FY 2024
NAOJ Project Review Report
Center for Computational Astrophysics

July 1st, 2025

Version 1.2: Final version

NAOJ External Evaluation Committee

Change Record

Version	Date	Affected Paragraphs(s)	Reason/Initiation/Remarks
v0.0	2025-4-17	All	Initial draft
v1.0	2025-5-31	All	Agreed draft from EEC
v1.1	2025-6-13	Minor edits on p6 and p7	Final version from EEC following comments from NAOJ review team.
v1.2	2025-7-1	Minor edits	Corrected typos identified by NAOJ team

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Conflicts of interest:
Prof. Kobayashi declared a close collaboration with Tominaga.
No other conflicts were noted.

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General Introduction

The External Evaluation Committee (EEC) for the Center for Computational Astrophysics (CfCA), composed of the members listed above [NAOJ-EEC-CfCA-001-A], held an online kickoff meeting on January 14th, 2025 [NAOJ-EEC-CfCA-003-B] led by the Chair of the NAOJ Project Review Committee. Following this meeting, the EEC members drafted the Review Plan [NAOJ-EEC-CFCA-009-A]. The EEC received the documents listed under the List of CfCA Review Documents in Appendix B (last updated on February 28th, 2025). The EEC met at the Mitaka campus of the National Astronomical Observatory of Japan (NAOJ) on 27th and 28th February 2025. The meeting followed the agenda outlined in the review plan [NAOJ-EEC-CFCA-009-A] and included in Appendix B.

The purpose of the evaluation was to identify and summarize the activities of the project since the previous project review conducted in FY 2017 (December 22nd, 2017) from the following perspectives and make recommendations for improving future activities:
-Does the project produce internationally competitive science through its Open-Use programs?
-Does the project improve the research capabilities of universities and other institutions?
-Does the project contribute to human resource development of young researchers?

This report describes the findings of the EEC review, based on the written submissions from the project team, detailed interviews conducted with the Director and members of the project team during the two-day review meeting, and interviews with a number of external stakeholders (see Appendices C, D and E for details of these interviews).

This report is structured according to the review categories and evaluation items listed in the evaluation plan [NAOJ-EEC-CFCA-009-A] and provides detailed replies to each charge. An executive summary is provided to summarise the main recommendations by the EEC.

Executive Summary

The committee commends the CfCA management and staff for their continued success over the past seven years. During this time, the CfCA has supported increasing numbers of computational astrophysics researchers, primarily in Japan, while maintaining very high user satisfaction levels. Publication rates for papers using CfCA resources remain strong, with high citation rates. The 4D2U project has continued to develop high quality movies and visualisation tools. In 2024, the CfCA successfully completed the deployment of their new supercomputer, ATERUI-III.

Over the coming years, the CfCA will face a number of significant challenges. Already, there is a risk that their funding levels will not be sufficient to accommodate future rises in energy unit costs. Staffing levels remain minimal, given the scale of services the CfCA supports, and there is continued risk of staff leaving which could threaten the sustainability of the CfCA services. Most significantly, there is an urgent need to create an engineer position whose sole responsibility is to CfCA services.

During the next review period, GPU computing will play an increasingly important role in computational astrophysics and both the CfCA, and the community it supports, need to prepare for this significant change.

Discussions are underway regarding the longer term future scale, design and role of the CfCA, presenting both opportunities (e.g. the deployment of more powerful, shared services which could benefit the CfCA user community) and risks (e.g. how to ensure that the close connection between the user community and the facility can be maintained in a shared service model).

Based on all the evidence we considered, the EEC is convinced that the CfCA continues to provide a vital, internationally competitive service to the computational astronomy community, both in Japan and externally. Our recommendations for future action in this report are intended to support the CfCA in building on this extensive track record to deliver sustainable services for their community into the future.

Finally, the EEC thanks the CfCA project and NAOJ staff for their time spent providing the committee with documentation, presentations, discussions, overall support and organizing a very constructive and enjoyable visit in February 2025. In particular, we would like to thank Hori-san and colleagues for the outstanding admin support for the whole process.

Evaluation

In the following subsections, we review each category in turn, using the evaluation criteria which were set out in the CfCA Review Report Plan [NAOJ-EEC-CFCA-009-A].

