Extrasolar Planets Search by Transit Method using the Subaru Telescope

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Introduction

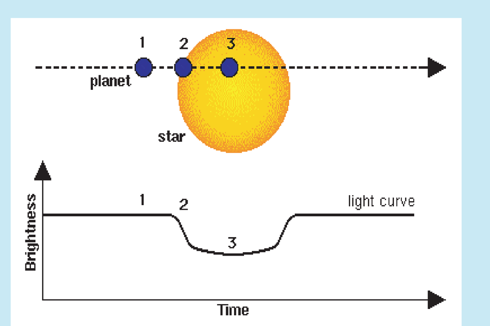
Over 140 extrasolar planets have been discovered since 1995. The discovery of extrasolar planets lead us to new understanding of planetary systems.

The radial velocity method has been used to discover most of them. On the other hand only 6 extrasolar planets were discovered by the transit method. Our purpose is the detection of extrasolar planets by the transit method. If extrasolar planets are discovered by both the transit and radial velocity methods, the radius and inclination of the extrasolar planets can be known. Therefore the density of extrasolar planets can be estimated improving knowledge concerning planetary systems and planets.

In our study, we confirmed that our observation achieved the enough photometric accuracy and number of stars to detect extrasolar planets by the transit method. In addition, we detected some variable stars and one potential extrasolar planet candidate.

Transit Method

The idea of transit method is to detect the luminosity change of a star due to occultation by extrasolar planets.



http://astron.berkeley.edu/~gmarcy/transit.html

Accurate photometry and the observation of many stars can yield the discovery of extrasolar planets.

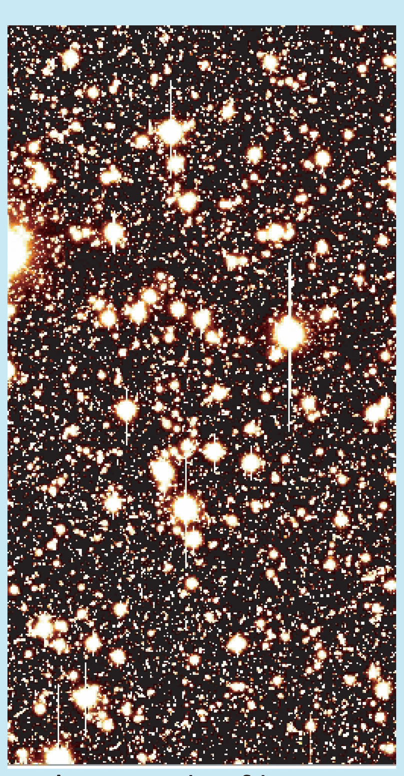
Observation

Instrument: Suprime-Cam FOV: 34'×27'
Date: Sept 27～Oct 1/2002
Field: Galactic latitude: 90° Galactic longtitude: 0°
Wavelength: i'band(683-854nm), B,Rc,z'band
Integration Time: 60s Fwhm: about 0.60"

Large Telescope and Wide Field of View → We can observe many stars.

Suitable observation for extrasolar planets by the transit method

Reduction



An example of image

Photometry method: Aperture photometry
(A radius of aperture is 2arcsec.)

Total number of observed stars is approximately 100,000 and 25,000 of them achieved high photometric accuracy of 3%.

The most accurate photometry is about 0.35%.

These values indicated that Suprime-Cam is an excellent detector to search extrasolar planets.

Results 1

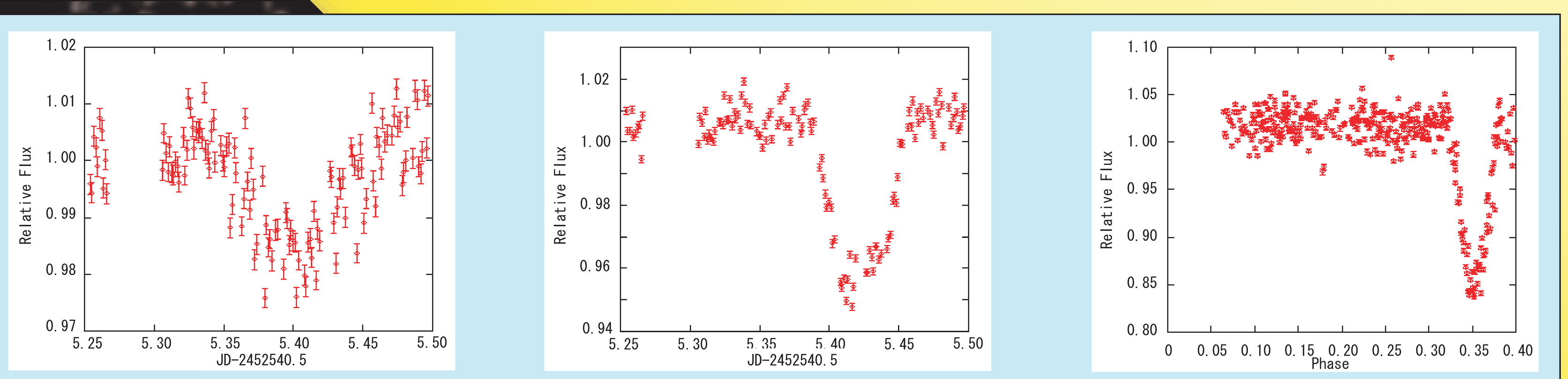


Fig1: Examples of detected light curve

A dip of flux: 1.5%
Detection of one transit.
Out-of-dip variation: High

A dip of flux: 4%
Detection of one transit.
Out-of-dip variation: Nearly Constant

