

# Inn'formal Probability Seminar

**Anders Karlsson, University of Geneva**

“A law of large numbers for noncommuting operations and its relevance for deep learning”

## **Abstract**

Products of random noncommuting transformations appear in many context in science. Bellman, Furstenberg and others asked from the 1950s and onwards to what extent there could exist a corresponding law of large numbers in such noncommutative settings. I will explain a general answer to this developed in joint papers with Margulis, Ledrappier, and Gouëzel. As special cases it implies Oseledets multiplicative ergodic theorem, random mean ergodic theorems, similar theorems for surface homeomorphisms and automorphisms of free groups (due to Horbez), and other corollaries. The setting could be viewed as a metric functional analysis.

The momentous rise of deep learning, giving the needed boost to AI, indicates that natural data tend to have a compositional structure. However, the power of deep learning is to a large extent a mystery and the lack of a theoretical understanding is something that both theorists and practitioners lament. The underlying neural networks are exactly large compositional products of certain non-linear operations, sometimes selected at random for various purposes. In a recent joint work with Avelin, we begin studying this and observe empirically what appears to be a cut-off phenomenon like in probability theory.

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SR 609 | civil engineer building