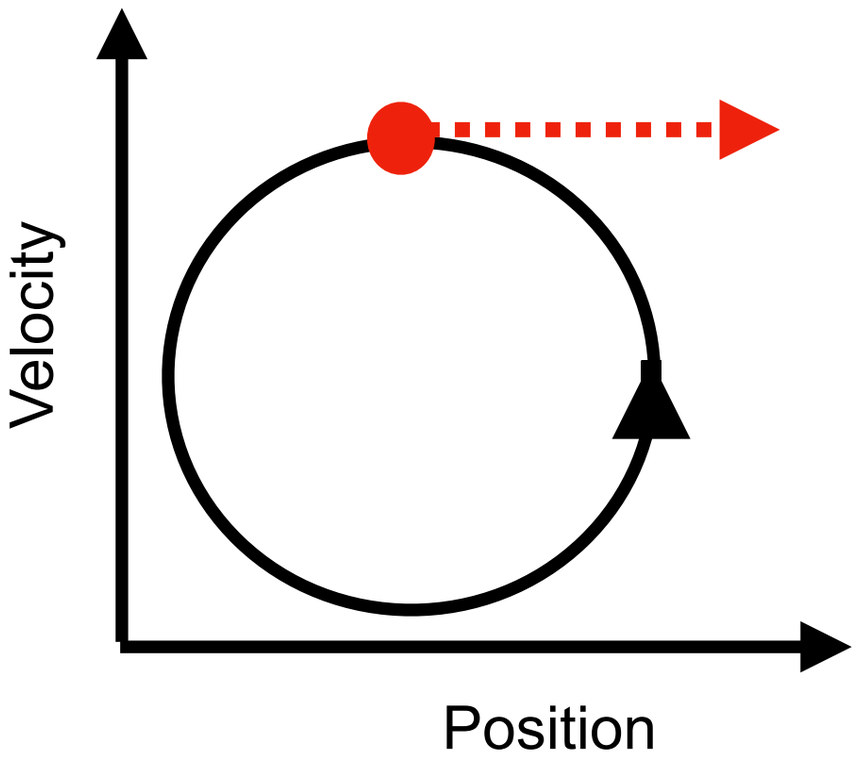
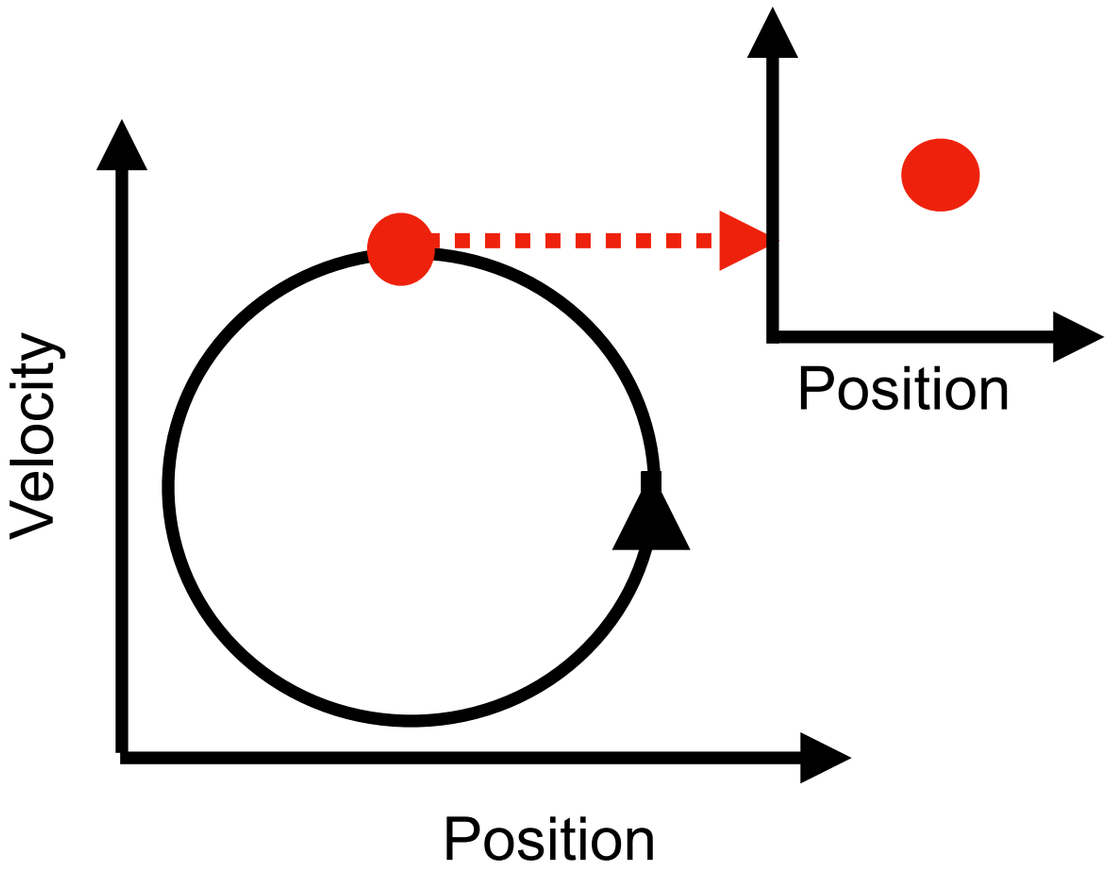
