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Machine learning phase transitions in the three-dimensional Ising model

The exploration of QCD phase diagram and critical point is one of the main goals in current relativistic heavy-ion collisions. The QCD critical point, if exists, is expected to belong to a 3D Ising universality class. By means of a parametrized form of the scaling equation of state and a mapping of the scaling variables in Ising model onto QCD coordinates, it is proposed to build an expression of pressure and any derivative over the whole phase diagram[1].

Unlike the calculation of order parameters in conventional statistical methods to study phase transition, machine learning techniques are recently introduced to detect and classify phases of matter without providing any other thermodynamic quantities but only the raw configurations at various temperatures in spin models[2]. In this talk, we report results of studies on the phase transitions in 3D Ising model by supervised learning methods. It is found that the 3D convolution neural network can be trained to predict physical quantities, such as magnetization and average energy with high accuracy. The neural network could encode phases of matter and discriminate phase transitions of both the first and the second order. Physics implications of the results in understanding the QCD phase diagram in heavy-ion collisions will be discussed.

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