The CfCA was established in 2006, following the division of the Astronomical Data Analysis Center (ADAC) into the Astronomy Data Centre (ADC) and the CfCA. Until recently, the Japanese name for the CfCA translated as “Astrophysical Research Project”: the EEC endorses the change of the Japanese name for the CfCA was recently changed to 計算科学センター, in order to match the English name and to reflect better the actual role of the CfCA. The overall purpose of the CfCA is to “promote computational astrophysics to explore the Universe as a Center of Excellence (COE) of this research area in Japan”. Its dual role, both supporting the computational astronomy community and delivering research is reflected across its activities and staff cohort.

At the time of this review, the CfCA staff comprised 9 tenured members (5 of whom are joint appointments with other NAOJ projects or divisions) and 15 members on fixed-term/age-limit retirement contracts (6 of whom are joint appointments). Their complement of project researcher positions has increased to five through the addition of two posts that were awarded to the CfCA in an NAOJ-wide competition. The research interests of CfCA members span cosmic magnetism, transient phenomena (supernovae, etc), galactic dynamics, star formation, planet formation and small solar system bodies.

1. Achievement of Establishment Objectives

(1-1) **Response to Mission 1** (to operate diverse computing resources, provide them to the Japanese astronomy community on an open-use basis, and support the progress of research activity in astronomy and astrophysics.):

(1-1-1) Does the open-use computing system meet the needs of the Japanese astronomy community?

The user satisfaction scores in the annual user survey are consistently very high with 91% of users being either “very satisfied” or “satisfied”. Taken together with the high publication rates, the EEC concludes that the system is meeting the needs of the community. This was also reflected in the comments from the users we interviewed in the preparation of this report, who cited many reasons for their satisfaction, including:

1) the ease of use of the systems;
2) restriction to the astronomy community makes proposal development more straightforward

as applications can target an expert audience – this is particularly helpful for Early Career Researchers (ECRs);
3) absence of time limits on allocations means users can submit jobs throughout each quarter;
4) efficient and rapid responses from technical support staff (one user received an immediate, helpful response to a support request submitted at midnight relating to a network issue);
5) variety of available computing resources and project categories;
6) open access and free to use;
7) high quality documentation available for light users.

The open-use nature of CfCA resources means they are open to all researchers at Japanese universities and institutes. This includes anyone who gets a PhD from a Japanese University, even if they are working abroad. The EEC noted that this is very positive as it helps ECRs who go abroad to work as PDRAs.

Currently, all applicants request time individually rather than in groups or collaborations. While the EEC noted that the current system is very productive, it could be helpful to **allow joint applications** in the future. This should be approached carefully to avoid disrupting the existing community, but could be a means to encouraging more collaborative research projects across the community, both nationally and internationally.

While the user feedback was generally very positive, there were some specific concerns raised relating to insufficient memory for certain problems; the large gap in allocation scale between project categories A and B; lack of availability of eduroam at the Mitaka campus; some VPN connection issues with the new system. We encourage the CfCA to **continue to solicit, and listen to, feedback from the community and reflect it in future service improvements.**

(1-1-2) Is the open-use computing system operated stably?

The downtime for ATERUI-II, including monthly maintenance was below 10% after the first year and averaged 5% for the last 5 years.

(1-1-3) Is the open-use computing system updated appropriately?

Planning for the deployment of the new ATERUI-III system began in May 2022 and the process included a survey of user requirements to determine the appropriate specifications for the service. Major users of the ATERUI-II system attended committee meetings where the design of the service was decided. The new system was deployed in December 2024.

A number of interviewees commented that the theoretical peak performance of ATERUI-III is lower than that of the system it replaced, due to budgetary constraints. The EEC note that the theoretical peak performance is often a poor measure of the actual performance for real applications: and indeed ATERUI-III is delivering an 8x speed up for simple hydrodynamic calculations and a 2x speed up for more complex hydrodynamic calculations. Nevertheless, the EEC would encourage the CfCA to monitor throughput carefully on the new system in order to assess its productivity compared to its predecessor.

The EEC noted that approximately 10 FTE of the CfCA membership contributes to the operations of the computing resources, with three post-docs providing user support (contributing 0.5 FTE each). However, many of the people we spoke to highlighted that there is no full-time engineer position to

support the resources: by the end of this FY, only 0.1 FTE of engineer effort with primary responsibility for the CfCA will be in place. The CfCA has asked the NAOJ for the creation of such a position but has not yet been successful. The EEC considers that there is a serious risk to the future operations of the CfCA unless an engineer whose primary responsibility is the CfCA service can be appointed.
The transition from Fujitsu to HPE as the main CfCA HPC supplier has had some initial teething problems with the HPE deployment of Artura-III, in both hardware and software. Strong working relationships with suppliers are increasingly important for large-scale computing deployments and the EEC considers that the **creation of an engineer post** to develop and maintain relationships with suppliers is essential for the continued success of the CfCA computing provision. A dedicated CfCA engineer post would also ensure that sufficient effort is available to support the planning and deployment of future systems, without impacting on the on-going science programme – for the recent deployment, 6 CfCA staff were involved. It was noted that current CfCA staffing levels were not sufficient to support a wider consultation process for the co-design of the required services, including the development of science cases and technical designs.

