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## Observations and New Astronomical Facilities in Lijiang Observatory

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### Introduction

To achieve the scientific purposes, ground-based follow-up network (GAIA-FUN) for Gaia mission is necessary because of imposed date and position (Arlot 2011). The 2.4m optical telescope at Lijiang Observatory of Yunnan Astronomical Observatory (YNAO), Chinese Academy of Sciences, has the potential to play an important role in Gaia Follow-up Network (GAIA-FUN) in East Asia, especially for the follow-up of faint solar system objects (SSO) and Gaia itself (Thuillot 2011)[1]. Lijiang Observatory has joined the GAIA-FUN observation since 2010, and made some observations in collaboration with IMCCE, Paris Observatory in 2011 and 2012. New astronomical facilities like robotic telescopes have been installed in the observatory, and are possible to automatically response the VO-Event like GAIA-FUN observations.

### 1. Lijiang Observatory of YNAO

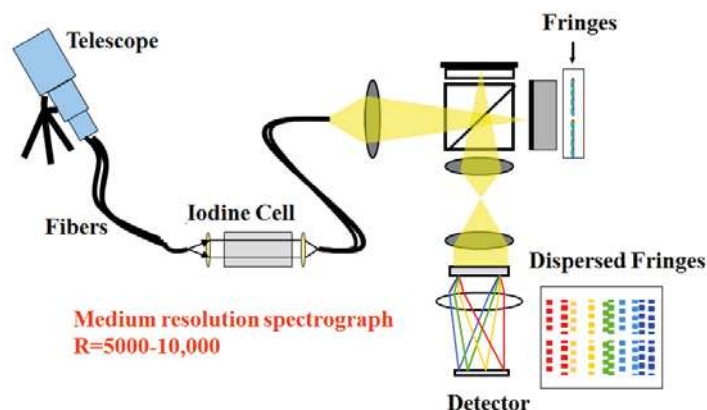
#### 1.1. Lijiang Observatory

The Lijiang Observatory of YNAO is located at 100° 2'(E), 26° 42'(N), in Yunnan, China. It is 3200m in altitude, and has the best seeing and astronomical conditions in southern China[1]. The observatory was built together with the Lijiang 2.4m telescope, which was open to astronomers since May 2008.

More facilities were installed at Lijiang Observatory since then. The spectrograph at Coude focus is now in commissioning on the 1.8m telescope, and is expected to open to astronomers in 2013. The 60cm robotic telescope of BOOTES-4 has been operated since March of 2012. The Lijiang site of Taiwan Automated Telescope Network was built in winter of 2011. There is a coating machine at the observatory, capable to re-aluminizing 2-meter or smaller mirror. The inner diameter of the vacuum chamber is 3.2 meter.

#### 1.2. Lijiang 2.4m telescope

The 2.4m optical telescope is the largest one at Lijiang Observatory at present. It was open to astronomers in May 2008 and joined the GAIA-FUN collaboration since 2010[1]. Lijiang 2.4m telescope is equipped with the Yunnan Faint Object Spectrograph and Camera (YFOSC) as the main instrument. Other instruments like the Lijiang Exoplanet Tracker (LiJET, see Figure 1), PI-CCD camera are mounted on the Cassegrain folding position. Observer may switch to each one of the instruments on demand[1]. The telescope could be remotely controlled by the observer who is not going to visit the observatory and sit behind his own laptop.



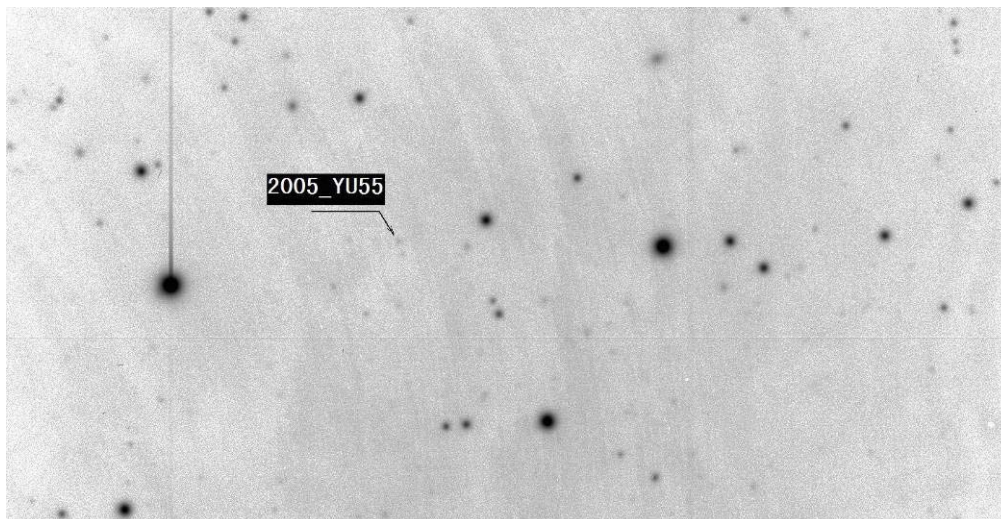
**Fig. 1:** Layout of Lijiang Exoplanet Tracker (Erskine & Ge 2000, 2002)