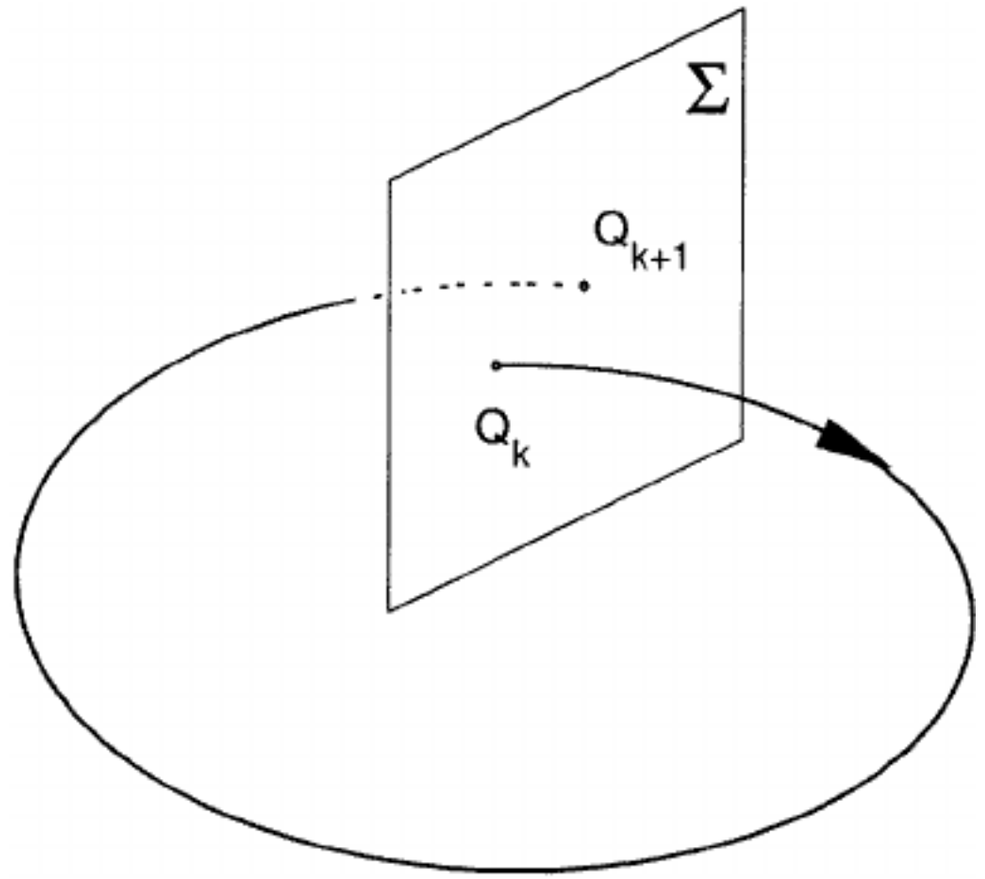
Poincare Map



