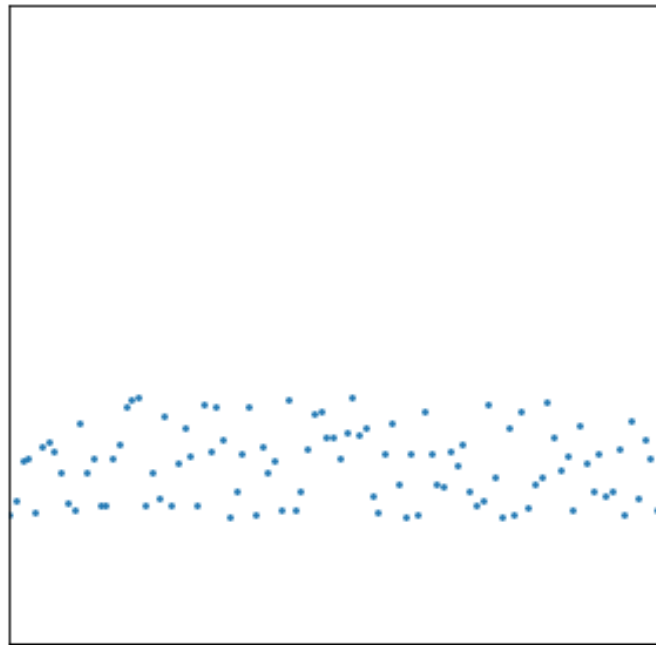


Shifting the activity bump



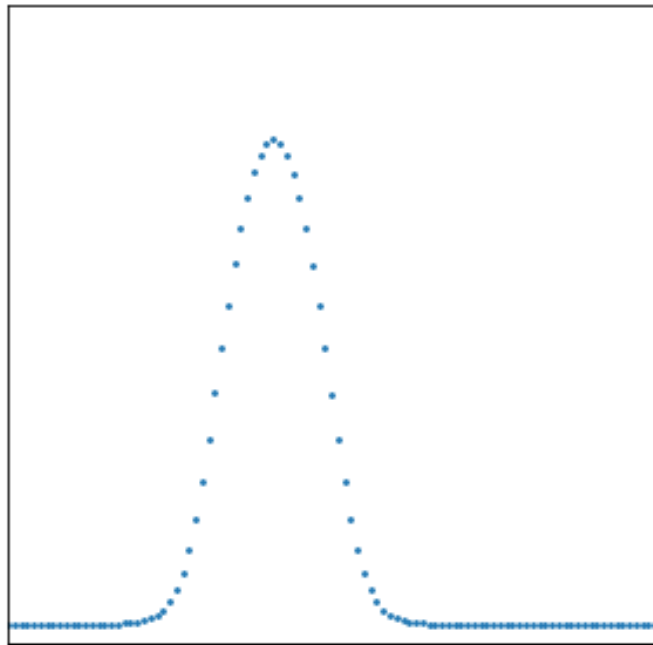
Zhang's (1996) ring attractor model

Bump formation



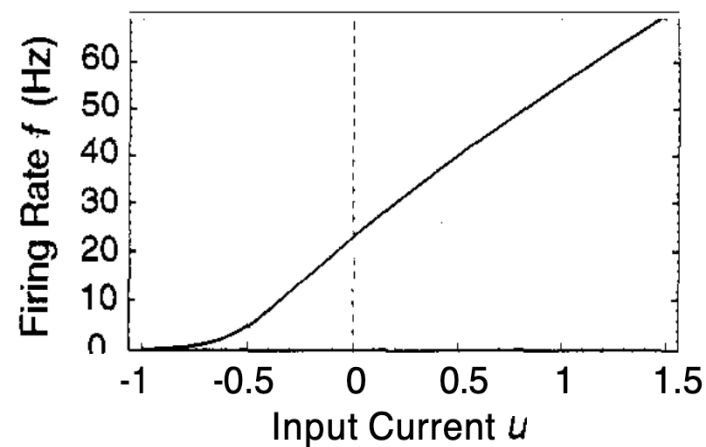
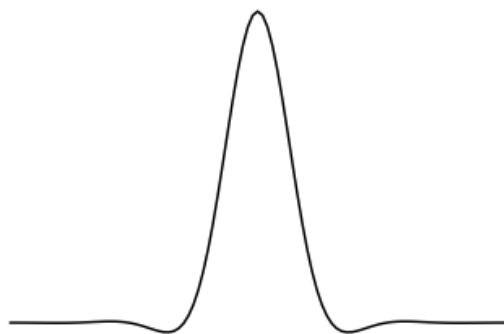
Zhang's (1996) ring attractor model

