Abstract

The first part of my thesis focuses on searching for and constraining the frequency of rogue planets in the Milky Way. The existence of free-floating planets, which are not gravitationally tethered to any star, is predicted by current planet formation theories. Although rogue planets emit little or no light, they can be detected during gravitational microlensing events.

I led the analysis of a large sample of microlensing events that were detected by the OGLE survey during the years 2010-2015. My statistical analysis showed that Jupiter-mass free-floating planets are much less common than previously thought (less than 0.25 objects per star). For the first time, I was able to study the population of the shortest microlensing events and I have found a few events that were likely caused by free-floating (or wide-orbit) Earth- and super-Earth-mass objects, as predicted by planet-formation theories.

Recognizing the potential importance for planet formation and evolution of such a huge population of ejected (or very distant) low-mass planets, I developed a new technique to characterize them. My subsequent studies, in collaboration with other microlensing surveys (KMTNet, MOA, Wise), led to the first measurements of the angular Einstein radius of free-floating planet candidates. These measurements enabled me to constrain masses of free-floating planet candidates as they remove a degeneracy between the mass and velocity of the lens.

In the second part of my thesis, I used microlensing events detected by OGLE to study the structure of the Milky Way. I created the largest and the most accurate microlensing optical depth and event rate maps of the Galactic bulge. These maps will have numerous applications: constraints on Galaxy models, constraints on the dark matter content in the Milky Way center, measurement of the initial mass function in the Galactic bulge, or planning the future space-based microlensing experiments.