- Looking at the evolution for a fixed velocity or position point that a trajectory oscillates through defines a poincare map

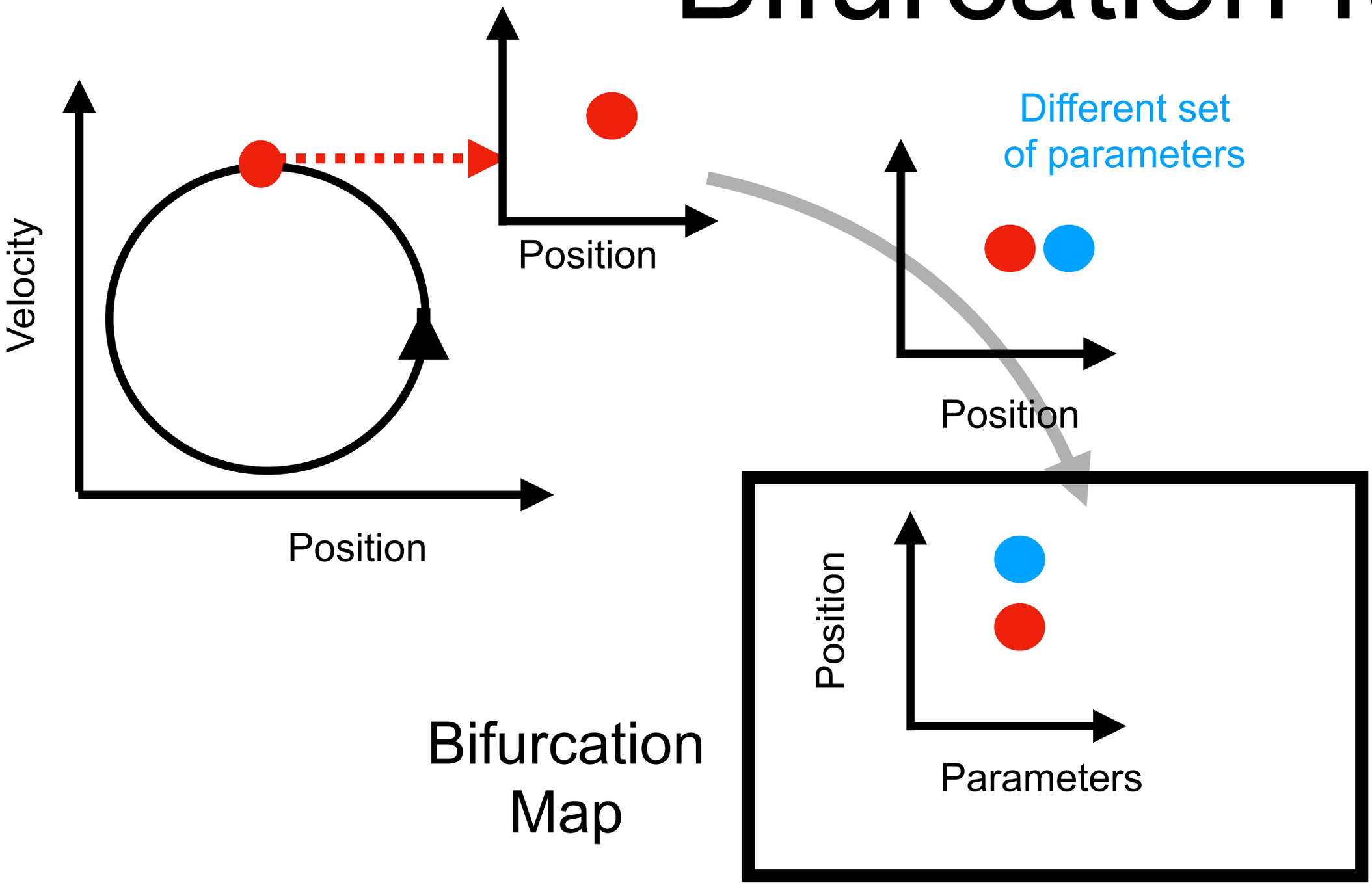
Poincare Map





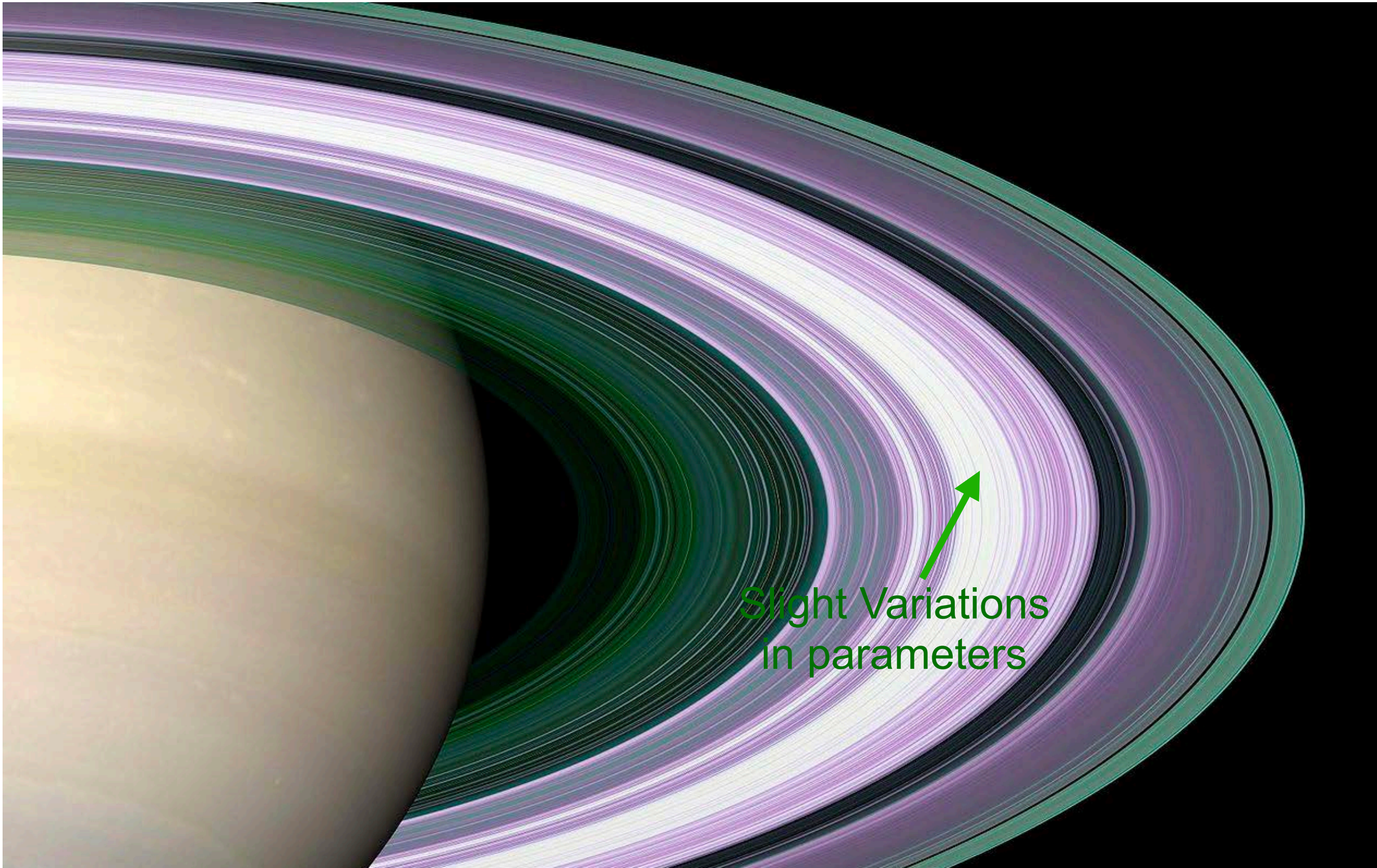
