

## Gunma astronomical observatory and its international activities with south-east asian countries

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**Abstract.** Gunma Astronomical Observatory (GAO) is a public observatory operated by the local government of Gunma prefecture. Its main telescope is a 150-cm reflector, which is not designed only for scientific research but for star gazing by public visitors, equipped with an eyepiece system in addition to powerful scientific measuring instruments. GAO has carried out a number of international activities with various countries. Many of them were cooperative works with South-East Asian countries. In 2002, a Memorandum of Agreement (MoA) between GAO and Institute of Technology Bandung (ITB), Indonesia was signed in which both institutions worked together in various fields of astronomical research and education for many years. It is a great honor of GAO that it could make some significant contributions to the establishment of the South-East Asia Astronomical Network (SEAN), which leads the rapid development of Astronomy in the South-East Asian countries by their international collaborations for themselves.

### 1. Introduction

Gunma Astronomical Observatory ( hereafter, GAO ) is located in Takayama village in Gunma prefecture about 120 km north-west of Tokyo ( N 36° 35' 47", E 138° 58' 22" ). GAO is a public observatory established in 1999 by Gunma prefectural government aiming at effective education and public outreach of astronomy and astrophysics for all kinds of people in addition to pure scientific researches by professional astronomers. It is a unique observatory since all the telescopes and facilities are designed as visitors can vividly see the real scenes of science of astronomy and astrophysics with their experiences of real universe. Its main telescope is a 150-cm reflector (see Fig.1) equipped with some powerful measuring instruments for high grade scientific researches [1]. Even such a professional research telescope has an eyepiece system for the star gazing by public visitors as seen in Fig.2. Since it was the largest telescope far beyond the second in the world as a telescope applicable to the public star gazing when it was built, GAO is regarded as a pioneer of public observatories equipped with such a large telescope of full scientific capability.

A number of unique programs have been proposed and carried out actively taking all the advantages of the powerful facilities of GAO in all fields of education, public outreach and scientific research. Among them there are a significant number of international activities with various countries. Many of them are cooperative works with the South-East Asian countries. In this paper, we introduce remarkable features in the unique facilities and activities of GAO including international relationships.

