Discovery of Previously Undetected Exocomet Candidates in Kepler Using ExoSeek: A Novel End-to-End Deep Learning Exocomet Detection Algorithm

Han, Gary (School: Syosset High School)

The study of exocomets, cometary bodies orbiting stars beyond our solar system, is essential for understanding planetary disc formation and the origins of life. Unfortunately, exocomets are still difficult to detect due to their low amplitudes and single-event nature, hindering exocomet research. Out of more than 800,000 stars observed by missions like Kepler, K2, and TESS, less than 70 exocomet candidates have been identified. Traditional manual searches are not scalable, while existing automated attempts struggle with candidate detection uncertainty and computational inefficiency. This project introduces ExoSeek, a novel, end-to-end deep learning system designed for the efficient mass detection of photometric exocomet signals. The pipeline utilizes a data preprocessing framework for detrending and normalization. Then, an updated Convolutional Neural Network (CNN) architecture trained on 1 million synthetic samples is used to identify potential candidates. To eliminate potential false positives, the system incorporates a novel and flexible candidate vetting system. In a search of 69,000 A and F-type stars from the Kepler database, ExoSeek successfully recaptured all previously known Kepler candidates and discovered two new rare exocomets that were missed by prior searches. One of these discoveries, KIC 4581434 D898, represents the smallest width exocomet ever recorded in the Kepler database. All candidates were validated through a rigorous multi-step confirmation process. ExoSeek demonstrates the power of deep learning to scale exocomet discovery across massive datasets from TESS, James Webb, and future missions, with potential broader applications in asymmetric signal detection for medical and meteorological research.

Awards Won:

Third Award of $1,200