- Looking at the evolution for a fixed velocity or position point that a trajectory oscillates through defines a poincare map

Bifurcation Map



- We can look at behavior over parameters

Saturn’s Rings



Machine Learning Diffeq

- Recently within ML community :
  - The concept of Physics informed ML emerged

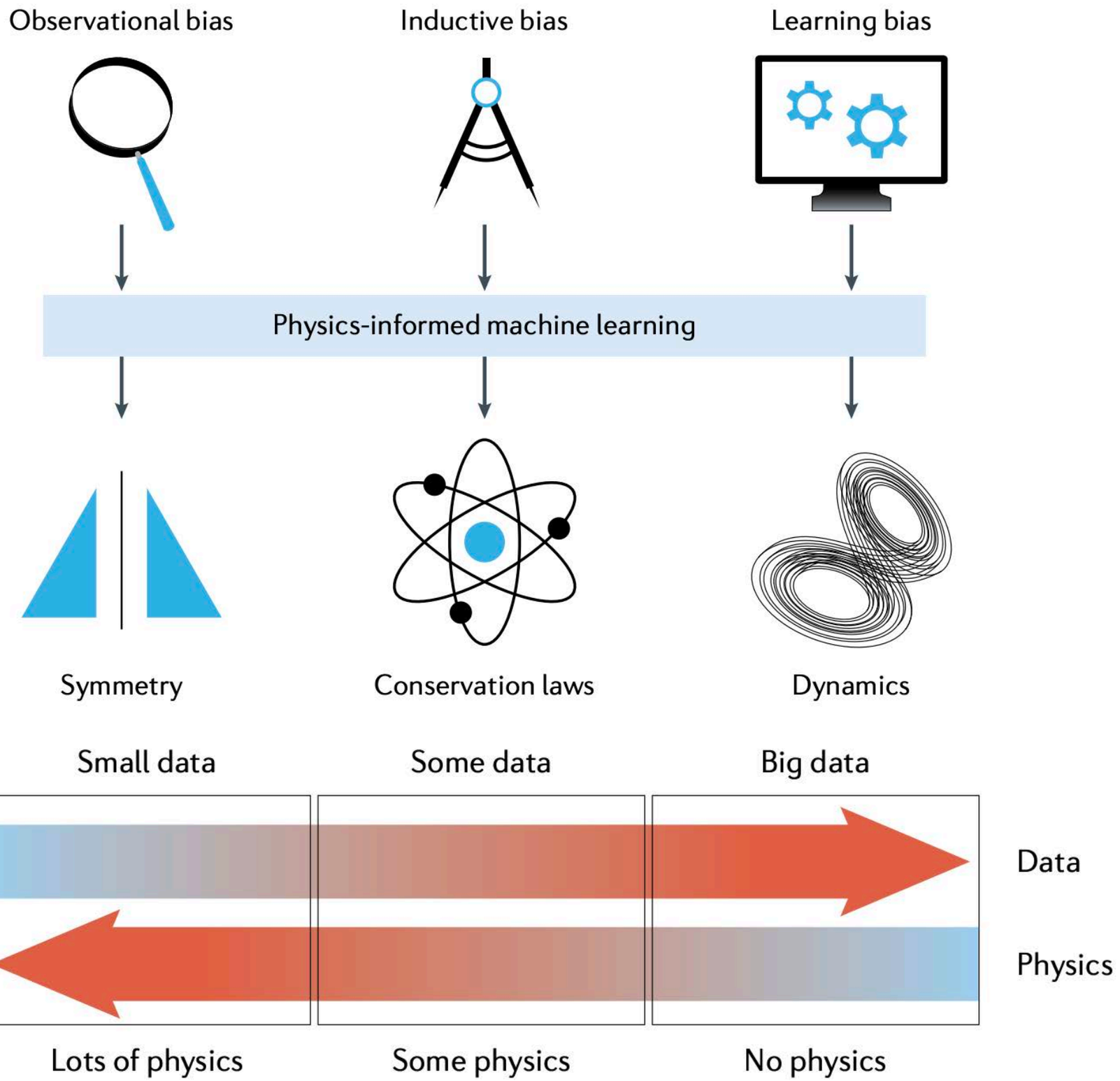
Strategy: $\mathscr{L}_{total} = \mathscr{L}_{NN} + \mathscr{L}_{\text{Diffeq}}$