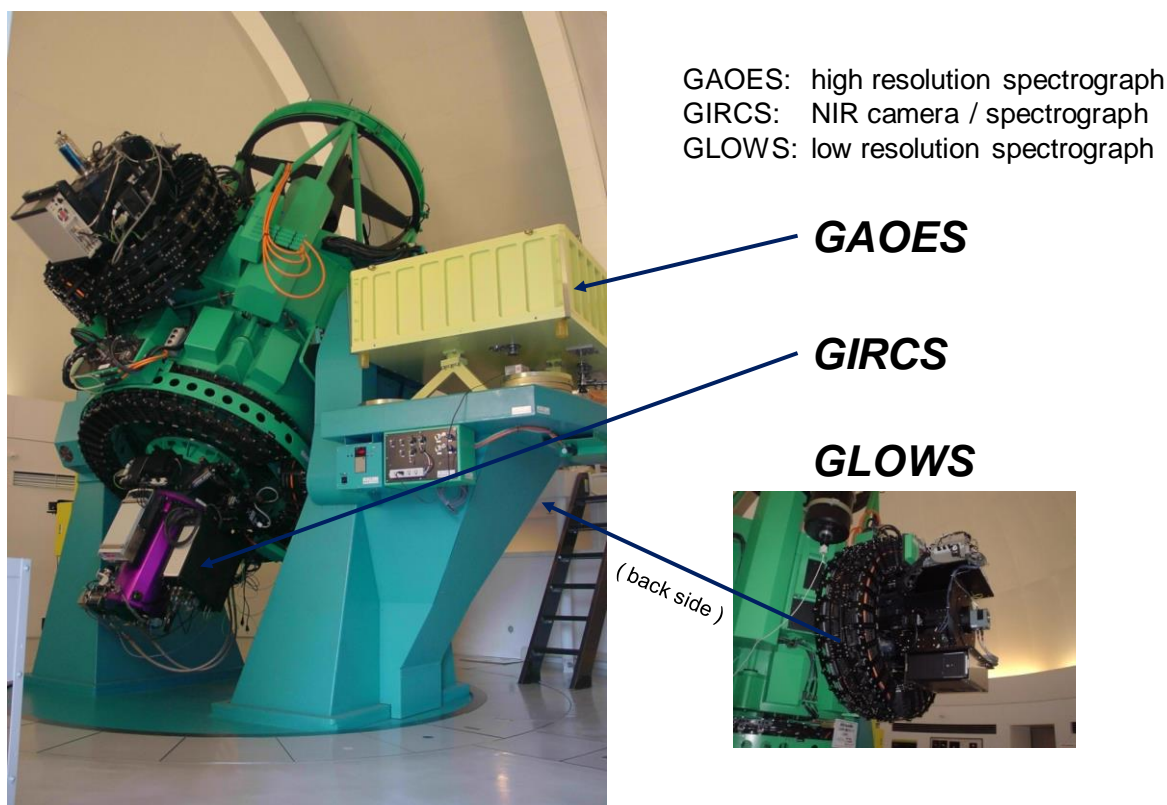


Fig. 1. GAO 150-cm reflector and its observation instruments.

## 2. Telescopes and facilities of GAO

### 2.1 Main telescope, the 150-cm reflector

The main telescope of GAO is the 150-cm reflector (Fig.1) which was the second largest telescope in Japan when it was built following the largest one of the 188-cm reflector of Okayama Astrophysical Observatory, National Astronomical Observatory of Japan. As a telescope with which people can watch stars by their own eye, it was the world largest at that time. The GAO 150-cm reflector, equipped with powerful measuring instruments, has a full capability for the scientific observations of high standard. The Gunma Astronomical Observatory Ech lle Spectrograph (GAOES) is a high resolution ech lle spectrograph set at the Nasmyth platform [2,3]. It is the most powerful instrument of GAO, providing very detailed insight on stellar properties through a spectrum of extremely high wavelength resolution up to  $R = \lambda/\delta\lambda \sim 10^5$ . The Gunma Infra-Red Camera and Spectrograph (GIRCS) at the Cassegrain focus and the Gunma LOW resolution Spectrograph (GLOWS) at the bent-Cassegrain focus are very powerful as well for the scientific researches of astronomy [4].

Using those measuring instruments on the 150-cm telescope a lot of scientific observations have been carried out. Most of them are studies of stellar astrophysics based on spectroscopic observations. Our observation system is most suitable and powerful in particular for the time-series studies of variable stars and the statistical studies by collecting a large sample of high quality. Detailed dynamic structure of an X-ray emitting binary system consisting of a hot star and an evolved

compact star ( probably a neutron star ), for example, has been made clear by continuous repetitions of precise spectroscopic observations by GAOES for a long period [5,6,7]. We could make a significant contribution as well by the spectroscopic observations for several years to solve some enigmas of  $\epsilon$  Aurigae, a variable star with an extremely long period of about 27 years [8,9]. Measurements of chemical abundances of a number of stars in M45 (Pleiades) open cluster have ensured the homogeneity of chemical abundance in the cluster [10,11] as it has been expected and strongly believed from the view point of cluster evolution. Chemical abundances measured for large samples a number of stars could also provide some key evidences for understanding the chemical evolution in the Galaxy [11,12].

The eyepiece system at the Nasmyth focus of opposite side of GAOES provides opportunities of star gazing through such a large telescope for the visitors of all kinds. A lot of photons gathered by the large aperture of the telescope can show interesting aspects of astrophysics in the stellar light seen by a human eye as well as beautiful images of the stellar objects. In addition to the differences of colors from star to star, it is quite impressive that various features in stellar spectra can be directly seen through the 150-cm telescope. A spectroscopic eyepiece system (see Fig.2) has been developed recently, as it can provide a direct image and a spectrum of target star simultaneously at two separate viewing points respectively. Observers can easily understand the physical meanings of the spectrum and the color through the simultaneous comparison of them.

