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Integrating Machine Learning and Physics-based Heuristics for Solitonic Excitation Classification in Bose-Einstein Condensates SOPHIA KOH, Amherst College, SHANGJIE GUO, AMILSON FRITSCH, IAN SPIELMAN, Joint Quantum Institute, University of Maryland, National Institute of Standards and Technology, JUSTYNA ZWOLAK, National Institute of Standards and Technology — Bose-Einstein condensates (BECs) are ultracold collections of atoms which exhibit macroscopic quantum effects. In BECs, we can create solitons–robust, localized waves which appear in images as a local decrease in BEC density. With a dataset of labeled BEC images, we trained a machine learning (ML) model to locate solitons. Though solitonic excitations such as solitons and solitonic vortices represent distinct physical states, the ML system identified all as solitons. We built a quality estimator to measure confidence in the presence of a soliton by summing the images vertically and using a five-parameter fit to a function describing an idealized soliton profile. While the quality estimator is effective with vertically-consistent solitons, it has limited applicability to vertically-varied distributions such as solitonic vortices. With the goal to determine the type of solitonic excitation, we estimated the quality of separate segments of each image and analyzed the differences between fit parameters to distinguish solitonic excitations. Using ML to locate solitonic excitations and the improved quality estimator to distinguish types of solitonic excitations, the integration of ML and physics-based heuristics improved our solitonic excitation classification and detection pipeline.

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