

**4th IAA Planetary Defense Conference – PDC 2015
13-17 April 2015, Frascati, Roma, Italy**

**IAA-PDC-15-01-05
ASIA-PACIFIC ASTEROID OBSERVATION NETWORK**

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Keywords: *Asteroid, Observation, NEO, Spaceguard*

Near Earth Objects (NEOs) are important not only for science but also for spaceguard, resources, and targets of manned missions. Recently observations of NEOs have become very active and more than 12,000 NEOs were already discovered up to the beginning of 2015. However, the observations of NEOs in Asia region are not so active as in USA or Europe, so we proposed to make Asia-Pacific Asteroid Observation Network (APAON). About 20 observatories, universities, and institutes from 10 Asian countries/regions have become the members of APAON. We will start collaborative observations.

Introduction

Near earth objects (NEOs) are now recognized very important from the point of spaceguard. The Chelyabinsk meteorite in February 2013 showed us clearly that the even small object could cause a large disaster. The issue of asteroid/comet collision to the earth has been discussed in COPUOS (The Committee on the Peaceful Uses of Outer Space) of UN for more than 10 years, and two groups, IAWN (International Asteroid Warning Network) and SMPAG (Space Missions Planning Advisory Group), have started their activities from 2014.

There are other reasons that NEOs are paid attention to. Some of the NEOs may have natural resources such as iron or rare metal. NEOs can be the targets of manned missions, when they are close to the earth. And of course, NEOs are important for planetary science, because they can be the clue to understand the origin and evolution of the solar system.

The observations of NEOs are quite active in USA and Europe, but they are not so active in Asia region. For example, Fig.1 shows the locations of astronomical observatories. Actually there may be more observatories than shown in Fig.1, but we can understand that the observation in Asia region is not so powerful than in USA and Europe. Considering that the nighttime moves from North America to Hawaii, Hawaii to Asia, and Asia to Europe, the observation in Asia could be important between Hawaii and Europe. Therefore, we proposed Asia-Pacific Asteroid

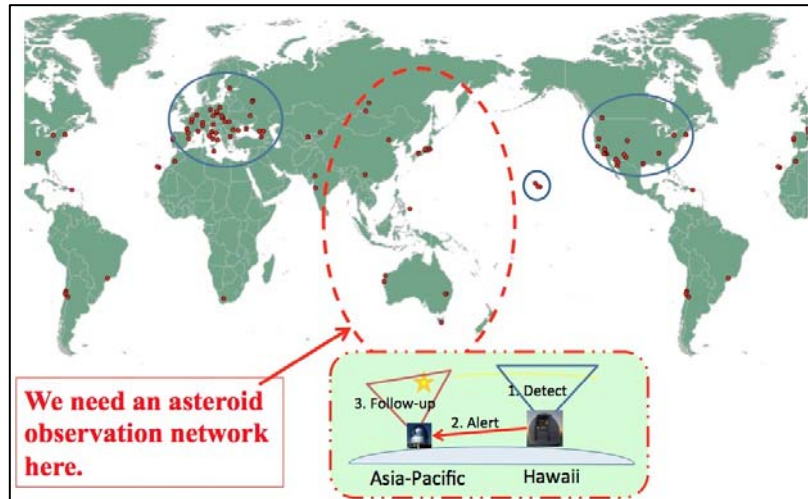


Fig.1 Locations of astronomical observatories
 (data source: <http://robslink.com/SAS/democd32/observatories.htm>)

Observation Network (APAON) to enhance the observations of asteroids in Asia-Pacific regions. In this paper, we explain the outline of APAON.

Starting of APAON

In the Asia-Pacific Regional Space Agency Forum (APRSAF) held in Hanoi, Vietnam in December 2013, we proposed to establish an asteroid observation network in Asia-Pacific region. The purpose is to enhance the observations of asteroid in Asia-Pacific region. APRSAF was established in 1993 to promote the use of space in Asia-Pacific region. More than 30 countries and regions are participating now and the meetings were held 21 times up to 2014. The main topics are activities using rockets or artificial satellites. But we proposed an activity using ground-based telescopes.