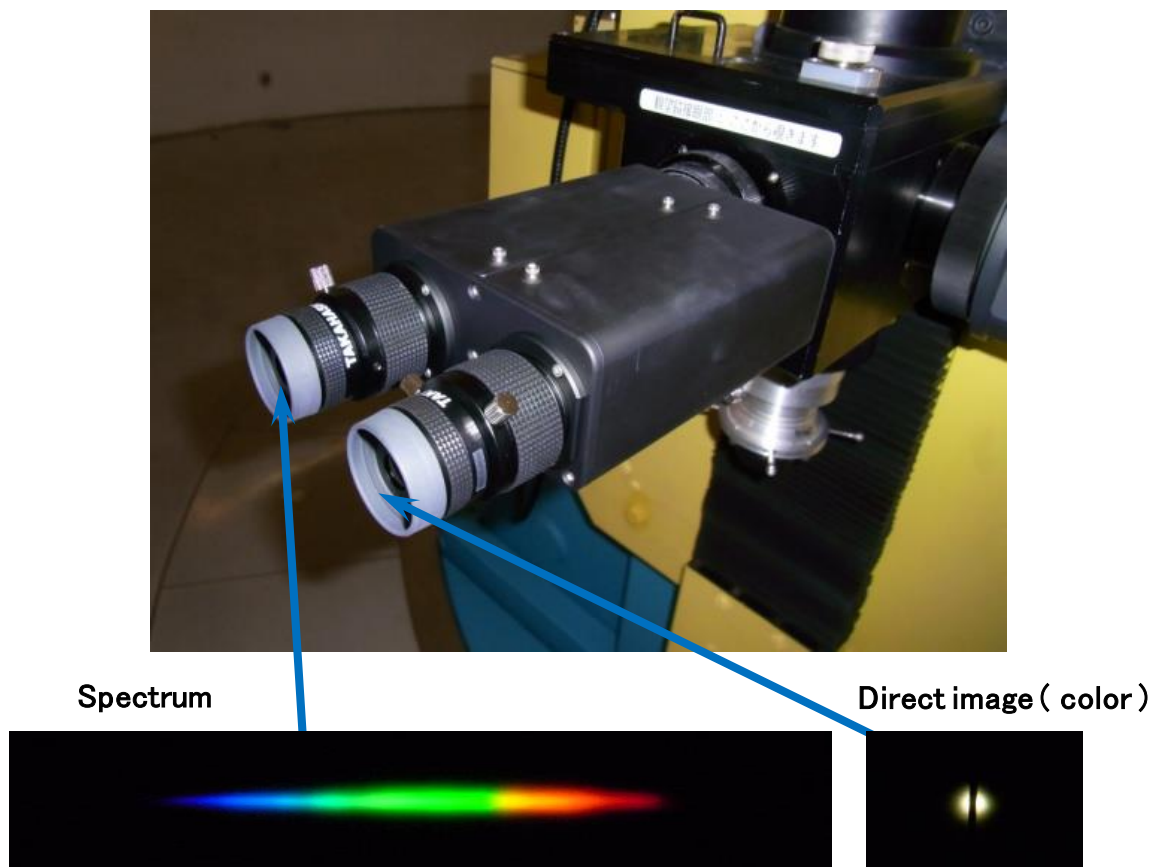


Fig. 2. The spectroscopic eyepiece system set at the star gazing optics of the GAO 150-cm reflector. Stellar spectrum and direct color image can be observed at the same time.

Star gazing programs for the public visitors are usually held in the evenings of weekends and holidays. Schools and various kinds of groups for their study programs are accepted in the weekday evenings. The GAO 150-cm reflector plays another role in daytime as an exhibition item. It is noted that GAO is not only working for the night time activities but it also welcomes daytime visitors as a scientific museum of astronomy and astrophysics [13]. There are various exhibition items inside and outside of GAO in addition to the telescopes.

## **2.2 Other telescopes**

There are some smaller telescopes in addition to the 150-cm main telescope. A 65-cm reflector on an equatorial mount, six sets of 25-30 cm reflectors and some portable telescopes are used for various kinds of star gazing programs for the public visitors [13]. They are also used by amateur astronomers for their observations on weekends. In the daytime of sunny day, a 30-cm solar telescope on the rooftop provides a direct image of sun as large as one meter in diameter and a high resolution spectrum on the screens in the exhibition area simultaneously (see Fig.3). There are some additional video screens which show white and H-alpha monochromatic solar images at the same time. Those real time solar exhibitions are not only attractive and popular for the daytime visitors but they also can be quite effective tools for the studies of solar and stellar astrophysics by students at university and high school levels.

