ULTIMATE microlensing survey

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Sensitive to cold planets beyond the snowline ($\sim 3a_{\text{snow}}$)

**Time scale:** $t_E \sim M^{1/2}$

$\sim 30$ days for $0.5M_{\text{Sun}}$
Sensitive to cold planets beyond the snowline ($\sim 3a_{\text{snow}}$)

Time scale: $t_E \sim M^{1/2}$
- $\sim 30$ days for $0.5M_{\text{Sun}}$
- $\sim$ a few days for $M_{\text{Jupiter}}$
- $\sim$ a few hours for $M_{\text{Earth}}$
Microlensing surveys need NIR

- The closer to the galactic center, the more stars & µlensing events
  - But
  - Much higher dust extinction
    - Much more crowded

→ NIR
  - wide FOV
  - high-resolution
Microlensing surveys need NIR

1-2m-class telescopes
2-4 deg$^2$ FOV
optical filters (I-band)

1.8m telescope
1.5 deg$^2$ FOV
NIR filters (H-band)

2.4m space telescope
0.3 deg$^2$ FOV
NIR filters (up to 2µm)

OGLE-IV  MOA-II  KMTNet

PRIME (PI: T.Sumi)

WFIRST

Chile  NZ  Chile, Australia, South Africa

Microlensing surveys need NIR

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2.4m space telescope
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Exoplanet distribution

- **Microlensing**
- **Transint**
  - **Kepler**
- **Radial Velocity**
- **Direct Imaging**
WFIRST – ULTIMATE-Subaru

Concurrent Obs:

1. To measure the microlensing parallax for mass & distance measurement
   ✓ K-band can penetrate highly extincted region, where event rate is higher.
   ✓ Complement to HSC/LSST/PRIME

2. To characterize the host (lens) star
   ✓ Complement to WFIRST filters (<2μm)
   ✓ (Z087-K) and (W146-K) colors
   ✓ → Metallicity of M-dwarf hosts

3. To detect long time-scale (BH) event
   ✓ light-curve, parallax + resolved images
   ✓ Mass measurement of isolated BHs

Acknowledgements to D. Bennett
K-band Microlensing Survey toward the Galactic Center

THE ASTROPHYSICAL JOURNAL, 446: L71–L73, 1995 June 20
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K-BAND MICROLENSING OF THE INNER GALAXY
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Received 1994 December 23; accepted 1995 April 11

ABSTRACT

Microlensing searches toward the inner galaxy (|l|, |b| ≤ 22.5) have several major advantages. First, the event rate is strongly dominated by bulge-bulge lensing events where both the source and lens lie in the bulge. Second, these bulge-bulge events have very short timescales $t_e \sim 2$ days and are therefore easily distinguished from the less frequent and much longer bulge-disk and disk-disk events. Third, since the optical depth is similar to that at higher impact parameters, while the events are shorter, the event rate is high, $\Gamma \sim 3 \times 10^{-7}$ day$^{-1}$. Fourth, because the Einstein rings are small, $r_e \sim 5 \times 10^{12}$ cm, and the source stars are large, $r_s \gtrsim 10^{12}$ cm, the lens will transit the face of the source for a significant fraction ($\sim 20\%$) of events. For these transit events it will often be possible to measure a second lens parameter, the angular Einstein radius (or proper motion). In addition to the bulge-bulge events, the optical depth of the disk is $\sim 3$ times larger toward the
K-band Microlensing Survey toward the Galactic Center

Microlensing events (OGLE)

K-band Microlensing Survey toward the Galactic Center

Microlensing events (OGLE)

Gonzalez+12
K-band Microlensing Survey toward the Galactic Center

Microlensing events (OGLE)
Microlensing events (VVV)
K-band Microlensing Survey toward the Galactic Center

Microlensing events (OGLE)
Microlensing events (VVV)
WFIRST μ-lens survey field (2025~)
K-band Microlensing Survey toward the Galactic Center

Microlensing events (OGLE)
Microlensing events (VVV)
WFIRST $\mu$-lens survey field (2025~)
JASMINE field (2024~)
K-band Microlensing Survey toward the Galactic Center

- Microlensing events (OGLE)
- Microlensing events (VVV)
- WFIRST μ-lens survey field (2025~)
- JASMINE field (2024~)
- Gould 95 suggestion
K-band μlensing Survey w/ ULTIMATE-Subaru

➢ To understand the inner Galactic bulge structure
  • 1/hour cadence will be enough to detect microlensing events (~2days time scale)
➢ To understand the planet formation at the inner Galactic bulge
  • High cadence (every 15-20min) photometry would be needed.
  • Strong finite source effect might wash out the planetary signals for the giant source stars.
  • \(\rightarrow\) K-band, wide FOV, high spatial resolution, deep imaging: only ULTIMATE-Subaru can achieve
K-band Microlensing Survey toward the Galactic Center

- Microlensing events (OGLE)
- Microlensing events (VVV)
- WFIRST $\mu$-lens survey field (2025~)
- JASMINE field (2024~)
- Gould 95 suggestion
- ULTIMATE Subaru (late 2020s)
Summary

ULITMATE-Subaru can be used for the ultimate µlensing surveys

1. WFIRST – ULTIMATE-Subaru concurrent observation
   • To measure the microlensing parallax toward the highly obscured region for **planet mass and distance measurement**
   • To characterize the lens star by the color measurement for the **host star metallicity**
   • To measure long events for **mass measurement of BHs**

2. K-band microlensing survey toward the inner Galactic bulge
   • To understand the **inner Galactic bulge structure**
   • To study the **planet formation at the inner Galactic bulge**