NITheCS

National Institute for
Theoretical and Computational Sciences

NITheCS MINI-SCHOOL:

From Physics to Machine Learning and back again: Applications of Machine Learning to Theoretical Physics, and Physics inspired Machine Learning

Wednesday 3, 10, 17 and 24 May 2023
14h00 – 15h00 SAST

TOPICS AND SPEAKERS

3 May — **'From Perceptrons to Energy-based Models, Physics and Biology-inspired Machine Learning'**

Prof Jonathan Shock (University of Cape Town)

In this talk I will give an overview of the history of machine learning from the perspective of how our understanding of the physical world has motivated machine learning advances and where we might go from here. This will include a quick dive into the world of active inference and Bayesian mechanics.

10 May — **'Machine learning, spin models and statistical mechanics'**

Dr Pallab Basu (*University of the Witwatersrand*)

In this talk, I will discuss some of our recent work in the application of machine learning techniques in spin models like Ising models. I will start with a generic discussion of what is machine learning and then venture into the application of machine learning in a physical system with an emphasis on our ongoing work on the Ising model and the role of adversarial training.

17 May — **'A string Standard Model from the top down'**

Prof Vishnu Jejjala (University of the Witwatersrand)

I motivate string theory as a model for quantum gravity. One of the central puzzles of string theory is the tension between the prediction that there are ten spacetime dimensions and the empirical observation that we see only four. While string compactification in principle addresses this issue, we are left with the vacuum selection problem. I discuss recent efforts to obtain the real world from string theory using machine learning to probe the geometry of extra dimensions.

24 May — **'Machine Learning Many-Body Localisation - A Practical Introduction'**

Mr Cameron Beetar (University of Cape Town)

Many-Body Localisation (MBL) is a fascinating phenomenon that violates the intuition afforded to us by quantum statistical mechanics — these are systems that do not thermalise. They are of interest for their potential use as quantum 'memories' as they retain (partial) information about their initial conditions. In this lecture, I will introduce simple models of systems that exhibit MBL and will demonstrate (with live coding in Mathematica) how one can use an Artificial Neural Network (ANN) to detect/classify states that do/do not thermalise. I also demonstrate how the ANN we build may demonstrate transfer learning.




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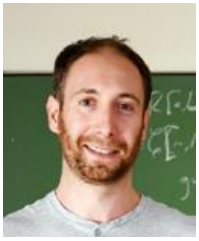
SPEAKERS' BIOGRAPHIES

Prof Jonathan Shock (University of Cape Town)



Jonathan Shock is an Associate Professor at the University of Cape Town in the Department of Maths and Applied Maths. He received his PhD from the University of Southampton in 2005 in the field of string theory and then completed postdoctoral research positions in China, Spain and Germany. His research career started in theoretical physics and has extended to various fields of AI including reinforcement learning, medical image analysis and active inference.

Dr Pallab Basu (University of the Witwatersrand)

Pallab Basu is a theoretical physicist with experience in AdS/CFT and string theory. He is currently a Senior Lecturer at the University of Witwatersrand in Johannesburg, South Africa. As a Senior Lecturer at the University of Witwatersrand, Pallab teaches courses in theoretical physics and supervises graduate students in their research. Before that he was a faculty member in ICTS-TIFR, Bengaluru, India.

Prof Vishnu Jejjala (University of the Witwatersrand)

Early in his scientific career, Vishnu Jejjala switched from vertebrate paleontology to astronomy. He was seven years old at the time. His interest in explicating the origin of the Universe and playing with cool mathematics led him to string theory. He completed a PhD in Physics at the University of Illinois at Urbana-Champaign in 2002 and subsequently held postdoctoral research appointments at Virginia Tech (2002--2004), Durham University (2004--2007), the Institut des Hautes Études Scientifiques (2007--2009), and Queen Mary University of London (2009--2011).

Since October 2011, Vishnu is the South African Research Chair in Theoretical Particle Cosmology at the University of the Witwatersrand. He is also a Professor in the School of Physics.

Vishnu's research interests are broad, but focus on exploring quantum gravity and the structure of quantum field theories with the goal of bringing string theory into contact with the real world. Black holes are one theoretical laboratory for investigating these issues. Another is string compactification on Calabi--Yau spaces.

Vishnu has recently been applying techniques from machine learning to study large data sets in string theory and mathematics.

Mr Cameron Beetar (University of Cape Town)

Cameron Beetar is a PhD candidate in the Laboratory for Quantum Gravity and Strings at the University of Cape Town (UCT). His current area of research is in exploring holographic quantum thermodynamics. Previously, Cameron completed an BSc in Physics, Mathematics, and Computer Science at UCT. This was followed by an Honours in Physics and MSc in Applied Mathematics, also at UCT. Most recently, Cameron completed his MSc in Quantum Fields and Fundamental Forces at Imperial College London. He is an Oppenheimer Doctoral Fellow, a Harry Crossley Research Fellow, and a Wolfram Physics Research Affiliate.