Shifting the bump

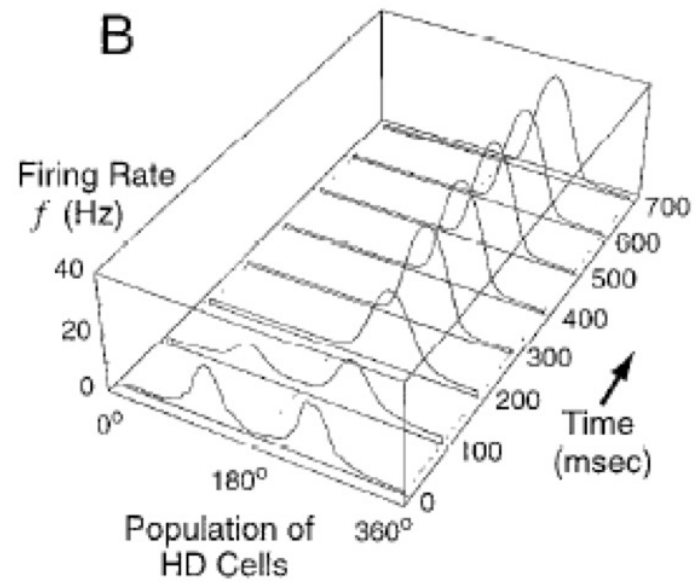
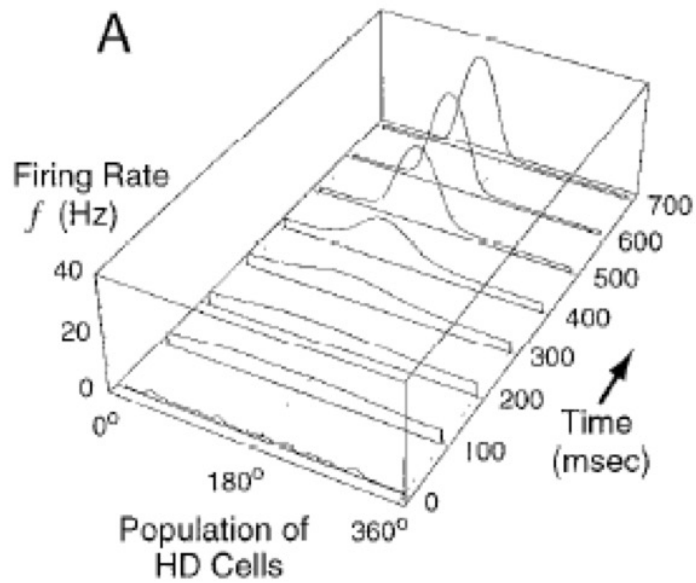
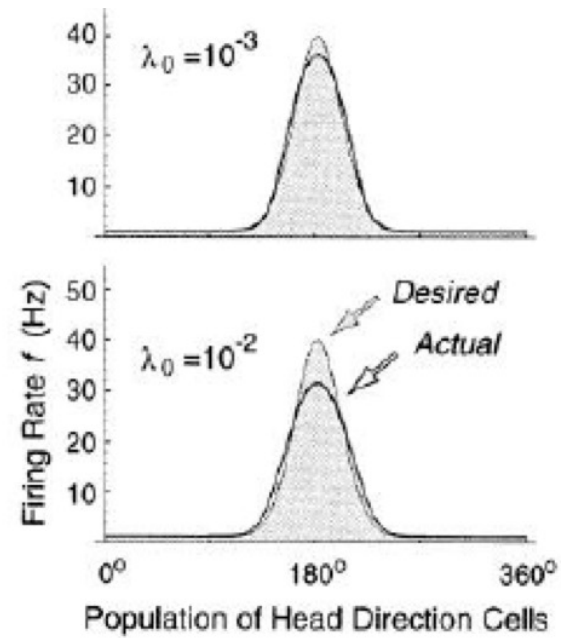
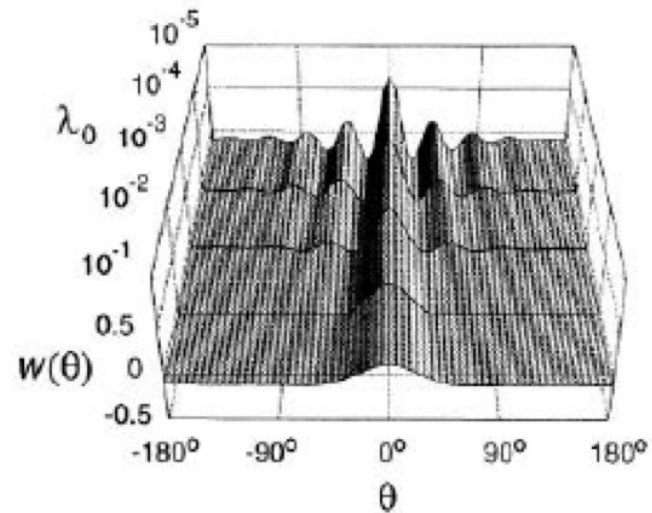


