Analysis of the Planetary Microlensing Event OGLE-2017-BLG-0406 with Spitzer Data

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High Magnification Alert

Anomaly detected

Planetary model

MOA–Red
OGLE–I
MOA–V
KMT–SSO–I
KMT–SAAO–I
LscA–I
cojA–I
Danish–Z
Auckland–R
Craigie–U
CTIO1.3m–I
CTIO1.3m–V
FarmCove–U
Perth0.3m–U

Red: PSPL model

Spitzer Observation

Spitzer observation

Spitzer-L

Flux

Spitzer I-band

OGLE-I, MOA-V

KMT-SSSO-I, KMT-SAAO-I

IscA-I, cojA-I

Danish-Z, Auckland-R

Craigie-U, CTIO1.3m-I

CTIO1.3m-V, FarmCove-U

Perth0.3m-U
Model Fitting (Ground-Based Data Only)

- Standard binary lens fit: \((t_0, t_E, u_0, q, s, \alpha, \rho)\)
- Conducted grid search by fixing \((q, s, \alpha)\)

\(\chi^2\) map in the \((s,q)\) plane

Best-fit model

- Wide solution is preferred over close solution by \(\Delta \chi^2 \sim 32\)
Best-fit model (Ground-Based Data Only)

$t_0 = 7908.8$
$t_E = 37.4$ (days)
$u_0 = 9.1 \times 10^{-3}$
$q = 6.0 \times 10^{-4}$
$s = 1.12$
$\alpha = 2.145$
$\rho = 0.0058$

MOA−Red
OGLE−I
MOA−V
KMT−SSO−I
KMT−SAAO−I
IscaA−I
cojA−I
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Craigie−U
CTIO1.3m−I
CTIO1.3m−V
FarnCove−U
Perth0.3m−U
- \( I - L = 1.33(V - I) - 4.3 \) and \( (V - I)_S = 2.58 \pm 0.05 \)

\( (I - L)_S = -0.84 \pm 0.06 \) constraint on Spitzer source flux
Best-fit Model with Spitzer Data

$\pi_{E,E} = 0.036$

$\pi_{E,N} = -0.054$

red: ground  
blue: spitzer
Source Properties

From Lightcurve Fitting

\[(V-I,I)_S = (2.58,17.61) \pm (0.05,0.03)\]

Assuming that the source suffers from the same dust extinction and reddening as RCG
(Bensby et al.2013, Nataf et al.2013)

Source Color and Magnitude

\[(V-I,I)_{S,0} = (1.01,15.83) \pm (0.08,0.08)\]

Relation between angular source size and the surface brightness
(Boyajian et al.2014)

Angular Source Radius
\[\theta_* = 3.0 \pm 0.3 \, \mu\text{as} \]
Lens Properties

Angular Einstein Ring Radius \( \theta_E = \theta_*/\rho = 0.51 \pm 0.04 \) mas

Proper Motion \( \mu_{\text{rel}} = \theta_E/t_E = 5.0 \pm 0.4 \) mas/yr

Lens mass \( M_L = \theta_E/\kappa \pi_E = 0.94 \pm 0.12 M_{\text{Sun}} \)

Planet mass \( M_P = q M_L = 0.60 \pm 0.08 M_{\text{Jupiter}} \)

Lens Source Relative Parallax \( \pi_{\text{rel}} = \theta_E \pi_E = 0.034 \pm 0.004 \) mas

Distance to Lens \( D_L = \text{AU}/(\pi_{\text{rel}} + \pi_s) = 6.3 \pm 0.4 \) kpc \( 6.9 \pm 0.4 \) kpc

Projected Separation \( a_{\text{proj}} = s \theta_E D_L = 3.6 \pm 0.4 \) AU \( 3.9 \pm 0.4 \) AU

Assuming \( D_s = 8 \) kpc \( 9 \) kpc

Sub-Jupiter mass planet around a G-type Star (Likely to be in the Galactic bulge?)
Summary

- We analyzed OGLE-2017-BLG-0406 and found that the best-fit model has $q = 6.0 \times 10^{-4}$ and $s = 1.12$
- We detected finite source effect from the ground based data and parallax effect from the Spitzer data
- The lens system consists of G-type star orbited by a sub-Jupiter mass planet likely to be in the Galactic bulge

Future Works

- Investigate the four-fold degeneracy solutions
- Include IR data from IRSF