$$\ddot{\theta} + \mu\dot{\theta} + k\theta = 0$$

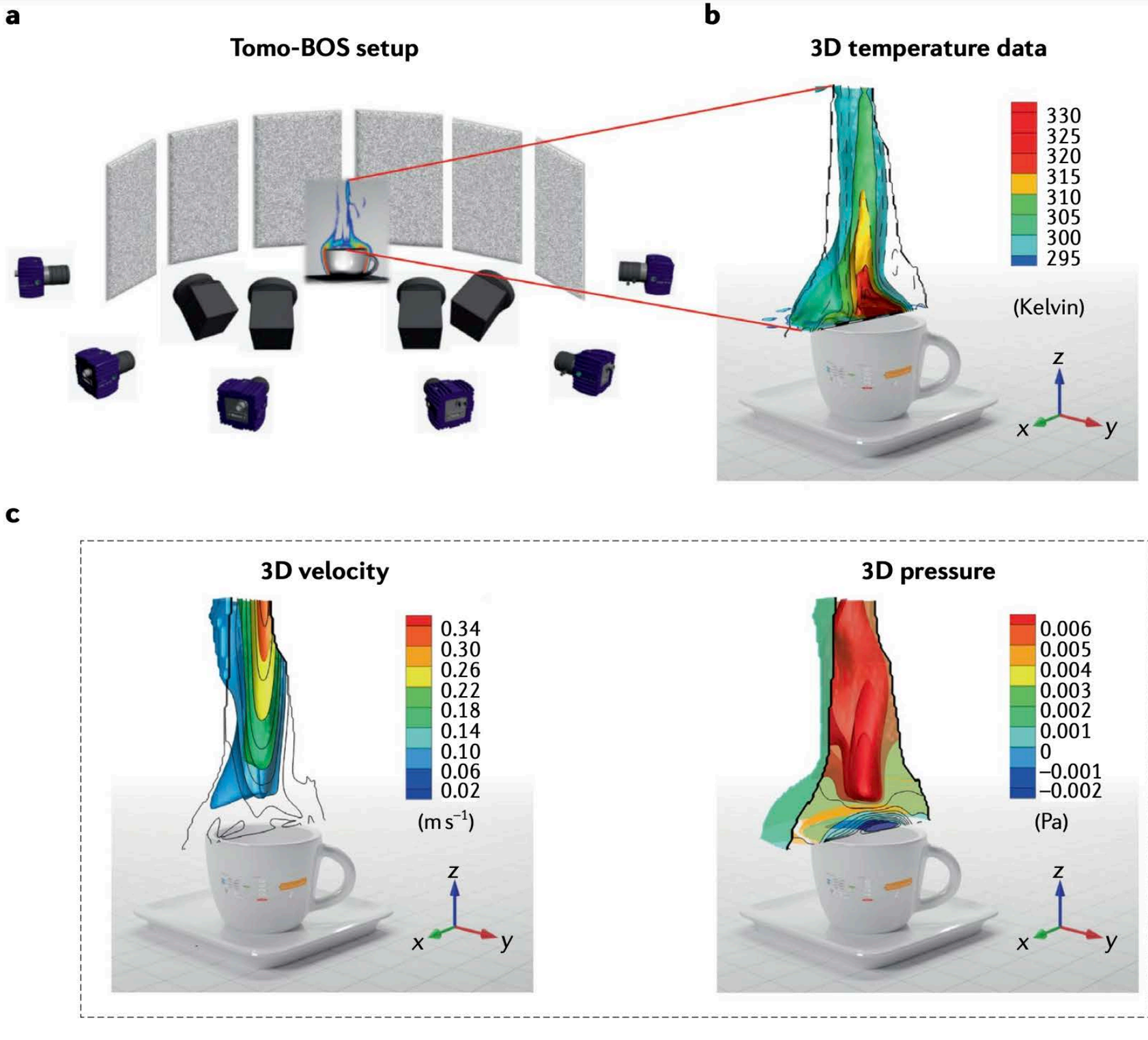
$$\mathscr{L}_{\text{Diffeq}} = \left(\ddot{\theta} + \mu\dot{\theta} + k\theta\right)^2$$