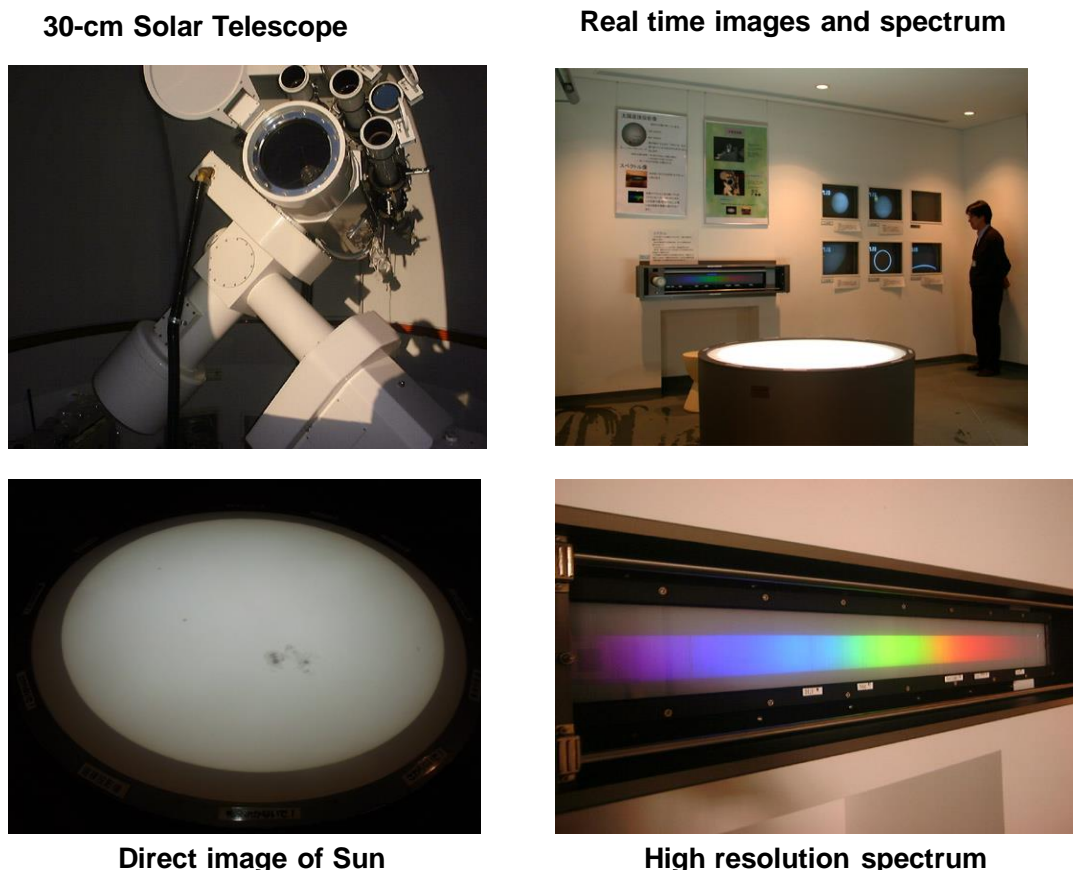


Fig. 3. GAO 30-cm solar telescope and its exhibitions in daytime.



### 2.3 Exhibitions and outside monuments

As GAO works as a science museum of astronomy and astrophysics in daytime, it has unique exhibits of various kinds in the exhibition area [13]. Most of them are designed as visitors can study by themselves. A scale model of the 150-cm reflector and its real size dummy weight of primary mirror explain how a large telescope works. Comparison of two telescopes with different aperture sizes shows why larger telescopes are required for the astronomical observations. Some exhibition items explain the basic principles of observations from the view point of astrophysics. One exhibit shows clear difference of spectra between a filament lamp and a fluorescent lamp, while both lamps look quite similar for human eyes. It explains how we can understand the detailed physics of distant objects through the spectroscopic observations without touching them directly. Several PCs and video tools are used for various sorts of explanations. Interesting characteristics of some individual stars and basic concepts of astronomical observations are provided by them. In addition, there are some exhibition boards of classical manner, which mainly explain the basic stories of stellar evolution.

GAO looks like a natural park since it is surrounded by natural woods in the mountain area. There are two monuments recalling astronomical instruments of the ancient [13] (see Fig.4). One is a scale model of Jantar Mantar, which was originally built and used in India in the 18<sup>th</sup> century. It consists of a number of measuring graduators. The other is a stone circle, which was inspired by Stonehenge in England. Both are redesigned as they can be used for real astronomical measurements at GAO. Visitors can enjoy historical feeling as well with those monuments in addition to the most advanced astronomy and astrophysics as a modern science.



