# How to Create Data From Noise:
# Score-Based Generative Modeling of Dynamical Systems
# Through Stochastic Differential Equations

Generative models are deep neural networks trained to approximate high-dimensional probability distributions using a large number of samples. When trained successfully, they can be used to estimate the likelihood of each observation and to create new samples from the underlying distribution. These models have many applications in machine learning and AI, from generating high-fidelity images to imitation learning.

Score-based generative models (SGMs), introduced in [2], have been shown to demonstrate remarkable performance, achieving new state-of-the-art inception scores on benchmark datasets. In SGMs based on stochastic differential equations (SDEs) [3], the SDE smoothly transforms a data distribution to a known prior distribution by slowly injecting noise, and a corresponding reverse-time SDE transforms the prior distribution back into the data distribution by slowly removing the noise. The key idea behind the success of this approach lies in the fact that the reverse-time SDE depends only on the time-dependent gradient field (score) of the perturbed data distribution.

The main objective of this project is to *explore the capability and robustness of SGMs based on SDEs in modeling data generated by random dynamical systems*, particularly those with nonlinear, chaotic and/or noisy dynamics [1]. This project is aimed towards students from mathematics, physics and computer science. In particular, we are looking for a motivated candidate with strong background in programming and scientific computing. Depending on the research progress, there may be an opportunity to present the final research product in one of the premier machine learning conferences.

## References

[1] William Gilpin. Chaos as an interpretable benchmark for forecasting and data-driven modelling. *arXiv preprint arXiv:2110.05266*, 2021.

[2] Yang Song and Stefano Ermon. Generative modeling by estimating gradients of the data distribution. *arXiv preprint arXiv:1907.05600*, 2019.

[3] Yang Song, Jascha Sohl-Dickstein, Diederik P Kingma, Abhishek Kumar, Stefano Ermon, and Ben Poole. Score-based generative modeling through stochastic differential equations. *arXiv preprint arXiv:2011.13456*, 2020.