Abstract Submitted
for the DAMOP20 Meeting of
The American Physical Society

**All-optical neural network with nonlinear activation functions using cold atoms**[1] YING ZUO, BOHAN LI, YUJUN ZHAO, YUE JIANG, YOU-CHIUAN CHEN, PENG CHEN, GYU-BOONG JO, JUNWEI LIU, SHENGWANG DU, Hong Kong University of Science and Technology — Most computer-based artificial neural networks with large number of neurons and interconnections require huge computational resources and power consumption. Optical implementation naturally has advantage with its intrinsic parallelism, high speed and low energy consumption. However, the experimental realization of all-optical nonlinear activation functions, which are necessary for deep machine learning, remains the bottleneck for optical neural networks. Here, we demonstrate a fully-functioned all-optical neural network (AONN) scheme with tunable linear optical operations and nonlinear optical activation functions. The linear operations are realized using spatial light modulators and optical Fourier lenses. The optical nonlinear activation functions are realized with electromagnetically induced transparency in a cold atomic ensemble. The AONN system is error-tolerant and scalable due to the independence of errors from different neurons. To verity the capability and feasibility of the AONN scheme, we built a two-layer dense AONN and successfully applied it to classify different phases for a prototypical Ising model in condensed matter physics. This work was supported by the Hong Kong Research Grants Council (Projects Nos. C6005-17G and ECS26302118).

[1]Hong Kong Research Grants Council (Projects Nos. C6005-17G and ECS26302118).

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Date submitted: 11 Dec 2019 Electronic form version 1.4