A dip of flux: 15%
Detection of two transits
Period: 1.0181 day
Out-of-dip variation: Constant

Results 2

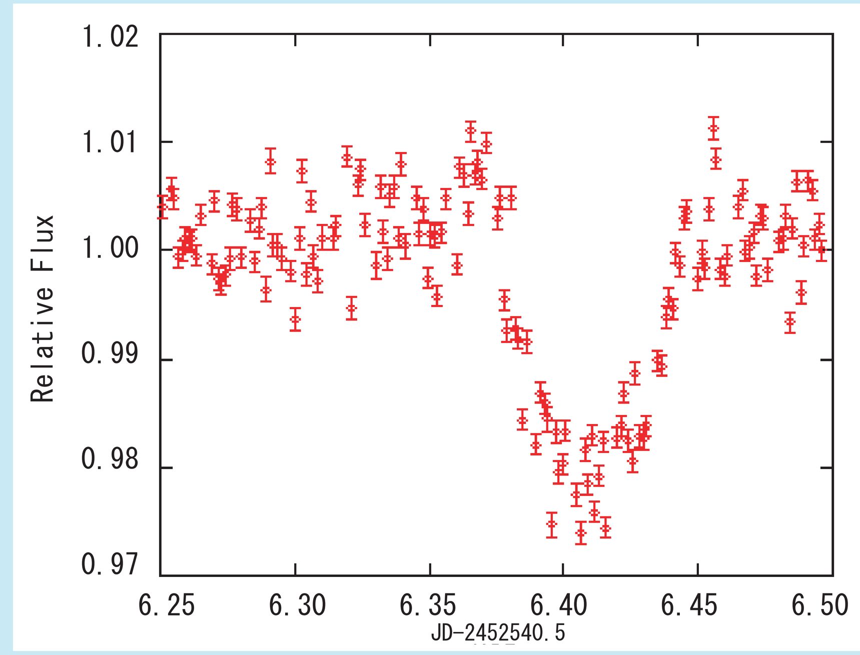
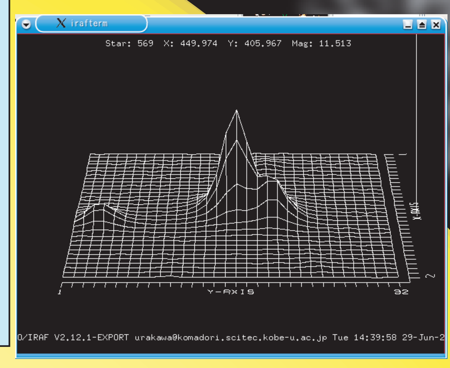


Fig.2: Light curve of a candidate which has possibility to be extrasolar planet.

A dip of flux: 2.0%
Duration Time: about 96 minutes
Ingress and egress time: about 25 minutes
Flat bottomed Time: about 46 minutes
Period: Unknown(One transit)
Out-of-dip variation: Constant



Double Stars

We tried to measure the flux of both sources by PSF Photometry.

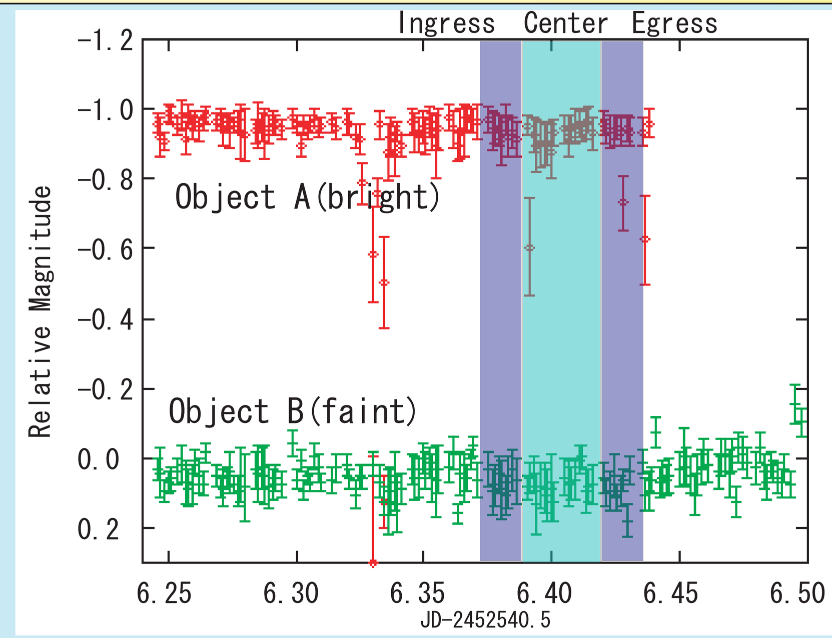


Fig.3: Light curve of object A and B by the PSF photometry

Photometric accuracy: 9.8%
Object A i'mag=18.1mag
Object B i'mag=19.1mag
Magnitude difference=1.0mag