Zhang (1996) dynamics

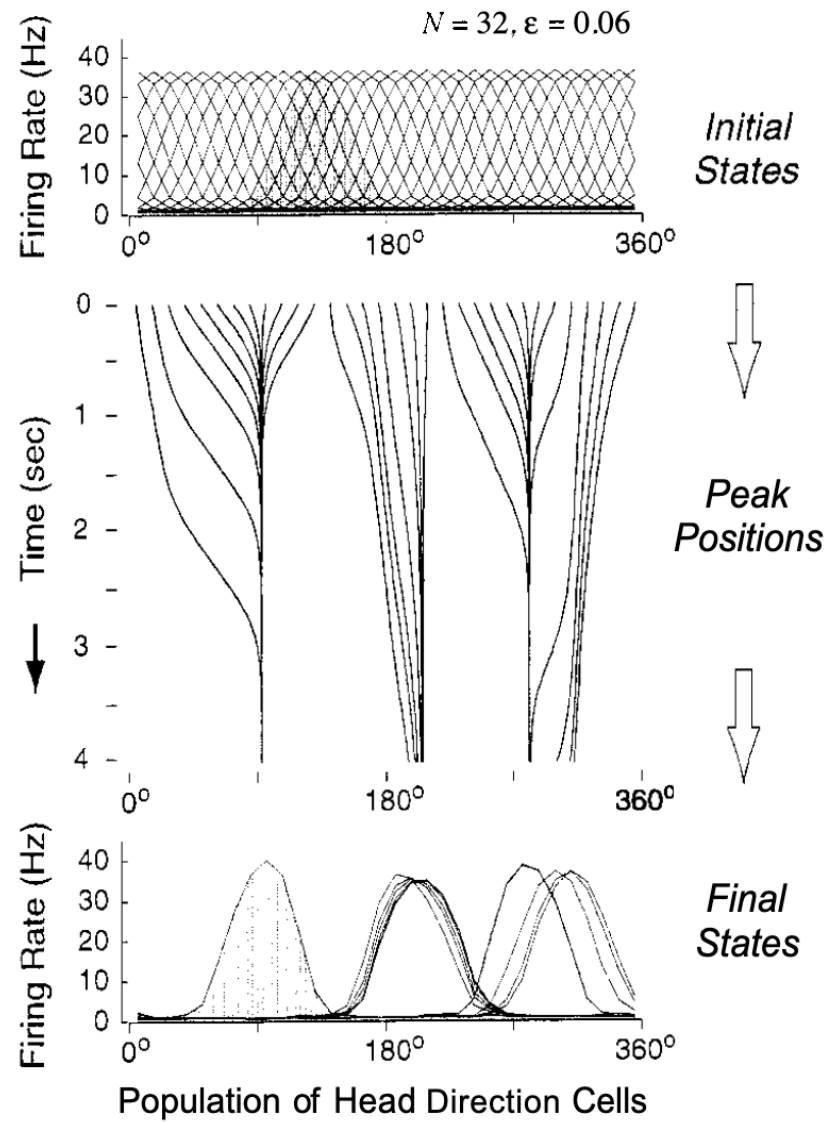
$$\tau \frac{du}{dt} = -u + w * \sigma(u)$$



