Abstract

WFIRST (Wide-Field Infrared Survey Telescope) is a NASA mission designed to study dark energy, exoplanets, and infrared astrophysics over a six-year period. One of WFIRST’s instruments, the Coronagraph Instrument (CGI), will use advanced technology to image exoplanets and characterize their atmospheres in reflected starlight. We used a Monte Carlo approach to model the population of planets around nearby stars (distance < 20 pc), and then applied the detection limitations of Gaia and WFIRST CGI. The distribution model predicts that Gaia observations of bright, single stars will yield around 9 planets, 3 of which are accessible to WFIRST.

WFIRST’s Coraonagraph Instrument is capable of directly imaging exoplanets by suppressing the starlight of the planets’ host stars. It can also characterize exoplanets through spectroscopy. There are already some targets that we know we want to look at; planets previously discovered by indirect detection methods such as the radial velocity technique. However, there may be observable exoplanets yet to be discovered. There are two ways of going about this: a blind survey of nearby stars with WFIRST, or discovering new nearby planets with other techniques. The recently launched Gaia astrometry mission may provide exoplanet discoveries observable by WFIRST. To assess the Gaia-discovered exoplanet yield we may expect, we created a planetary distribution model based from Cumming et al., 2008, which is derived from existing planet distribution frequencies.

Simulating the Gaia Exoplanet Yield for Nearby Stars

The planetary distribution model was coded in Python 3. It starts by randomly generating a set of planet masses and periods between 0.3 and 10 Jupiter masses, and 2 and 2000 days respectively. It feeds these masses and periods into the power law fit, generating a distribution of planets. We expect 10.5% of nearby stars in this mass-period range to have planets, so planets are randomly assigned to known nearby stars (from the NExScI EXOCAT). The astrometric signatures and contrasts of these planet-star systems are calculated, and limitations from Gaia and WFIRST are applied to constrain the data. Finally, the results are displayed as a series of plots, based on distance, astrometric signature, G magnitude, and planet-star contrast. This process can be repeated many times if the user chooses, each trial representing a different “universe”, so to speak.

To understand exactly what we can expect nearby planets to be like, different plots were created based on a number of different trials.

Conclusions & What’s Next

The figures generated from the planetary distribution model reveals some information about the type and yield of exoplanets that may be discovered by Gaia and characterizable by WFIRST. The stars within 20 pc around which Gaia discovers exoplanets will most likely have a G magnitude between 4 and 5 mags and an astrometric signature between 70 and 100 μas. There are some stars that have a tendency to yield the most joint Gaia-WFIRST detections, for example Tau Ceti. If we model nearby exoplanetary systems with the Cumming et al. mass-period distribution, then we estimate that 3 planets detected by Gaia will also be observable with WFIRST CGI. Higher fidelity will be added to the the planetary distribution model, using a simulator of exoplanet imaging called EXOSIMS (github.com/dsavransky/EXOSIMS). EXOSIMS has its own planetary distribution function, and we want to combine the our simulation framework with EXOSIMS, and see if there is any appreciable difference in Gaia yield predictions between the model we have now and the EXOSIMS model.

References