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Enhancing LHC searches for Dark Matter with Graph Neural Networks

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Approximately one-fourth of the energy density of the known Universe is attributed to Dark Matter (DM), the nature of which remains enigmatic. If DM is made of particles, producing and studying them at the Large Hadron Collider may be possible. A promising method to achieve it is to consider a monojet channel, in which at least one hard jet recoils against a missing transverse momentum, and there are no isolated leptons.

This study presents a novel approach to discovering Dark Matter at the Large Hadron Collider with Graph Neural Networks (GNNs). Contrary to the traditional analyses relying on hand-picked high-level variables, GNNs allow to capture the underlying spatial and topological features of the event, leading to enhanced discrimination between signal and background processes.

We demonstrate the utility of our approach for a scenario, where Dark Matter candidates are wino-like and higgsino-like neutralinos. We present the limits on DM particle masses that could be obtained by the end of the Run 3 and High Luminosity phases and we discuss the benefit of including different production processes. Finally, we interpret the Neural Network in an attempt to understand the connection between its output and the physical properties of the underlying events.

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