In the summer of 2014, we started to ask some of the researchers in Asia-Pacific region to join this observation network. Researchers from 10 countries and regions showed their interest to this network. The first meeting was held on 6th November 2014 as one of the sessions in the 7th spaceguard conference in Japan. In the APRSAF held in Tokyo in December 2014, we reported that we started the observation network called APAON (Asia-Pacific Asteroid Observation Network).

Outline of APAON

The main purpos of APAON is to observe NEOs for the spaceguard activities. But we do not restrict the activities and do not impose obligations much on the members. Our aim is to promote or enhance the observation of asteroids by collaborating or communicating each other.

At first, It is easy to use telescopes already exist. There may be a lot of telescopes that can be used for asteroid observations in Asia-Pacific region. The activity of APAON may be as follows: The members of APAON select some target objects such as NEOs approaching the earth, and ask to other members to observe them. The telescope locations are wildly spread out, so we may avoid the risk of weather.

Table 1 Organizations of APAON Participants

Countries/ Regions	Organizations
China	- Yunnan Observatories - Purple Mountain Observatory
Indonesia	- Bandung Institute of Technology - National Institute of Aeronautics and Space (LAPAN)
Japan	- Japan Spaceguard Association (JSGA) - National Astronomical Observatory of Japan (NAOJ) - Japan Aerospace Exploration Agency (JAXA) - Misato Observatory - National Museum of Nature and Science
Korea	- Korea Astronomy and Space Science Institute (KASI)
Macao	- Macau University of Science and Technology (MUST) - National Central University (NCU)
Malaysia	- National Space Agency of Malaysia (ANGKASA)
Mongolia	- Mongolian Academy of Science - ISON-Khureltogoot Observatory
Taiwan	- National Central University
Thailand	- National Astronomical Research Institute of Thailand (NARIT) - Learning center for Earth Science and Astronomy (LESA) - Chulalongkorn University
Uzbekistan	- Ulugh Beg Astronomical Institute (UBAI)

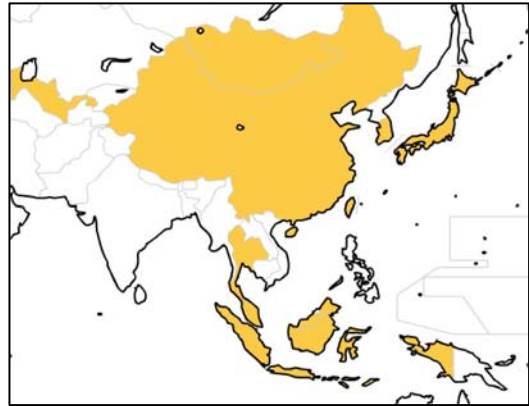


Fig.2 APAON members' countries
The countries which APAON members belong are hatched.

The data we will get are positions (astrometry), light curves (photometry), and spectrum (spectroscopy). In addition to these scientific data, we can make use of such observations for educations or outreach activities. Throughout these activities, we aim to establish NEO observation network in Asia-Pacific region.

The members of APAON at present (March 2015) are shown in Table 1 and Fig.2. The members are coming from about 20 organizations of 10 countries and regions in Asia. At present, the membership is in personal level and we do not make such agreements between organizations or between nations.

Activities of APAON Each Member

As we mentioned before, we had a first meeting of APAON on 6th November 2014 at National Astronomical Observatory of Japan (in Tokyo, Japan) as one of the sessions of the 7th Spaceguard Conference. We had nine presentations. The titles and authors are shown in Table 2. (Most participants from Asia attended by the Internet conference system.)

The rough outlines of the presentations are as follows: In Thailand, they have a 2.4m telescope and now they are planning to make a network observation system using several 0.6-0.7m robotic telescopes for NEO observations. In China, they have a quite long history of asteroid observation and they are considering to make NEO observation network by using exist telescopes and new 2.5m telescopes. Korea has a project to put three 1.6m telescopes in the Southern Hemisphere. They are used for astrophysical observations, but they are also powerful for asteroid observations. In Taiwan, they have 1m telescope and now they are constructing a 2m telescope.