Fig. 4. Outdoor monuments, Jantar Mantar (left) and Stone Circle (right)

### 3. International activities of GAO

Using the facilities of GAO we have carried out a number of international activities with various countries. Many of them were cooperative works with South-East Asian countries as seen in Table 1. Our international collaborations have never been realized only based on any interests of physical materials but on mutual understanding and mutual exchange of human resources for working together on an equal footing. There are a number of good telescopes and measuring instruments already in many of South-East Asian countries, but occasionally they are not used so actively as they can produce scientific results sufficiently enough. Such situations have been caused mainly by the lack of local human resources who can use their valuable observation equipments properly. Therefore, we have much devoted ourselves to support young people who really work using their

own facilities for themselves. We have received young astronomers and students from various countries. Many of them have stayed in Gunma for a period longer than a few months in order to experience sufficient amount of astronomical studies using the telescopes and instruments at GAO. The statistic data of such long period visitors are summarized in Table 1 as the trainees. Some senior visitors have also stayed for a sufficiently long period. Astronomers of GAO have visited some of the South-East Asian countries as well to work together with the local people. For instance, we have worked in Indonesia, the Philippines, and Vietnam to support the developments and operations of the observation systems in those countries.

Visitors to GAO ( 1999 – 2009 )

Country	number of visitors	total ( visitor-day )
<i>Indonesia</i>	30	1348
<i>Thailand</i>	13	296
<i>Vietnam</i>	6	322
<i>Philippines</i>	4	221
China	4	178
Korea	4	8
Sweden	3	5
United States	3	4
<i>Malaysia</i>	2	6
New Zealand	2	4
Mongolia	1	28
South Africa	1	2
Iran	1	2
Turkey	1	1
<i>Southeast Asia</i>	55	2193

Trainees from Asian countries ( 1999 – 2009 )

Country	number of trainees	total ( visitor-day )
<i>Vietnam</i>	3	214
<i>Indonesia</i>	3	193
<i>Philippines</i>	2	211
<i>Thailand</i>	1	219
China	1	150
Mongolia	1	28

Table 1 Foreign visitors to GAO for the period of 1999-2009.  
South-East Asian countries are denoted by Italic characters.

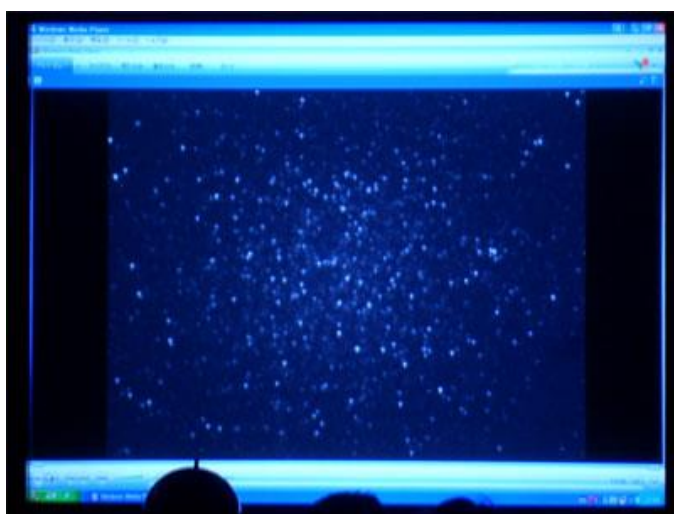
## 4. Examples of the international activities of GAO

### 4.1 Institute of Technology Bandung, Indonesia

GAO and many Japanese astronomers have kept good relationship with Indonesia for many years [14]. International collaboration between GAO and Indonesian astronomers has started before the official establishment of GAO. Dr. Hakim L. Malasan, an astronomer from Bosscha Observatory,

Institute of Technology Bandung (Institut Teknologi Bandung: hereafter, ITB) joined the project of building GAO in its very early phase. He made a lot of contributions to the establishment of the 150-cm main telescope system and the high resolution spectrograph GAOES. He has also played an important role to establish a deeper collaboration framework between GAO and ITB by signing a memorandum of agreement (MoA) for our mutual collaboration. After the signing the MoA in 2002, GAO and ITB have carried out various collaboration works [14,15]. The most important activities have been the mutual exchange of human resources to realize a number of scientific studies as well as to promote various programs in the fields of education and public outreach. We have developed same spectrographs and data analysis systems at both GAO and ITB in order to carry out the cooperative studies efficiently [15,16]. Two small telescope systems were set in GAO in Japan and Bosscha Observatory in Indonesia respectively [17]. Each system can be controlled from other side through the internet. Since Japan is located in the northern hemisphere and Indonesia in the south, those remote telescope systems can provide interesting opportunities of observing stars in the opposite hemisphere from each country. Figure 5 shows a stellar image coming from Indonesia at a public event of GAO where a hundred people gathered on a rainy day. They could enjoy astronomical objects that can only be seen in the southern hemisphere from rainy Japan in the northern hemisphere. Similar remote observation events have also made from Indonesia.