## 2. Observations of asteroids 2005\_YU55 and 1996\_FG3

Some observations of asteroids had been made by Q.Y. Peng (tpengqy@jnu.edu.cn), using the 2.4m telescope at Lijiang observatory, the asteroid of 2005\_YU55 was observed for three nights during Dec 16-18, 2011 and 1996\_FG3 was observed on Feb 19, 2012. Following we will take the asteroid of 2005\_YU55 for an example to describe the observation, and measurement and reduction. Detailed information can be got from the website <https://www.imcce.fr/gaia-fun-ss0/>.

### 2.1. Observation

No filter was used during the observations, and usually 120-180s was used for each CCD exposure time. After clipping and magnifying, the objective 2005\_YU55 can be found (see Figure 2) during the observation.

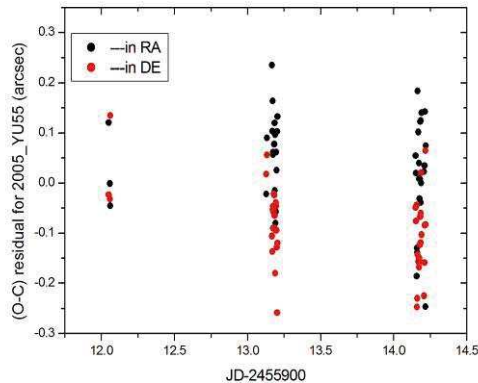


**Fig. 2:** Part of the CCD frame is clipped and the objective is found

### 2.2. Measurement and reduction

All CCD frames were measured by a 2D Gaussian fit (via our own codes) to obtain the pixel positions for both reference stars and the objective 2005\_YU55. In total, 44 CCD frames were derived in 3 nights with the 2.4m telescope.

Because of the obvious geometric distortion[4] (called GD later on) for the CCD FOV, only some reference stars (about 5-7 stars in UCAC2[3]) around the objective asteroid were used as calibration. Specifically, a 6-constant plate model was used to calibrate the CCD FOV. The theoretical positions of reference stars were computed into their topocentric positions and the atmospheric refractions were also added to them. The topocentric positions of the objective asteroid was transformed from its geocentric apparent positions (via the website <http://www.imcce.fr/>), taking the atmospheric refractions into account. Figure 3 displays the observed minus computed (O-C) positional residuals of the asteroid 2005\_YU55. The mean (O-C) residuals are 0."035 and -0."089 in r.a. and declination, respectively. The positional precision (the standard deviation) is about 0."10 in each direction.



**Fig. 3:** (O-C) residuals for 2005\_YU55 in 3 nights

### 2.3. Conclusions of the observation

The Lijiang 2.4m telescope is capable to take observations for faint asteroids like 2005\_YU55. In order to improve its positional precision, some works will be needed, such as to derive its GD at the observational period of time (the pattern of GD is changing). The CCD frames obtained for 2005\_YU55 cannot be corrected by its former results in [2] because of the mounting difference. Besides, the removal of its fringes would be interesting to refine its observational capability.

## 3. BOOTES-4 Robotic telescope

The Burst Observer and Optical Transient Exploring System, is a network of astronomical observatories with sites in Southern Spain, New Zealand and China. It has four sites mostly installed with 0.6m diameter telescope and EMCCD camera and a g'r'i'ZY filterset. The main goal of the network is to quickly observe transient events within few seconds/minutes of being detected by scientific satellites. The network now has four operating sites and few more under construction in south Africa and America(Figure 4).

The fourth station (BOOTES-4) was completed in spring of 2012, and starts operation as an autonomous observatory. It is the result of the collaboration between the Spanish Research Council (CSIC) and the Yunnan Astronomical Observatory (YNAO) signed in 2011.

The robotic control software used for BOOTES is the Robotic Telescope System version 2 (RTS2). RTS2 is being developed by P.Kub'aneK, starting in 2000. The source code is open, and widely used in GRB searches. At present the pipeline for automatic data analysis, both astrometry and photometry is under developed. RTS2 has a trigger to response alerts from scientific satellites to make ToO observation automatically. It is possible to code the VO-event trigger for BOOTES4 to make ToO for GAIA-FUN. Figure 5 shows the web interface of BOOTES monitor and observe system.





Fig. 4: Location of four existing BOOTES sites on Google map

Fig. 5: Web interface of BOOTES observe monitor (Gil 2012)

## Conclusion

Lijiang Observatory has joined the GAIA-FUN since 2010 and made observations with the 2.4 meter telescope in collaboration with IMCCE in recent years. The new build 60cm robotic telescope has the capability for automated observation response to trigger like VO-Event.

## References

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