

**Invited Talk Abstract**

ICOML 2026 | July 27–29, 2026

**The Duality between Sampling and Optimization: New Perspectives from Diffusions and Optimal Control****Lorenz Richter***Zuse Institute Berlin*

<b>Date</b>	July 28, 2026
<b>Time</b>	10:30–11:00
<b>Session</b>	Session 4
<b>Venue</b>	S102, Lecture Hall, Gong-Guan Campus, NTNU

**Abstract**

The duality between optimization and sampling provides a powerful mathematical framework for exploring complex probability measures and highly non-convex landscapes. In this talk, we examine this relationship in both directions and show how ideas from one domain can be used to overcome fundamental limitations in the other. We begin with the direction from optimization to sampling. By formulating stochastic optimal control as an optimization problem over path space measures, we derive a new trust-region-based approach for sampling from high-dimensional, multimodal target distributions. This perspective enables principled control of exploration and improves robustness in challenging sampling settings. We then reverse the viewpoint and use diffusion-based sampling techniques to address global optimization problems. We introduce a non-convex optimization method that combines controlled diffusion dynamics with temperature tempering. Through systematic benchmarking, we analyze the failure modes of classical first-order optimizers and traditional MCMC approaches such as Simulated Annealing. Our results show that leveraging diffusion dynamics leads to improved scaling behavior and more reliable escape from local minima in highly multimodal objectives.