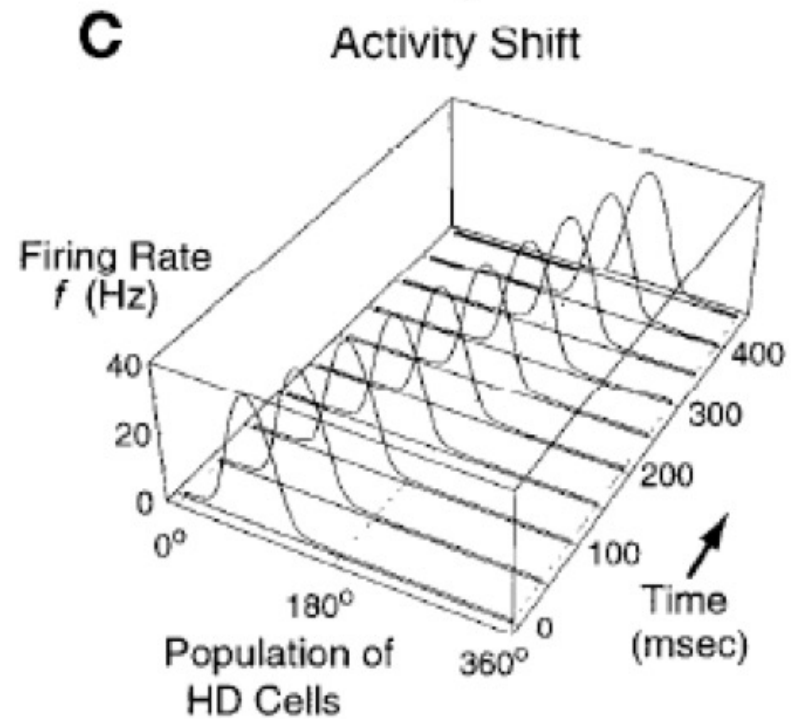
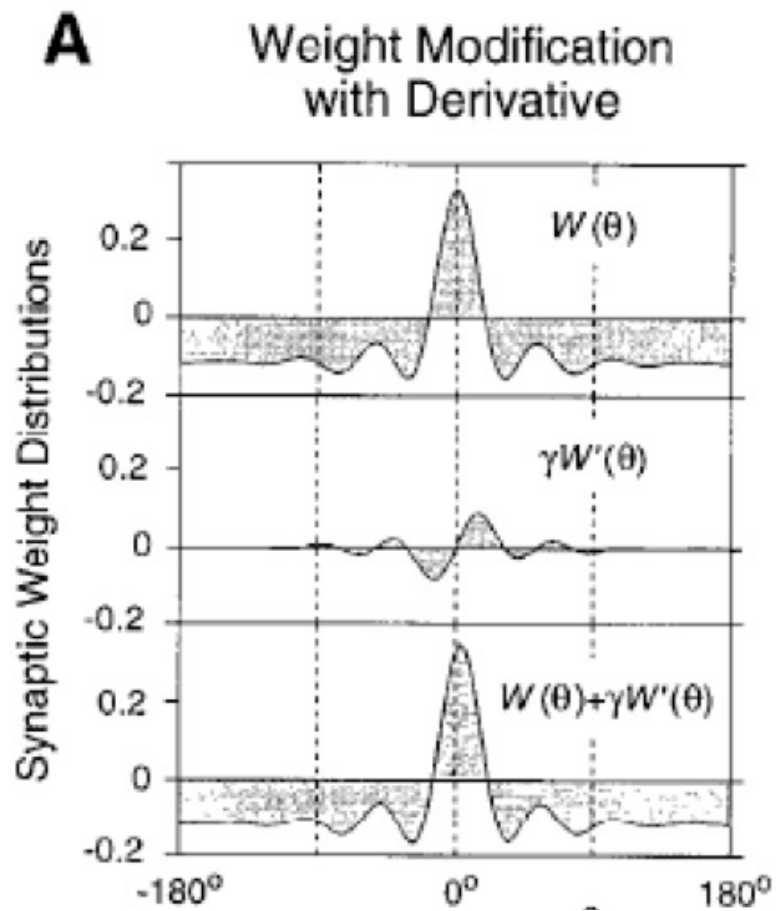
B Weight Regularization



