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Searching for Dark Matter Subhalos in Astronomical Data using Deep Learning

The search for dark matter (DM) has grown into an endeavour spanning many orders of magnitude in terms of potential DM particle candidate masses probed by numerous direct and indirect experiments. A potential new avenue to explore the nature of DM is to test the predicted abundance of dark subhalos in the LCDM framework. According to the current model of structure formation, our Galaxy has grown by mergers with smaller halos. Thus, hinting at a large population of subhalos orbiting the Galaxy with some of them completely void of stars. The dramatic increase in high-precision observations from current and future stellar surveys of our Galaxy (e.g. Gaia satellite) encourages the gravitational detection of subhalos using deep learning techniques. On the one hand, these methods have already unravelled the stellar substructure of the Milky Way. On the other hand, Milky Way-like galaxy simulations can be used to explore the Galactic dark substructure by training and testing machine learning algorithms. Motivated by the above, our work estimates the feasibility of using supervised and unsupervised deep learning methods on simulations and synthetic Gaia observations to detect disturbances in the stellar phase-space induced by orbiting dark matter subhalos. We quantify the magnitude of the perturbations using a deep learning based anomaly detection algorithm. The enormous sizes of current and future astronomical surveys call for further development of scalable computational methods to identify potential regions of interest in future dark matter searches.

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