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Exoplanets and Space-based microlensing: the Galactic distribution of exoplanets with the Spitzer program and the statistical census of planets with the WFIRST survey.

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Abstract

Microlensing is a key technique for the search and the characterization of exoplanets, with the ultimate goal to understand their formation mechanism. Here I report on two space-based programs. The main scientific goal of the ongoing *Spitzer* program is to measure the galactic distribution of exoplanets towards the Bulge. The primary science goal of the forthcoming WFIRST microlensing survey is to "complete the statistical census of planetary systems in the Galaxy, from the outer habitable zone to free floating planets, including analogs of all of the planets in our Solar System with the mass of Mars or greater." ([9]).

1. Introduction

Microlensing, with over 70 planetary systems known to date (NASA Exoplanet Archive, https://exoplanetarchive.ipac.caltech.edu/index.html), is a key technique for the search and the characterization of exoplanets ([5]). In particular microlensing allows to access relevant parts of the physical parameter spaces which are currently difficult to access by other methods. As a main point, microlensing is sensitive to planets in bound systems located far enough (of order of a few AU) from their host star, beyond the "snow line" (a key location in the framework of planet formation theories), and is sensitive to low mass planets, in principle down to below Earth-mass analogs. Additionally, microlensing is sensitive to planets distant from the solar neighbourhood, all the way to the Galactic bulge and in principle also to extragalatic planets. Finally, microlensing is sensitive to unbound planetary systems ("free floating planets"). In this summary I focus on ongoing and forthcoming space-based programs. In Section 2 I will update on the status and perspective of the ongoing Spitzer microlensing campaign. In Section 3 I will introduce the forthcoming WFIRST microlensing survey.

2. The Spitzer microlensing program

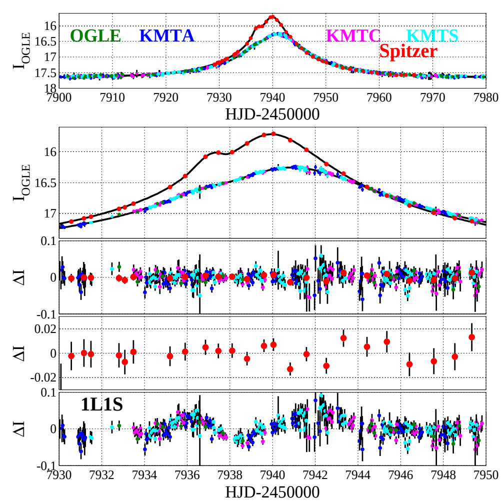

Figure 1: Ground-based and *Spitzer* data together with the best, planetary, model for OGLE-2017-BLG-1140. From top to bottom: data and best fit model (top two panels); residual light curves for the best planetary model (next two panels); ground-based data residual light curve for the single lens model. Figure adapted from [3].

The Spitzer microlensing program started in 2014 and the sixth and last expected season is to be carried out in summer 2019. The program consists in the follow up with *Spitzer*, a space telescope in Earth-trailing orbit currently located at more than 1 AU from the Earth, of microlensing events alerted and monitored from ground. The simultaneous observation of the same microlensing event from two distant observers allows the measure of the microlensing parallax, which is key to determine the physical parameters of the lens system and in particular, although only in a statistical sense, of the overall population of single lens systems. Together with the observation of planetary events and the analysis of the planet detection sensitivity, this can be used for the determination of the Galactic distribution of planets in distance ([1, 13]). The statistical sample for the determination of the Galactic distribution of planets, and the selection procedure for the microlensing events to be followed up, is built according to the protocol described in [12]. The photometry for *Spitzer* data is carried out using the pipeline developed in [2]. To date over 700 microlensing events have been monitored, and the microlensing parallax has been determined for almost 100 of them. Over 30 systems, single and binary lens, have already been characterized in detail, and in particular six planetary events, [11, 10, 8, 7, 3, 4], four of which are located in the disk (the analysis of four additional planetary systems is in preparation). In Figure 1 I show data and best fit model for the planetary event OGLE-2017-BLG-1140.

3. The WFIRST microlensing survey

The *Wide Field InfraRed Survey Telescope*, WFIRST, is a flagship NASA mission planned for launch in 2025 [9]. One of the survey programs in the baseline mission is a microlensing survey expected to discover over 1000 exoplanets [6]. In particular, the WFIRST design will allow a systematic analysis of a large sample of cold, low-mass exoplanets with semimajor axes beyond about one AU, a region of the parameter space difficult to access by other methods (Figure 2). The key advantage for a microlensing space mission, carried out in the near-infrared, is the ability to resolve stars in crowded fields, which greatly enhances the expected yield and will allow in most cases to extract the physical parameters of the lens systems, and to monitor fields without interruptions, with an expected cadence of 15 minutes key to properly sample the short duration microlensing planetary signatures, overall changing both quantitatively and qualitatively what can be achieved with microlensing from ground only. With the nominal baseline mission design, and fiducial planet mass function, the prediction is for ~ 1400 bound exoplanets, about ~ 200 of which with mass smaller than $3\,\mathrm{M}_{\oplus}$, and a few hundreds of free-floating planets with mass down to that of Mars.

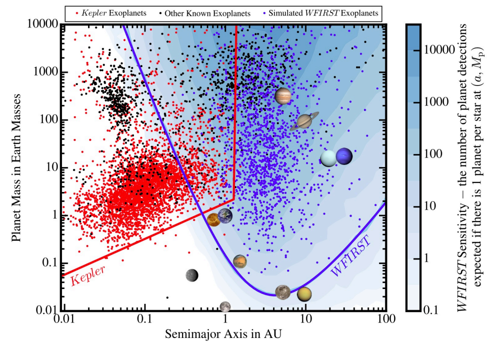

Figure 2: WFIRST microlensing survey's predicted sensitivity, as compared to other methods, in the planet mass versus semimajor-axis parameter space. Solar system bodies, including Ganymede, Titan and the Moon, are also shown. Figure adapted from [6].

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