Finally, we note that the CfCA has seen a reduction in the number of credible bids received in tender processes. A mitigation of this is to **engage more widely with industry** in the years between deployments and an engineer post could support this.

(1-1-4) Is the cost-effectiveness of resource utilization in the open-use computing system appropriate?

The EEC considers that the CfCA is exceptionally cost-effective for a service of this scale, particularly given the high level of user support which is provided.

The CfCA has also reduced the costs of providing data storage by moving to a DIY solution rather than procuring a vendor appliance-based solution. This approach delivers cost savings of approximately a factor of 10 and is now being adopted by the ADC (Astronomy Data Center).

Overall, the cost per publication for CfCA resources compares very favourably with other NAOJ resources, being at least a factor two lower than those for observational facilities (even when observatory construction costs are excluded).

(1-1-5) Has risk management been appropriately implemented in the operation of the open-use computing system?

Risk management for the open-use service is at an appropriate level with mitigations in place for all major risks that have been identified.

At present, the most serious risk to the service appears to be the uncertainty over the energy budget. In mitigation, the CfCA made power consumption control an explicit part of the specification of the ATERUI-III system.

The total annual budget for ATERUI-II was previously fixed. The NAOJ Executive Committee approved the allocation of additional funds until December 2024 to support the ATERUI-III deployment, but these have now ended. At current energy prices, CfCA can continue to operate ATERUI-III within the available allocation of funds, but if prices increase there is a serious risk that the scale of the service would have to be reduced in order to reduce its energy bill. Discussions with

the new Executive Committee regarding an underwrite of future energy costs are underway, but are challenging due to the NAOJ-wide requirement to reduce budgets which puts any increase in energy budget for the CfCA in tension with budgets in other areas of NAOJ activity. The EEC strongly recommends that the **NAOJ underwrite the risk of energy price increases** for the ATERUI-III service, given its importance to the community and its significant contribution to the scientific output of the NAOJ.

In terms of CfCA risk management more generally, the EEC noted that a **live risk register** covering all areas of CfCA activity is a very useful tool for planning and monitoring. This register should include technical risks such as network security (the responsibility of the NAOJ network team) as well as strategic risks such as significant cuts to the CfCA budget.

Recommendations:

1. Consider allowing joint applications for computing resources as well as individual applications, as a means to encourage larger groups to work together.
2. Continue to solicit, and listen to, feedback from the community and reflect it in future service improvements.
3. The CfCA should begin a programme of engagement with industry partners as soon as possible, to allow for good working relationships to be built up with multiple potential suppliers in advance of the design and deployment of the ATERUI-IV service.
4. The NAOJ should approve the creation of a full-time engineer position whose primary responsibility is for the CfCA systems. This would support both the operation of current services, planning for future services and the development of the industrial engagement programme.
5. The NAOJ should underwrite the risk of energy price increases in order to maintain full operations of ATERUI-III.
6. The CfCA should create and maintain a live risk register for the organization, covering all areas of risk, which can be used for monitoring and planning purposes.

(1-2) **Response to Mission 2** (to produce first-rate research achievements in the area of computational astrophysics.):

(1-2-1) Has research and development of hardware/software dedicated to computational astrophysics been carried out?

The CfCA has supported the development of a number of valuable computational astrophysics codes and provides users with associated training.

The EEC consider that there are a number of opportunities to increase further the impact of this work and encourage the international adoption of Japanese-developed software:

1) **Make some, or all, of the CfCA codes fully open source**: while some of the codes (e.g. the supernova MHD code) have very specific use cases, a CfCA open-source code could have a significant impact internationally in terms of making it easier to perform these calculations and expanding the user community. In addition, it would become possible to leverage community effort to increase adoption in the future, so that CfCA no longer has to provide all the required effort for this.
2) **Establish a "CfCA software hub"** for specific codes which could be pre-installed on CfCA

systems. External users could then explore the use of the codes which would be a potential boost to their adoption internationally. “Community leaders” could be identified who would be responsible for specific codes. A modest level of CfCA effort, probably at the level of 2-3 FTE based on similar schemes internationally, could then coordinate the maintenance of a larger set of community codes.

