Mapping the Habitability of the Milky Way with Gaia and Stellar Kinematics

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From using the sky for navigation and time-keeping to sending probes and telescopes into space, one question that has always driven astronomy is: are we alone in the Universe? Although most research in this field focuses on the hunt for Earth-like exoplanets, is it also essential to factor in the so-called Galactic Habitable Zone (GHZ), a relatively new concept that accounts for galactic hazards detrimental to life, such as radiation and gravitational perturbations. However, existing GHZ models are not consistent with each other, most are based on either simulations or general trends, and none have fully addressed the contribution of stellar kinematics. Therefore, based on well-accepted constraints on habitable galactic environments, this project develops a model for the GHZ and applies it to stellar data from the Gaia satellite on 6,350,087 stars, including 1,146 confirmed exoplanet systems. This model consists of the following criteria: orbits that avoid the Galactic bulge and have limited spiral arm intersections, which were evaluated by calculating each star's orbit backwards in time over the past 4 billion years using the Milky Way's gravitational potential, and sufficient stellar metallicity. The results of this model predict that there is a potential for habitable worlds in a large region of our galaxy; however, many of the confirmed exoplanets that have been found may not be habitable because their host star's orbit encounters too many galactic hazards. Thus, this work advances our understanding of the potential for life, not only for confirmed exoplanets, but also throughout the Milky Way.

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