Constraint on Differential Equation
Aim to approximate learning

Physics Informed ML



Physics Informed ML

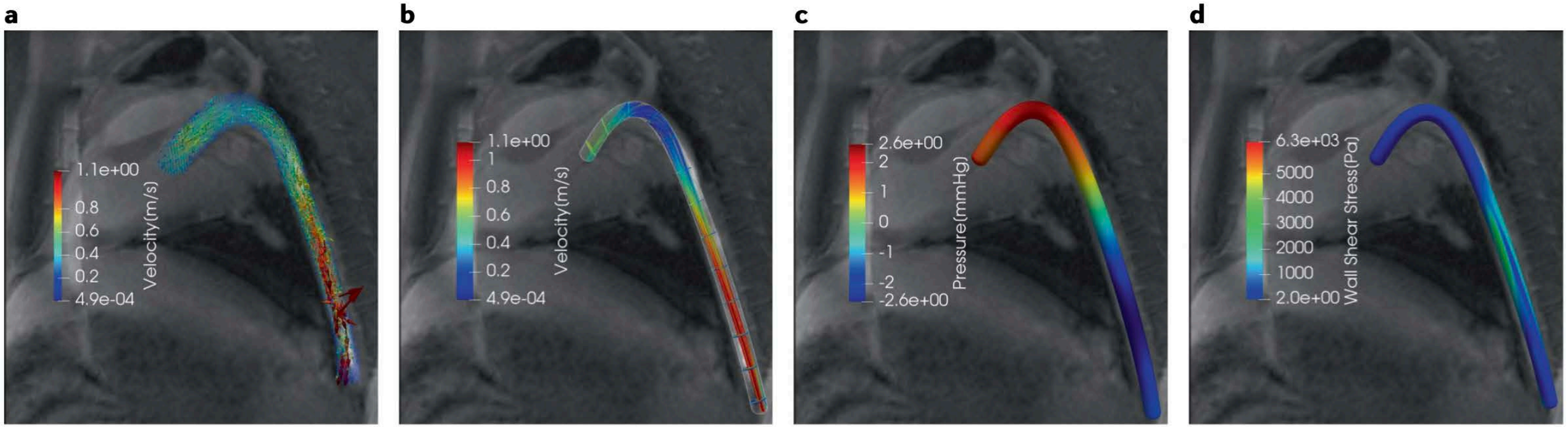


Given the
Laws of fluid flow

How do we model flow

These give us
Phyiscs informed ML

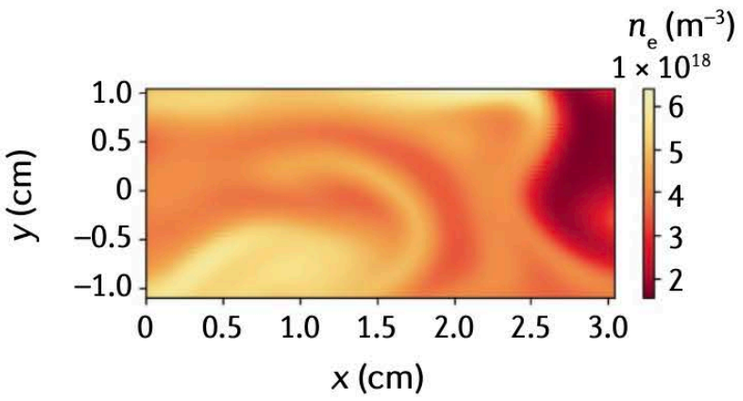
Physics Informed ML

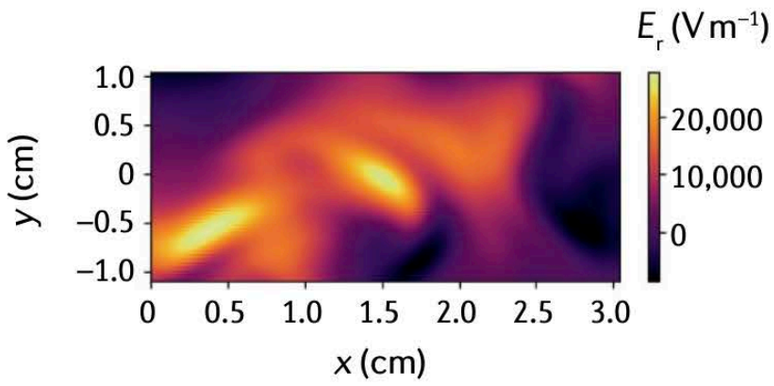


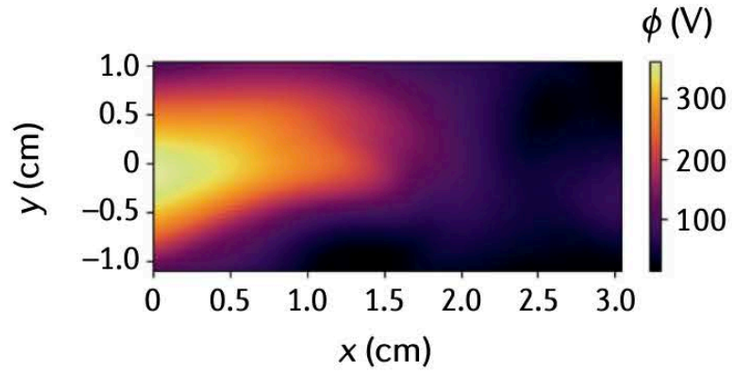
Navier Stokes equation to extrapolate blood flow in system

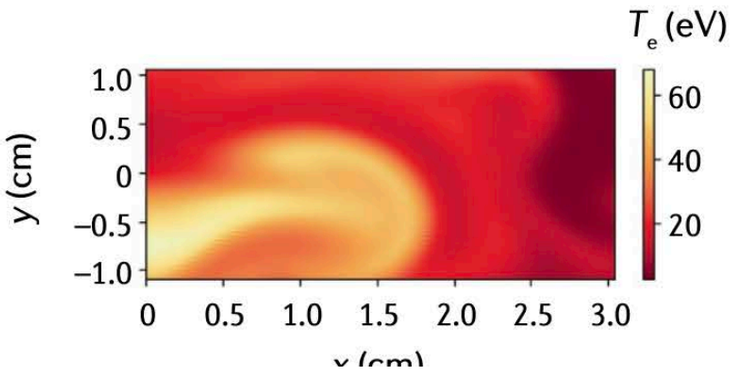
Navier Stokes equation to extrapolate blood flow in system