(1-2-2) Has CfCA achieved internationally outstanding research results, both in quality and quantity?

Between 2018 and 2023, CfCA users published 1000 papers (an average of 167 papers per year) with average citation counts of 38.7 and including 14 Nature/Science papers. During this period, the highest cited paper attracted 345 citations and the top 5 papers had a total of ~1200 citations. The number of papers per user per year has remained constant at ~0.6 throughout the period.

The EEC commended the CfCA for their high publication rate of papers which make use of CfCA resources, and noted the increasing use of CfCA resources in papers based on observational data from facilities including Subaru, ALMA and the ADC.

Recommendations

1. Explore more open-sourcing of code as a means to increase the international adoption and impact of Japanese-developed software.
2. Consider the creation of a CfCA software hub to support specific codes which would be pre-installed on CfCA services and leverage community effort for support and maintenance.

(1-3) ***Response to Mission 3*** *(to develop cutting-edge contents with astronomical data, and publicize the latest achievements in astronomy.):*

(1-3-1) Have sufficient contents been developed (especially cutting-edge contents for the 4D2U program)?

The 4D2U project continues to be very successful, with 40 movies now available online. The Mitaka visualization tool is used in schools and is also available in English. A web-based version of Mitaka will be released during the next FY, which will increase access as primary school children will be able to use it on tablet devices. Dome movies using 4D2U visualization tools Zindaiji (for SPH simulations) and Oosawa (for grid-based simulations) have been used in planetariums in New York and Germany, in addition to Japan.

Currently, the four dome movie presentations per month at the CfCA are delivered by the NAOJ PR division. The EEC noted that public audiences are generally interested in meeting the people who carry out research and therefore it would be good if more CfCA members were involved in the delivery of these presentations as well as creating the content. The NAOJ could encourage this by making outreach a formal part of staff members’ activities, to indicate its value to the NAOJ.

It would also be useful to monitor the demographics of audiences at these events in order to explore whether there are ways to broaden engagement across society in Japan. The EEC noted the low female fraction at all levels (students, postdocs, faculty) in STEM in Japan and encourage the CfCA to actively contribute to improving it, in collaboration with the PR division.

(1-3-2) Are the contents being appropriately disseminated to society?

There is an active programme of activities to publicise the work of the CfCA including TV programs,

school textbooks, planetarium programs and other events. The Mitaka software has been downloaded ~40k times during the review period and the movies have been viewed over 500k times.

Recommendations

1. The NAOJ should encourage CfCA staff to participate in the delivery of movie presentations by including outreach in CfCA members' formal activities.
2. The CfCA should request the PR division to provide demographic data for audiences at the monthly movie presentations in order to monitor engagement levels from different sectors of society.

*(1-4) Has CfCA appropriately addressed the four key issues listed in the **Scientific Goals and Missions** (established 19 August 2022, with a deadline at the end of March 2024) (Note: considering the short time frame from establishment to the deadline)?:*

(1-4-1) Support the research activities of users of the supercomputer installed at the Mizusawa VLBI Observatory during the current lease period (2018-2023) and the next lease period. Support users in publishing over 100 peer-reviewed papers annually.

The average publication rate between 2018 and 2023 was 167 papers per year. It is thus clear that the CfCA are delivering a productive computing service for the community.

The EEC were very impressed by the high productivity of the CfCA service in terms of published papers. We note that the number of papers per year is comparable to the output of the Subaru telescope, and that the number of papers with at least one Japanese author is larger than that of Subaru and comparable to that of ALMA. We also noted a significant increase in the number of papers which made use of both CfCA computing resources and another NAOJ facility (ALMA, ADC or Subaru). These figures highlight the importance of the CfCA services to the Japanese astronomy community.

(1-4-2) Consider the specifications of the supercomputer to be provided after the current lease period, taking into account budget constraints, and determine its details by Q1 2023.

This issue was fully addressed and the ATERUI-III supercomputer was successfully deployed in December 2024.

(1-4-3) Continue to develop hardware/software dedicated to computational astrophysics to support the Japanese astronomy community.

This point is discussed in section 1-2-1 above.

(1-4-4) Has the 4D2U section of the CfCA continued to update the visualization application "Mitaka" and produce at least three 3D animations annually, as well as continued the development of VR systems?

During the review period, regular updates of the Mitaka application were rolled out and significant developments of the VR content were delivered for the Oculus Quest, HTC Vive and Youtube VR platforms.