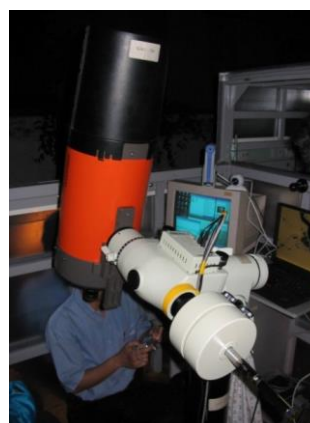
GAO also has a good relationship with Watukosek Solar Observatory, LAPAN as well as ITB. Recently a project of constructing a new astronomical observatory in Sumatera is in progress. It is prompted by Institute of Technology Sumatera (ITERA) in cooperation with ITB and the local government of Lampung province. GAO is invited to cooperate with that project.



Omega Centauri globular cluster  
seen at GAO in Japan through the  
remote telescope system from  
Bosscha Observatory, Indonesia



GAO,  
Japan



Bosscha,  
Indonesia

**Fig. 5. Remote telescope systems between GAO and ITB. They can provide opportunities for astronomical experiences of the opposite hemisphere from both sides.**

#### **4.2 National Research Institute of Thailand (NARIT)**

National Research Institute of Thailand (NARIT) [18] was established in 2008. It has built a national observatory equipped with a 240-cm telescope which is the largest telescope in the East Asia area including Japan. In addition, NARIT has been building five local observatories for the public in Thailand. Prof. Boonrucksar Soonthornthum, the first director general of NARIT has stayed at GAO for several weeks in 2001. He was drawing up his initial idea of the new Thai observatories there. He says that many concepts of GAO are directly reflected in his new observatories. NARIT is promoting various activities of astronomical education and outreach based on the scientific researches using their own facilities, similar to what GAO has been doing. In particular, many features similar to GAO can be seen in their local observatories. GAO is accepting a number of visitors from NARIT in various occasions. For instance, groups of high school students organized by NARIT often visit GAO to experience real observations by themselves using the telescopes of GAO.

#### **4.3 SEAN and SEAYAC**

It was quite natural that personal relationships among visitors coming from various countries spontaneously took place and deepened during their stays at GAO for a significantly long period. Such relationships of their own have lead to one of the most effective driving forces that develops their inter-cooperative relationships between their home countries. South-East Asian countries, Brunei Darussalam, Cambodia, Indonesia, Lao, Malaysia, Myanmar, the Philippines, Singapore, Thailand and Vietnam have established the South-East Asia Astronomy Network (SEAN) in 2007 [19]. It aims at an effective development of astronomical research and scientific education in their area for themselves based on their mutual collaborations. While their activities are going on the basis of equal footing, Indonesia and Thailand are playing leading roles in practice since ITB in Indonesia and NARIT in Thailand are the most advanced and active organizations in South-East Asia. It is a great honor of GAO that it could make some significant contributions to the establishment and development of the SEAN.

The South-East Asian Young Astronomers Collaboration (SEAYAC) [20] is a similar cooperating framework by young astronomers from the South-East Asian region. Students and young astronomers gathered at GAO to kick off the SEAYAC in December 2008. It is noted with an honor of us that GAO is the birthplace of the SEAYAC.

#### **5. Conclusion**

Gunma Astronomical Observatory (GAO) can be regarded as a pioneer of public observatories equipped with large telescopes of full scientific capability. Its telescopes equipped with powerful measuring instruments for astronomical observations are not only used for scientific studies by professional researchers but for various kinds of activities by public visitors. Taking all the advantages of the observational facilities of such a large scale, GAO has been carrying out a lot of unique programs both in education, public outreach and scientific research. A substantial number of international collaboration works are included among them. GAO has been proven to be a really useful means for such international cooperating activities. It is a great honor and pleasure for GAO in particular that it could have made some significant contributions to the development of Astronomy in the South-East Asian countries.

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