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Machine learning parameters of attosecond pulses based on photoelectron momentum distributions

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Experiments with ultra-short laser pulses applied to a single atom invoke highly non-linear phenomena. Thus, they are strongly sensitive to the laser pulse parameters such as intensity, carrier envelope phase (CEP), frequency, polarization, and the number of cycles. Several techniques of retrieving pulse parameters have been developed, with state-of-the-art precision and accuracy achieved through in situ measurements that fit atom ionization rates to values predicted by the exact time-dependent Schrödinger equation [1]. Ref. [2] identifies room for one to two orders of magnitude accuracy improvement through the measurement of 2-D photoelectron momentum distribution. However, recovering laser pulse parameters by comparing these distributions to theoretical predictions is a complicated inverse problem. Here, we propose a machine learning approach, namely - to train a convolutional neural network in a supervised way to interpolate between 2-D momentum distributions for a finite set of laser pulse parameters, and then to use it to predict those parameters given a new momentum distribution. We find that upon training the network can predict pulse parameters with satisfactory accuracy, e.g. with mean absolute error of less than 1% for intensity. The model may serve as a pretrained architecture for further fine-tuning on real-world data from attosecond laboratories.

[1] M. G. Pullen et al., Phys. Rev. A 87, 053411 (2013)
[2] A. S. Maxwell et al., Phys. Rev. A 103, 043519 (2021)

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