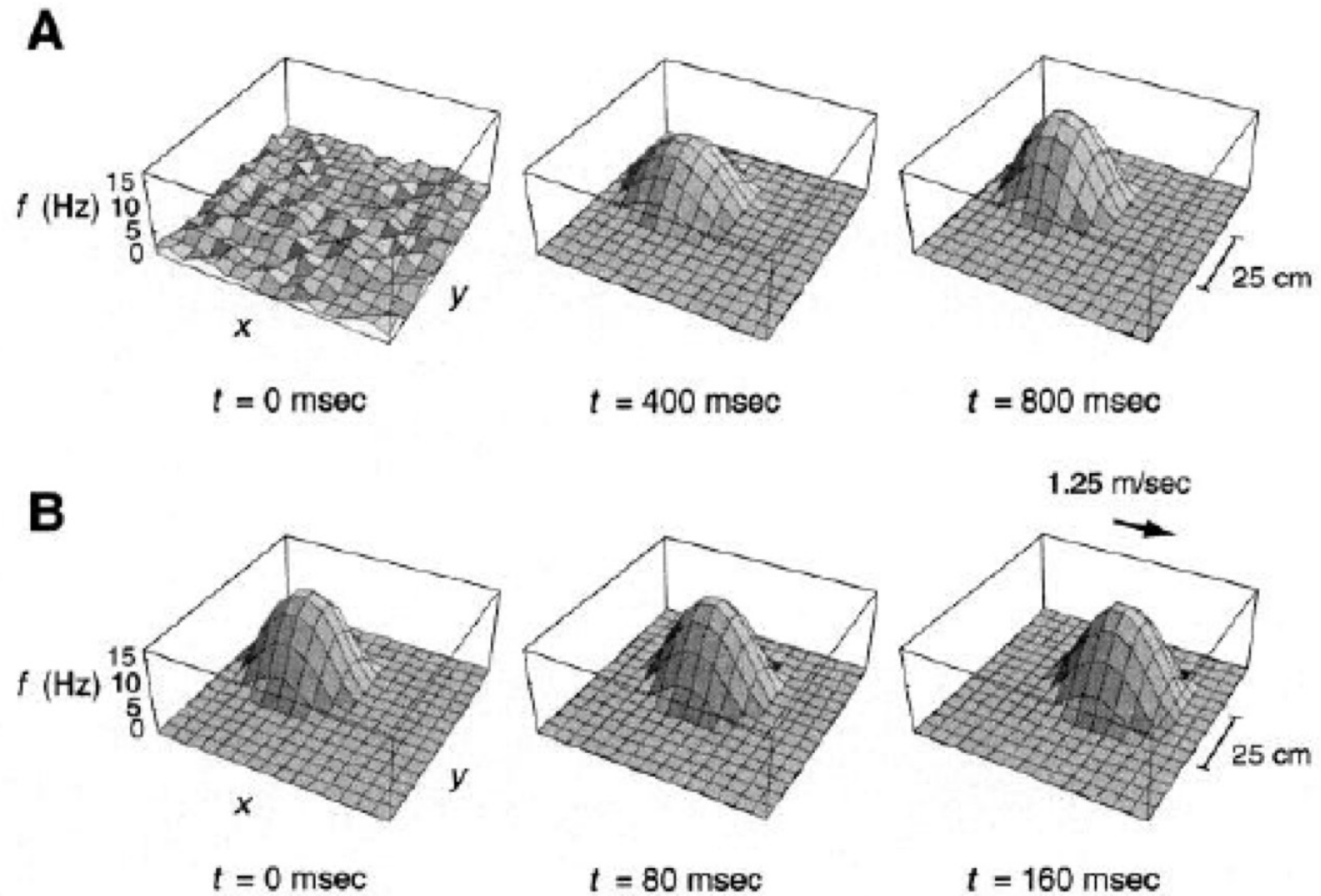
A Effects of Noisy Weights



Shifting the bump



2D bumps



Accurate Path Integration in Continuous Attractor Network Models of Grid Cells

Yoram Burak^{1,2*}, Ila R. Fiete^{2,3}

