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Discovering Stellar Streams with Graph Neural Networks

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Stellar streams are thin, elongated structures in the Galactic halo, formed by the tidal disruption of bound groups of stars. They provide valuable insight into the Milky Way's gravitational potential and dark matter substructure, as breaks in their structure can reveal past interactions with dark matter clumps.

Previous stream searches often prioritized either astrometric or photometric data, limiting their ability to fully exploit the combined available information. We present a new approach that smoothly integrates both data types from Gaia to improve stream identification.

Our algorithm uses a graph neural network that naturally handles the geometric and heterogeneous structure of streams, and applies a weakly supervised framework known as Classification Without Labels (CWoLa), which does not require labeled training data.

Tested on the known GD-1 stream, our model recovers over 96% of member stars in the supervised case and over 50% in the weakly supervised setting. We are now scaling our algorithm to run on the full Gaia dataset. Our framework supports systematic discovery of stellar streams and improved knowledge of the Galactic halo.

Author: PRATSOS, Alexandros (University of Toronto)

Co-authors: Dr DEY, Biprateep (University of Toronto); LI, Ting (University of Toronto)

Presenter: PRATSOS, Alexandros (University of Toronto)

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