→ Flux contribution from object A=71%
Flux contribution from object B=29%

How is the dip of 2.0% explained?
Hypothesis 1:
Object A's flux decrease 2.8% caused by the companion.
Hypothesis 2:
Object B's flux decrease 6.9% caused by the companion.

We see from Fig.3 that object B hardly show any sign of transit in spite of an expected moderate dip.
Thus we applied the hypothesis 1.

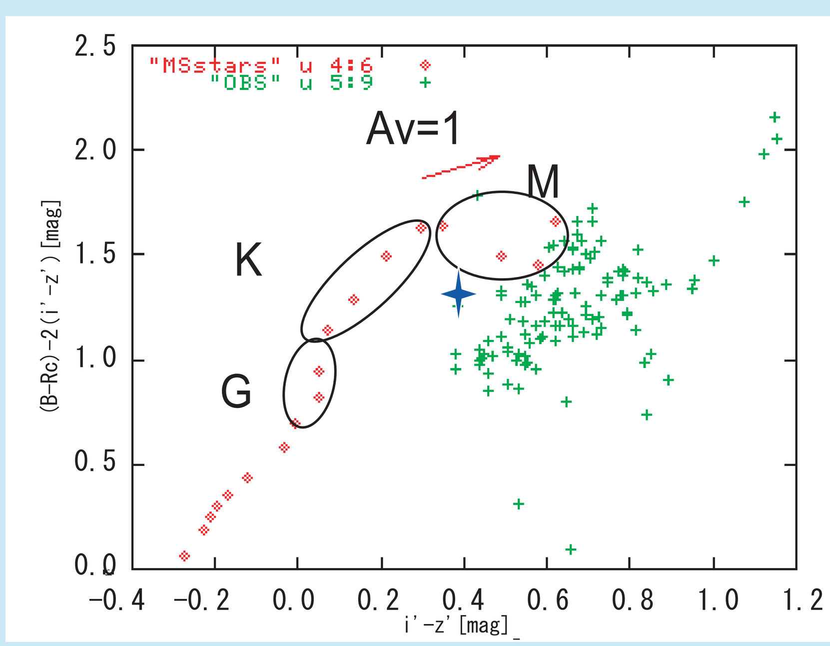


Fig.4: Color-Color Diagram

Object A: G5～K0 star. (Av=2.3)

If we assume object A is a giant star, the distance is 10-80 kpc.
Outer galaxy
→It is difficult to be a giant star.

If we assume object A is dwarf star, the distance is 2-3 kpc.

→We can surely say that the object A is a G5～K0 dwarf star.

The size of the companion is 1.4～1.5 Jupiter radius.

Potential extrasolar planet candidate!

Discussion: Estimation of Orbit

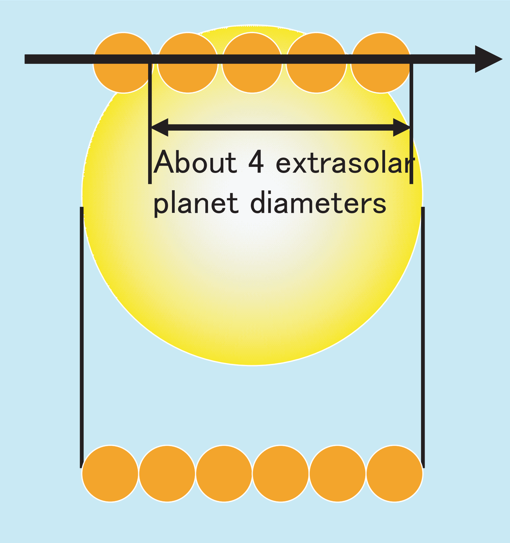


Fig.5: Schematic diagram of our extrasolar planet candidate.

We can estimate the orbital elements from ingress, flat-bottomed, and egress time.

Time ratio during the transit
Ingress: Flat-bottomed: Egress≒1:2:1
The candidate passes through distance of about 4 extrasolar diameters for 96 minutes.(Fig.5).

If we assume circular orbit and a K0V primary star,

Inclination: 88° Semimajor axis: 0.15 AU
Orbital period: 23 days

SUMMARY

- Suprime-Cam achieved enough photometric accuracy and number of stars to detect extrasolar planets but the observation run is too short to confirm the orbital period.
- We detected a small dip of flux in the light curve of a late G ～ early K dwarf star. It is possible that the dip is caused by the existence of an extrasolar planet.
- We will conduct new observation plan to detect two transits for brighter stars at Kiso Observatory.