Microlensing Surveys for Planets with WFIRST

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Planet Formation Physics from WFIRST Planets

• Snow Line Physics
• Planet Embryos & Planet Ejection
• Galactic Distribution of Planets
The Physics of the Snow Line
A break in the mass ratio function
No planets with $\log q < -4.5$

Event Sequence

Udalski et al. 2018 arXiv:1802.02582

No planets with $\log q < -4.5$
What will WFIRST tell us about the Mass Ratio Function?

- What is $q_{br}$?
Kepler break is @ smaller \( q \) (\( \sim 3 \times 10^{-5} \))
$q_{br}$ is independent of Stellar Mass

WFIRST can combine many techniques to measure Host Masses

\[ M = 0.5, \quad D = 4.0, \quad H_S = 18.0 \]

- Flux
- Finite Source
- Parallax
What will WFIRST tell us about the Mass Ratio Function?

• What is \( q_{br} \)?
• How does \( q_{br} \) vary with semi-major axis?
• How does \( q_{br} \) vary with host star mass?
Ground-based microlensing cannot measure the lowest mass ratios.
Only WFIRST can measure low mass ratio slope.
What will WFIRST tell us about the Mass Ratio Function?

• What is $q_{br}$?
• How does $q_{br}$ vary with semi-major axis?
• How does $q_{br}$ vary with host star mass?
• What is the slope of the mass ratio distribution at small $q$?
Large planets at a wide range of separations.
$a_{\text{snow}} \propto M^x; x = 1.0$
What does the Mass Ratio Function tell us about Physics?

• Where is the snow line?
• How does the snow line depend on stellar mass?
• Is the snow line fuzzy or sharp?
The Leftovers of Planet Formation
Ganymede-sized planets outside the snow line.
Are there other features at low mass ratios?
What will WFIRST tell us about the Smallest Planets?

• What does the mass (ratio) distribution look like for small $q$? Is there a feature at Mars mass?
Population of Free-Floating Super Earths?

Mroz et al. 2017 Nature 548, 183
What will WFIRST tell us about the Smallest Planets?

• What does the mass (ratio) distribution look like for small $q$? Is there a feature at Mars mass?

• What is the mass spectrum of free-floating planets?
Are Free-Floating Planets bound?

What will WFIRST tell us about the Smallest Planets?

• What does the mass (ratio) distribution look like for small $q$? Is there a feature at Mars mass?

• What is the mass spectrum of free-floating planets?

• How do free-floating planets relate to bound planets? Are free-floating planets really free-floating?
What do the Smallest Planets tell us about Planet Formation?

• How efficient is planet formation?
• What is leftover from planet formation?
• What is ejected during planet formation?
The Galactic Distribution of Planets
A Mass Measurement = Distance Measurement

$M = 0.5, \ D = 4.0, \ H_S = 18.0$
Microlensing finds planets from 0—8 kpc.
• How do planets vary with galactic distance?
• How does planet formation vary with galactic location?
Planet Formation Physics from a Complete Census

- Snow Line Physics
- Planet Embryos & Planet Ejection
- Galactic Distribution of Planets
WFIRST will resolve many microlensing events.
$a_{\text{snow}} \propto M^x; \ x = 2.0$
$a_{\text{snow}} \propto M^x; x = 1.5$