Table 2 Program of APAON session in the 7th Spaceguard Conference in Japan

1. Proposal for Asteroid Observation Network in Asia-Pacific Region Makoto Yoshikawa (JAXA), Junichi Watanabe (NAOJ), Noritsugu Takahashi (JSGA)
2. Thailand's Robotic Telescope Network for NEO and Space Debris Observation Saran Poshyachinda (National Astronomical Research Institute of Thailand) and Thagoon Kirdkao (Royal Thai Air Force)
3. NEO Survey and alarming of China Haibin Zhao (Purple Mountain Observatory)
4. The DEEP-SOUTH: Round-the-clock Physical Characterization of NEOs in the Southern Hemisphere Hong-Kyu Moon, Young-Jun Choi, MyungJin Kim (KASI)
5. Observing facilities accessible from Taiwan and recent Taiwan-Japan collaborations Kinoshita Daisuke (Institute of Astronomy, National Central University)
6. Optical Observations and Color Survey of Near Earth Asteroids Chien-Hsien Lin (Space Science Institute, Macau University of Science and Technology, Macau) and Wing-Huen Ip (Graduate Institute of Astronomy, National Central University, Taiwan)
7. Asteroid Observation in Mongolia N.Tungalag (Research Center of Astronomy and Geophysics, Ulaanbaatar, Mongolia), S.Schmalz (Leibniz Institute for Astrophysics, Potsdam, Germany), V.Voropaev, I.Molotov (Keldysh Institute of Applied Mathematics, RAS, Moscow, Russia)
8. Observations of Small Bodies and Space Debris Information System in Indonesia B. Dermawan*, M. Putra*, T. Hidayat*, C. Y. Yatini**, BO Team*, and SDIS Team** * Bosscha Observatory and Astronomy Research Division, Bandung Institute of Technology, Indonesia ** National Institute of Aeronautics and Space, Indonesia
9. Finding NEOs in the Context of an Agency Grand Challenge Lindley Johnson (NASA HQ) and Paul Abell (NASA JSC)

Also they are working with Pan-STARRS. In Macao, they are collaborating with other observatories to study NEO's physical characters. In Mongolia, they are collaborating with ISON (International Scientific Optical Network) using 0.4m and 0.19m telescopes. In Indonesia, they have 0.71m telescope and now planning to build a 2-3m class telescope.

These presentations indicate that there are rather strong interests toward NEO observations in Asia region. In Table 3, the telescopes that each country already possesses and plans to have are summarized. This fact encourages the activities of APAON.

Table 3 Telescopes of APAON members

Countries/Regions	Telescopes that can be used for NEO observation
China	1.04m, 0.20m @ Purple Mountain Obs. Survey by 2.5m telescopes (plan)
Indonesia	0.71m @ Bosscha Obs. 2-3m (plan)
Japan	1m, 0.5m @ Bisei Spaceguard Center
Korea	3 x 1.6m
Macao	use telescopes in other observatories
Mongolia	0.4m, 0.19m @ Khureltogoot Obs. ISON
Taiwan	1.0m @ Lulin Obs. 2.0m under construction
Thailand	2.4m @ Thai National Obs. Network robotic telescopes : 0.6 - 0.7 m

The size indicates the diameter of telescope aperture.

Future Plan

Now we have established the basic framework of APAON, so we want to start actual observations. To begin with, we announced the observations of Asteroid 2004 BL86, which approached the earth at the distance of 1.2 million km on 26th January 2015. Unfortunately the weather in Japan was not good on this day, but the observations were successful in Malaysia and Korea. Thus APAON can avoid the weather risk. We would like to continue collaborative observations like this.

As for the organization issue, we will fix a kind of "Joint Statement" in order to have common understandings among the participants of APAON. We want to increase the members of APAON and contribute the NEO observations.