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Exoplanet Survey Observations of NGC 6494 and NGC 6633 at Bosscha Observatory

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Abstract. We present the preliminary result of exoplanet survey observation of NGC 6494 and NGC 6633 at Bosscha Observatory. This research is part of a long-term program of exoplanet survey observations in the open star cluster near the celestial equator. Transit method is used to detect planets orbiting stars in the open star clusters. We are using the 11 inch diameter telescope and targeting transit depth up to 0.01 magnitudes. So far, we still do not detect transiting exoplanets. However, we detect several stars showing variability in its flux resembling the characteristic of variable star. Follow up observation would be needed to identify the type of variable stars.

Keyword: Exoplanet, transit, open star cluster.

1. Introduction

1.1. Progress on Exoplanet Discoveries

Exoplanet research is one of the fastest growing field of research in astronomy. Exoplanet exploration began since the first confirmed discovery of exoplanet 51 pegasi b in 1995 by the Geneve Astronomers Michel Mayor and Didier Queloz [4]. Since then, exoplanets become a popular topic in astronomy observation and theoretical. Using variety of detection methods and equipment both ground-based and space-based, until now it has been confirmed the existence of 3540 exoplanets in 2655 planetary systems. The annual progress on exoplanet discoveries can be seen at Figure 1.

The use of Kepler spacecraft in last 5 year has pushed the discovery of exoplanet rapidly. Kepler spacecraft using the transit method in the search for exoplanets. Although Kepler benefit from its position outside the Earth's atmosphere but it shows that the transit method has a great chance in finding exoplanets compared to the use of other methods. Transit method allows small-sized telescopes to detect the presence of exoplanets. Small telescopes generally have a wide field of view so that it can scan the vast skies in a relatively short time. This is the reason of exoplanet survey observations using a small telescope in large quantities. Where the main task is to search the stars of exoplanet candidates as much as possible.
1.2. Research Background
Currently, out of 3535 confirmed exoplanets only 7 exoplanets discovered orbiting stars that are members of open cluster [2] [5] [8]. In his paper, Meibom [5] showed that the frequency of finding exoplanets in star clusters as large as the outside of a star cluster. Theories of star formation suggest that the star was born in the form of clusters. Open star cluster is able to sustain its group of stars for hundreds of millions to several billion years. Whereas the planet, especially the giant gas planet, can form within 5 million years since the parent star is formed [1] [3] [7]. This indicates that we should have discovered exoplanets in the open star cluster more than what we find today.

Exoplanet survey observations on open star cluster is a long-term research program conducted at Bosscha observatory. The purpose of this research is to find the star of exoplanet candidates in the open star cluster system using transit method. We observe several open cluster located near the celestial equator. The selected star cluster will be observed continously. The stars that show periodic changes in the flux will be observed further to identify whether changes occur as a result of flux variability star or planetary transits. For this paper, we only report result from two open cluster NGC 6494 and NGC 6633. Currently, only these two open cluster where its observation data available for periodicity searching.

2. Observations

2.1. Instruments
In the process of collecting observational data for this research, we use one of robotic capable telescope at Bosscha Observatory, the Bosscha Robotic Telescope Experiment 2 (BRTX2). We use these telescopes because it has a wide field of view that is sufficient for the survey observation of the open star cluster. During image acquisitions, filters are not used in order to get sufficient flux in a short time. This research aims to find exoplanet candidates so that use of the filter is not required. Technical specifications of the telescope can be seen in the Figure 2.
2.2. Object of Observations

The objects that we present in this paper is open star cluster NGC 6494 and NGC 6633. Both star clusters located near the celestial equator and relatively bright cluster with brightness 5-6 in visual magnitude. More parameters of the clusters can be seen at Table 1. Figure 3 shows samples of the cluster images taken in our observation sessions.

| Table 1. The Cluster Parameters | NGC 6494     | NGC 6633     |
|--------------------------------|--------------|--------------|
| RA (J2000)                      | 17° 57' 04"  | 18° 27' 15"  |
| Dec (J2000)                     | -18° 59' 06" | +06° 30' 30" |
| Log (age)                       | 8.477        | 8.63         |
| Diameter                        | 29 arc min   | 20 arc min   |
| Distance                        | 628 parsec   | 376 parsec   |
| Member                          | 1342 stars   | 872 stars    |
| Magnitude (V)                   | 6            | 5            |

Figure 2. Technical specification of the Bosscha Robotic Telescope Experiment 2.

Figure 3. Sample of inverted images of NGC 6494 (left panel) and NGC 6633 (right panel).
3. Result
These are the preliminary results of exoplanet survey observation program on open star cluster conducted at Bosscha Observatory. As mentioned at previous section, we only have observation data from NGC 6494 and NGC 6633 that available for periodicity searching. We use data from six night observations of NGC 6494 and three nights observations of NGC 6633. LEMON program were used to measure fluctuation of star brightness [9]. This program use differential photometry method. For now, we measure every star detected on the direction of the cluster. Vstar program were used to search the periodicity in the lightcurve and produce the phasefold lightcurves. We aim to find hot Jupiter type exoplanet. This type of exoplanet usually have short orbital periode and produce relatively deep transit depth on its lightcurve. Using 28 cm diameter telescope we targeting transit event to the depth (delta magnitude) of 0.01 magnitude.

Currently, reduction and analysis process of star images is still done manually. We still analyzing less than 100 lightcurves out of nearly 2000 lightcurves generated by the LEMON program. So far, we have not found any fluctuation of star brightness that indicates the transit event of exoplanet. However, we found some changes on the star brightness that showed the characteristic of pulsating variable star and eclipsing binary star. This variable star candidates need further observation focused on each of the stars to determine the type of the variable star. Follow-up observations will be made on a separate observation program. Figure 4 shows the phaseplot lightcurve of the variable star candidates.

![Figure 4](image_url)

Figure 4. Sample images of lightcurves of pulsating stars (left panel) and eclipsing binaries (right panel) found in the observed open clusters.
References

[1] Boss A P 2001 *Astrophysical Journal* **563** 376
[2] Brucalassi A, Pasquini L, Saglia R, Ruiz M T, Bonifacio P, Bedin L R, Biazzo K, Melo C, Lovis C and Randich S 2014 *Astronomy & Astrophysics* **561L** 9B
[3] Haisch K E Jr, Lada E A and Lada C J 2001 *Astrophysical Journal* **553** 153
[4] Mayor M and Queloz D 1995 *Nature* **378** 355
[5] Meibom S, Torres G, Fressin F, Latham D W, Rowe J F, Ciardi D R, Bryson S T, Rogers L A, Henze C E, Janes K et al 2013 *Nature* **499**
[6] Pollacco D L, Skillen I, Collier Cameron A, Christian D J, Hellier C, Irwin J, Lister T A, Street R A, West R G, Anderson D R et al 2006 The Publications of the Astronomical Society of the Pacific **118** 1407
[7] Pollack J B, Hubickyj O, Bodenheimer P, Lissauer J J, Podolak M and Greenzweig Y 1996 *Icarus* **124** 62
[8] Quinn S N, White R J, Latham D W, Buchhave L A, Cantrell J R, Dahm S E, Furesz G, Szentgyorgyi A H, Geary J C, Torres G et al 2012 *Astrophysics Journal* **756** 33
[9] Terron V dan Fernandez M 2011 *Highlights of Spanish Astrophysics VI Proceedings* **755**