Future Exploration of Star and Planet Formation with Subaru
— Workshop Report —

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(Circulated among all the SOC members and the participants for revision)

We held a workshop “Future Exploration of Star and Planet Formation with Subaru” on December 7-9, 2017 at ASIAA, Taipei, Taiwan (http://events.asiaa.sinica.edu.tw/workshop/20171207/index.php). This workshop is an initial meeting for researchers in star and planet formation in Japan and potential partner organizations/regions to discuss the future directions of our research field, how Subaru could impact our research field in the future, and to seek collaborations if appropriate.
The workshop was tremendously successful as described below in detail. We have proven that international collaboration is powerful and exciting for exploring a variety of science cases, exploring new ideas, and trying to polish our science cases. One of the senior representatives from potential partnership countries/regions/organization encourages Subaru and the Japanese community to have more workshop like ours this time for a variety of research fields.

The rest of the report is organized as follows:-

1. **SOC** (A-Z)

Misato Fukagawa (Nagoya Univ., Japan)
Greg Herczeg (Kavli Institute, China)
Paul Ho (EAO/ASIAA)
Jae-Joon Lee (KASI, Korea)
Nagayoshi Ohashi (Subaru Telescope)
Tae-Soo Pyo (Subaru Telescope)
Hsien Shang (ASIAA, Taiwan)
Hiro Takami (ASIAA, Taiwan)
Motohide Tamura (ABC/NAOJ/Univ. of Tokyo, Japan)

2. Number of participants, Funding

We had about 45 participants from 7 countries/regions (Japan, Taiwan, Korea, China, Australia, Canada, India) and 1 international organization (EAO). While most of them attended the entire workshop, 4 researchers at Subaru and NAOJ attended the workshop only partially through the zoom system organized at Subaru. Also, there were several unregistered local participants who was at the workshop only partially.
A low ratio of female/male ratio (4-5/~40) was pointed out by one of the female participants. We need to try to improve this in the future.

We are grateful for Subaru and ASIAA covering expenses needed for the workshop. The travel expense for some invited participants and regular speakers was covered by both Subaru and ASIAA. See below for detailed statistics. Several invited participants and one of the SOC members kindly agreed to cover their expense by themselves. ASIAA also covered lunch boxes, coffee breaks and the banquet.

Country/ Organization	Participants	Talks		SOC	Financial Support Provided			
		Invited	Total		Subaru		ASIAA	
					Airfare	Other expense	Airfare	Other expense
Japan	15	10	10	4	6	6	1	1
Taiwan	~10	0	4	3	0	0	0	0
Korea	8	5	6	1	6	0	0	7
China	6	3	5	1	5	0	1	4
Australia	2	1	2	0	2	0	0	1
Canada	1	1	1	0	0	0	1	1
India	1	0	0	0	1	0	0	0
EAO	2	1	1	1	0	0	0	0
Total	**~45**	**21**	**29**	**10**	**20**	**6**	**3**	**14**

3. Sessions

We had the sessions below during the workshop. The detailed program is available at the following links for individual dates.
http://events.asiaa.sinica.edu.tw/workshop/20171207/program.php
http://events.asiaa.sinica.edu.tw/workshop/20171207/program.php?d=2
http://events.asiaa.sinica.edu.tw/workshop/20171207/program.php?d=3

(A) Subaru: Present and Future

This session was organized in the beginning of the workshop for us to learn about Subaru's present instrumentation, operation and future plans. The SOC members from Subaru gave talks about the present status and future plans of Subaru, respectively. Three invited speakers gave talks about SCExAO, IRD, and Ultimate Subaru, respectively.

(B) Science Sessions

We had five science sessions for the following topics:

- ISM to Stars
- Protoplanetary Disks
- Roles of Winds and Jets
- Star Formation as Clusters
- Exoplanets

We had 22 oral talks in total, including 14 invited talks. We strongly encouraged the speakers to present what they would want to do with Subaru in the future, and/or how Subaru would be exciting for your research activities in the future.
At the end of each science session we had extra 30-min. to discuss the issues below, and any other appropriate issue to understand the science topics in depth and/or our future directions.

- Would Subaru be exciting for us for the next 10 years?
- If yes, which instruments do we want Subaru to keep?
- Otherwise, what kind of new instruments do we want?
- Any ideas about large programs for our community?

(C) Synergy with Other Missions

We had invited talks about TMT, K-GMT, IGRINS (the prototype instrument for GMT), ALMA, JCMT, JWST and SPICA to seek synergies with Subaru for our research fields.

(D) Wrap-Up Discussion

We summarized the above discussions, and discussed our next steps toward collaboration, and also requests for Subaru. See below for details.

