Assessing the Habitability of Exoplanets: An Integrated Framework Incorporating Similarity Evaluation and Kinetic Theory of Atmospheric Gases

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The rapid discovery of exoplanets in recent years has presented a complex challenge in determining their habitability. Remote detection and limited spatial and spectral information, as well as a lack of detailed models for exoplanet atmospheres, pose difficulties in studying these distant worlds. There have been significant advancements in implementing novel technologies and analytical methods, though, and thus it is critical to prioritize potential candidates for future investigation. In this study, two frameworks were proposed and evaluated for determining the most Earth-like exoplanets. The first approach utilizes atmospheric composition and Bayesian analysis, but its accuracy is heavily dependent on the quality and availability of data from missions like James Webb Space Telescope (JWST), which may not be readily available. The second method employs kinetic theory of atmospheric gases and was found to be a more viable option for further investigation. A variety of techniques used to measure similarity, commonly applied in machine learning classification and regression models, were implemented to rank the most Earth-like exoplanets. Then, a thermal escape model was applied to examine potential atmospheric biosignatures that may be retained within each exoplanet's atmosphere; the results of such a model were then compared to the results for the well-studied Solar System planets. This integrated approach has the potential to greatly enhance our understanding of exoplanet habitability. Furthermore, the findings suggest that a comprehensive examination of habitability should be conducted to address current limitations in determining the habitable zone and presence of an Earth-like atmosphere on exoplanets.

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