Follow-Up Observation Plan on SSO of Purple Mountain Observatory

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1. Introduction

Our planet inhabits a hazardous environment. Earth is continually bombarded by cosmic objects. Luckily for us, most are very small and cause no harm to life. Some, however, are large and cause considerable harm. Humanity has the capacity to detect and perhaps to counter an impending natural disaster. One testimony is the discovery in the late 1980s of the approximately 200-kilometer-diameter Chicxulub crater formed by an impact 65 million years ago in the Yucatan peninsula (Hildebrand 1991). The asteroid or comet that caused this crater is estimated to have been about 10 kilometers in diameter; its impact wrought global devastation, likely snuffing out species in huge numbers including dinosaurs. As another realistic testimony, the collision of comet Shoemaker-Levy 9 with Jupiter in 1994 emphasized that impacts are currently possible.

Recognizing that impacts from Near Earth Objects represent a hazard to humanity, the United States, European Union, China and other countries cooperatively organized to identify, track and study NEOs in an effort termed Spaceguard. The NEOST is constructed to undertake this mission. From October of 2006, the 1.04/1.20/1.80 m NEOST equipped with a 4096 by 4096 pixels SI CCD camera was installed completely and began regular survey operations. Due to fast optics and the high quantum efficiency (QE) of the CCD detector, the observational system can reach 22.46 mag with only 40 s exposure, which makes the sky survey with great efficiency. For example, about 22G raw image data, with respond to the sky coverage of 2700 square degree, will be produced within a good observable night, and the data will be extracted more than 2000 asteroids' positions (Zhao et al. 2008; Zhao et al. 2010; Ma et al. 2007).

The large field of view of NEOST, 1.94 degree by 1.94 degree, guarantees high efficiency of optical sky survey program, while the stable performance of NEOST observational system guarantees high accuracy of photometry and astrometry over all field of view. So NEOST is suitable for all kinds of imaging survey programs. The following two sections describe two ongoing survey program and present staged achievements.

2. Ongoing survey program I: China Ecliptic Plane Survey and China Near Earth Object Survey (CEPS & CNEOS)

As primary scientific target of NEOST, China ecliptic plane survey and china near earth object survey is the first ongoing survey program from the fall of 2006. It aims at to join George E. Brown, Jr. Near Earth Object Survey Act authorized by NASA in 2005 to detect, track, catalogue, and characterize the physical characteristics of at least 90 percent of potentially hazardous NEOs larger than 140 meters in diameter by the end of year 2020 (National Research Council 2010).

From December of 2006 to September of 2010, we carry out CEPS & CNEOS program and achieve more than 3 Tera raw image data with the sky coverage near the ecliptic plane. In the same period, our observation ranked the top-ten observational program in the World. Until September of 2010, CEPS & CNEOS program has observed 121,438 asteroids with more than

500 thousands observations, has found 933 new provisional designation asteroids, and has catalogued 97 numbering asteroids including five Jupiter Trojans, two Hildas and one Phacaea.

There are four Near Earth Asteroids (NEAs) having been found including an Apollo type NEA and three Amor type NEAs. We obtain the four NEAs' orbital elements and its uncertainties. Dynamic evolution result shows that all the four NEAs have no chance to approach the Earth within 0.05 AU during the following 200 years. A new periodical comet, P/2007 S1 found in 2009, is defined as a Jupiter-family comet. On March 10, 2010, a highly unusual rapidly moving asteroid was discovered and designated as 2010 EJ104. Connecting from the Kuiper Belt to the Main Asteroid Belt, 2010 EJ104 cannot be classified into any dynamics type and be considered as unusual object, and a study on the possible origins of 2010 EJ104 is carried out (Zhao et al. submitted to ApJ Letter).

3. Ongoing survey program II: Xuyi Schmidt Telescope Photometric Survey of the Galactic anti-center (XSTPS-Gac)

This survey program is a cooperation program between Kavli Institute for Astronomy and Astrophysics (KIAA) at Peking University (PKU) and Purple Mountain Observatory. The main scientific target is to study the structure and dynamics of Milky Way, along with its stellar populations and chemical composition. The outer parts of the Milky Way's dominant stellar component, the galactic disk, have already revealed complex structure that is poorly-understood. The Galactic anti-center survey addresses questions key to understanding how resilient galaxy disks are after gravitational interactions. XSTPS-Gac will obtain the high-quality photometric survey, which will be the most important data for analysis and target selection of LAMOST spectroscopic survey. The XSTPS-Gac will obtain three-color photometric catalogue with the coverage more than 6000 square degree near the Galactic anti-center in g′-band, r′-band and i′-band respectively.

4. Summary and outlook

CEPS & CNEOS program has produced a large amount of images of the ecliptic plane with deep to 21st magnitude. About 200 new asteroids will be discovered and designated every year. However, with the operations of PanSTARRS and future LSST (Pierfederici 2009), the competitive power of NEOST to detect asteroids will go down. So the primary scientific target should be shifted from detection to characterization. Detailed knowledge of the physical properties of the NEO population lags far behind the current rate of NEO discoveries, CNEOS will be contributed to collect information about these bodies not only to obtain a better understanding of the NEO population, but also to understand how the physical and compositional properties vary from one NEO to another. Such information is important for assessing the hazard potential of individual NEOs that may threaten Earth and the viability of proposed mitigation strategies.

XSTPS-Gac program has obtained SDSS-g′, SDSS-r′, and SDSS-i′ band images of 6000 square degrees near Galactic anti-center. The point-source with SNR of 10 limit is achieved at or fainter than g′, r′, i′ equal to 19 magnitude for virtually the Galactic anti-center sky. For sources' SNR at or above threshold 10, the XSTPS-Gac Point Source Catalog is highly complete and reliable. Bright source photometric accuracy is better than 0.02 mag, and astrometric uncertainty is ~ 0.10″ relative to the ICRS. The images and catalogs of point sources will be publicly available in the near future.

A new large field of view survey program, 4 square Degree Exoplanet System Survey (4DESS) program, is in preparation. Large FOV exoplanet survey program, like TrEs (O'Donovan 2007) and WASP (Pollacco et al. 2006), can't reach deep magnitude, while deep sky survey by Hubble Space Telescope (Spergel et al. 2003) can only obtain small sky coverage. To meet half way of above mentioned type survey, 4DESS will cover a sizable sky field near the point of intersection of galactic and ecliptic planes, and obtain all the stars brighter 14 mag in i′-band with SNR greater than 100. The foreseeable results of 4DESS program will be transit observation or detection of exoplanet, a large amount of new variable stars and a large amount of asteroid lightcurves.

NEOST will also carry out the Gaia follow-up observation of solar system object. We will aim at astrometric observation of the new solar system object firstly: to obtain more position data, carry out the orbital determination, especially for fast moving NEAs and exhibiting a possible cometary activity; to carry out the impact risk assessments for NEO; to supplement the observations by Gaia of asteroids gravitational deflected during asteroid encounters. We will also observe for the physical characterizing (light curve, albedo, etc.) of the new solar system object: to carry out the light curve survey of asteroid, in order to determine the rotation period, the spin axis, and the shape of asteroid; to carry out the multi-bands observation of asteroid (esp. NEO & Jupiter Trojans), to know the period-size distribution, brightness variation distribution, etc.

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