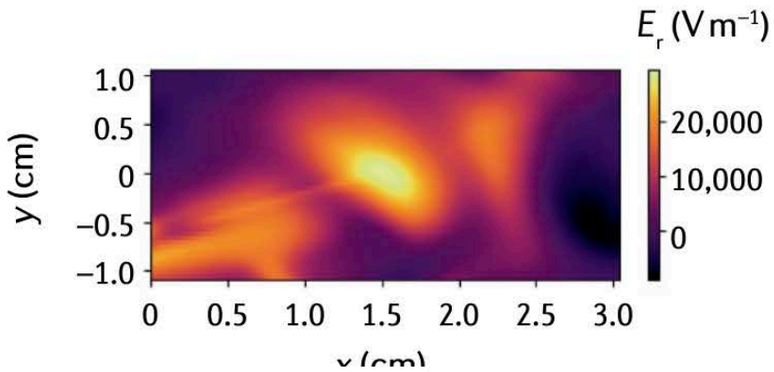
Physics Informed ML

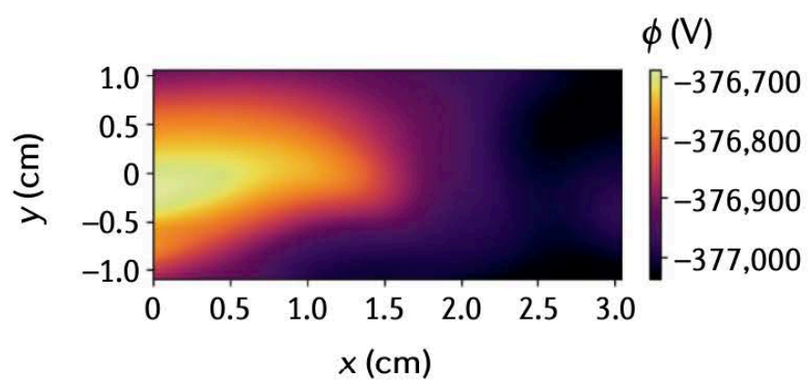


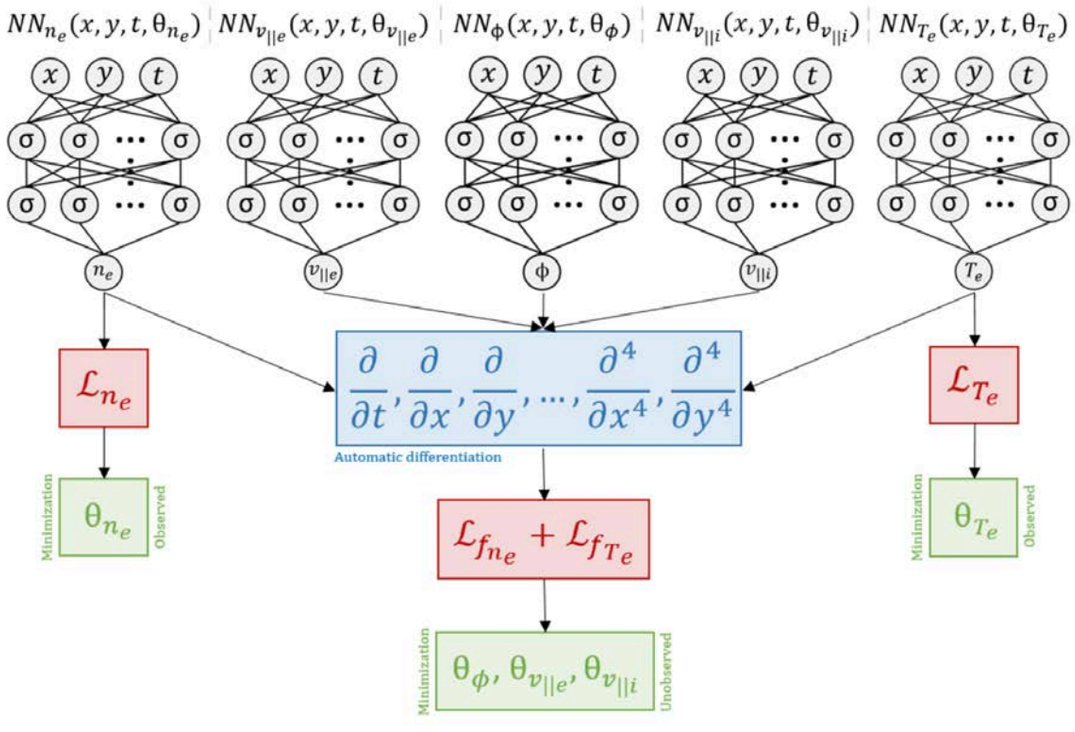












$$\mathcal{L}_{n_e} = \frac{1}{N_0}\sum_{i=1}^{N_0}|n_e^*(x_0^i, y_0^i, z_0^i, t_0^i) - n_{e,0}^i|^2,$$

$$\mathcal{L}_{T_e} = \frac{1}{N_0}\sum_{i=1}^{N_0}|T_e^*(x_0^i, y_0^i, z_0^i, t_0^i) - T_{e,0}^i|^2,$$

Image Sources

poicare maps and diagrams

link: https://www.researchgate.net/figure/Sketch-of-Poincare-section-and-Poincare-map_fig1_230660497

attribution: Abdullaev, S.. (1999). A new integration method of Hamiltonian systems by symplectic maps. Journal of Physics A General Physics. 32. 2745-2766. 10.1088/0305-4470/32/15/004.

Saturn's rings

link: https://commons.wikimedia.org/wiki/File:Unraveling_Saturn%27s_Rings.jpg

attribution: NASA / JPL, Public domain, via Wikimedia Commons

physics informed ML diagram; fluid flow figures; blood flow plots figures; plasma dynamics figures

link: https://www.nature.com/articles/s42254-021-00314-5

attribution: Karniadakis, G.E., Kevrekidis, I.G., Lu, L. et al. Physics-informed machine learning. Nat Rev Phys 3, 422–440 (2021). https://doi.org/10.1038/s42254-021-00314-5