4. Discussions

We confirm that Subaru would remain exciting for our research field for the next decades. But Subaru may consider the improvements below for our high productivities and science impacts.
We fully understand that these improvements highly depend on budget, human resources, and/or interests from the other research fields. Even so, we believe Subaru would like to keep our wish in mind to organize international partnership, and try to solve some (if not all) through international collaboration in the future.

Queue Observations, COMICS, IRCS
The queue system would make Subaru even more productive, as some projects require very good observing conditions (in terms of seeing/PSF, photometric conditions, water vapor). It would also improve the efficiency of the observations.
Furthermore, we are concerned about decommission of COMICS and IRCS in near future. These would be key instruments for our research activities, despite the facts that some other instruments (IRD, SCExAO, HDS, Ultimate Subaru) are also useful for us.

Through the questionnaire just after the workshop (see Appendix). about 15 researchers (both non-Japanese and Japanese) expressed their interests in using COMICS and IRCS, respectively, for studying protostars, pre-main sequence stars, disk, jets and winds. These studies would require a variety of instrumental modes, such as imaging, low-to-medium resolution spectroscopy, high-resolution spectroscopy and polarimetry. We also have received ~15 feedbacks to support queue observations.

We note that ~15 is a significant fraction of the participants, considering the facts that some of us are non-experts for optical-IR observations (therefore they may need more time to figure out in detail what they want to do using Subaru), and others are invited as project representatives rather than their own science interests. Regarding the queue system, it is fair to report that one of the participants rather prefer the remote observing system.

We also remind you that COMICS offers a unique opportunity for mid-IR observations at a 8-m telescope in the northern hemisphere.

Possible Upgrades and New Instrumentation
These would also enhance the science impact of Subaru in our research fields. The upgrades discussed at the workshop were:

- **SCExAO** — IR wavefront sensor, PDI, IFU with a higher dispersion (R>100).
- **IRCS, COMICS** — higher spectral resolution (R~10^5); high spatial sampling for spectro-astrometry; replacement of the detectors for higher sensitivities and observing efficiencies; adding the polarimetry mode to COMICS
- **HDS** — the following for higher precision of the RV measurements
  - Millikelvin thermal stability
  - pressure stability, échelle in vacuum
  - Octagonal fibres and improved scrambling to remove spatial information

A possible new instrument requested and discussed is a wide-field imaging polarimeter to study magnetic fields.

Archive
While some of us are interested in archival data, the present archival system is not extremely convenient due to lack of pipelines and insufficient info about data quality. We wish Subaru and potential partnership countries will discuss them to try to improve the system. In particular, it would be significantly more convenient for users if the archive system provides reduced data. Subaru and potential partnership countries might discuss it as possible in-kind contribution from the latter.
We note that our workshops in the future may also be useful to improve some issues (see below).

Our Next Step
While our workshop was tremendously successful, our discussion was not complete for the manners described below due to limited budget, time and space:-

(A) We were not able to fully cover science targets in our research fields. These include exoplanets (we were able to include only a few researchers this time), debris disks, solar-system objects, and photodissociation regions;

(B) While all the science cases have strong science goals, some require further investigation for feasibility with Subaru, or which kind of observational approach would be the best for our science goals. Obviously, a single 3-day workshop with ~40 participants is not sufficient to solve these issues;

(C) We were not able to discuss possible large programs in details (except the fact that one of the participants proposed such a program to observe disks using SCExAO).

(D) We were not able to extensively discuss synergies for our proposed studies using Subaru and other powerful missions.

More workshops with a smaller number of participants and more focused topics would be useful for our discussion in depth, leading us to actual collaboration using Subaru. At least a few of us talked about a possibility to organizing such a workshop for high-resolution spectroscopy next year, to seek for collaboration for science and pipeline development. Other participants may also try to plan more workshops in the future.
Besides, the SOC also hopes this opportunity was useful for some participants to seek or extend personal collaborations.

Appendix: Our questionnaire used after the workshop

IRCS

1. Which observing mode are you interested in using?
    - Imaging?
    - Low-to-medium resolution spectroscopy?
    - High resolution spectroscopy?
    - Imaging polarimetry?
    - I do not know (Note: it is not a bad answer at this moment)

2. For which science topics are you interested in using?
    - Protostars, PMS stars
    - Disks
    - Jets, Winds
    - Clusters
    - Exoplanets
    - Others > Please describe if you would like

COMICS

1. Which observing mode are you interested in using?
    Imaging
    Low-to-medium resolution spectroscopy
    High resolution spectroscopy
    I do not know (Note: it is not a bad answer at this moment)

2. For which science topics are you interested in using?
    Protostars, PMS stars
    Disks
    Jets, Winds
    Clusters
    Exoplanets
    Others > Please describe if you would like

Queue observing

For which instrument would you like queue observing?

For which conditions would you like queue observing?
    Photometric conditions
    Better PSF
    Low water vapor
    Others > please describe