Neural Networks ansätze: quantum Long-range systems and quantum phase transitions

Manuel Gallego[1,2], Sebastián Roca[2], Jesús Carrete[2], David Zueco[2]
1. Department of Theoretical Physics, University of Zaragoza.
2. Instituto de Nanociencias y Nanomateriales de Aragón (INMA), CSIC.

Corresponding author: Manuel Gallego: manuel.gallego@unizar.es

In the study of many-body systems, finding analytical solutions for the Schrödinger equation is often difficult. The conventional brute force method for determining eigenstates faces limitations in scalability, constrained by the exponential growth of the Hilbert space with the system size. To address this challenge, a recent innovative approach leveraging machine learning has emerged. This approach takes advantage of the insight that wave function coefficients are governed by symmetries within the problem, thus they are not entirely independent. Therefore, one tries to embed the Hilbert space into a Neural Network's feature space, which only scales polynomially with the system size. We implement a relatively new architecture in the field, namely Visual Transformers, to study the quantum long range Ising model, determining its phase diagram and critical coefficients. Additionally, we study how to determine phase transitions in different quantum many-body systems from the states generated by the Metropolis-Hastings sampling. We find that with a rather small sample set, we can train a set-transformer to learn to discern if a state falls under the category of paramagnetism or not. We also find that we can train a perceptron to do the same task with the singular values of the matrix of the coefficients from the trained neural networks that represent the quantum state.