In terms of movies, the COVID-19 pandemic and personnel shortages reduced the number of movies which could be produced. In addition, the higher resolution of the current generation of movies and the fact that more formats are now being produced (VR, Dome, YouTube) means that movies take longer to create. Nevertheless, a total of 8 were published during the review period.

In section 3, we discuss a number of recommendations regarding staff positions in the 4D2U programme which would make the team more sustainable.

2. Benchmarking Against Similar Projects

(2-1) Can CfCA's research results and plans be considered sufficiently competitive when compared to other similar projects both domestically and internationally?

Direct, quantitative comparison with other facilities is challenging. However, the publication rates and citation rates for the CfCA are high and the international experts we consulted considered the CfCA to be outstanding in comparison to other international facilities.

(2-2) What are CfCA's strengths and unique features in the field of international computational astrophysics, and are there appropriate strategies and operational policies to sustain them?

The CfCA has a number of unique features which contribute to its success; many of these were noted by the users and external experts that spoke to the EEC:

1. CfCA resources are dedicated to the computational astrophysics community, which makes the application process easier for new users.
2. There is a strong scientific connectivity with the NAOJ observational resources.
3. Once awarded access to the system, users have flexibility on how to manage their resources as there is no upper limit to the amount of available resources per year.
4. Queue times on the systems are generally shorter than other, general use services that users have access to.
5. Services include compute, analysis servers and storage, all connected through a high-bandwidth network. The system is optimized for organizing and visualizing numerical output, supporting the generation of academic publications by enabling cutting-edge astrophysical simulations.
6. Do-It-Yourself On-Premises deployment has allowed the construction of a range of different services at reduced cost.

Other key strengths of the CfCA include:

1. A strong connection to the user community, which now numbers almost 300 users.
2. A user-focused approach to service delivery.
3. Robust high-performance hardware systems and integration of advanced software tools tailored for astrophysical research.
4. Knowledgeable and proactive support staff, and, responsive technical support, ensuring minimal downtime and efficient progress on projects

It would be useful to have **data on why users choose to use CfCA resources** in preference to other services to which they have access, so that future planning can ensure that the CfCA continues to provide the appropriate support to the community.

The above features and strengths are supported by a number of key policies:

1. Peer-review system: Scientific-merit based evaluation.
2. Individual-based proposals allowing ECRs to submit proposals.
3. Separate proposal category for graduate students who can apply for relatively large amounts of resource.

4. Unlimited use (not credit-based): Users are not restricted by usage credits and can continue accessing resources throughout the fiscal year.
5. Free of charge to remove potential financial barriers for ECR usage.

Recommendations

1. Include additional questions in the user survey to understand why user choose CfCA resources as their primary computational service.

3. Response to External Feedback

(3-1) Have the findings of the 2017 project review been adequately addressed?

With regard to 2017 project review, the CfCA have taken concrete actions to address all five key remarks from the panel:

1) Changes to the prioritization of large calculations (1k-2k cores) on ATERUI-II have enabled these jobs to run successfully even when the system was full.
2) The internationally successful GRAPE system was decommissioned in FY2021 and the CfCA has begun a programme of GPU activities based around a small GPU cluster.
3) CfCA has continued to support the development of a numerical magneto-hydrodynamics code and a relativistic radiation hydrodynamics code, including the provision of training in their use.
4) CfCA now has a number of technical positions to support their operations which are shared with the Mizusawa VLBI Observatory and the Astronomical Data Center. Such shared posts are now supported by NAOJ policy and the CfCA has found this to be an efficient approach. There were some initial teething issues, which have resulted in better definitions of how time is divided in shared roles and identifying annual goals for all shared staff. Additional support is now being provided by NAOJ to compensate for past years in which CfCA did not receive its full share of joint positions.
5) The CfCA actively supports the career development of its staff members and encourages them to be active researchers as part of their CfCA roles. The majority of their fixed term early career staff have moved on to research positions in Universities following their time at CfCA.

GPU adoption: With regard to the question of preparing for the increased adoption of GPU hardware in computational science, the EEC noted that this is an area in which the CfCA needs to provide leadership for the community to prepare them for the future. The **community need to be encouraged to engage with the challenges and opportunities of GPU-based** computing now, as future systems may be GPU-based. However, the CfCA should also remain open to the conclusion that CPU is still most cost effective computing option for some research areas and indeed this might be a differentiator between the CfCA TNG system and FugakuNEXT. In order to foster community engagement, the EEC recommends that **the CfCA seeks additional external funding to increase the size of its GPU cluster** beyond the current 32 GPUs. A **joint service with the NINS** may be appropriate in this case, as CfCA resources are specifically for the field of astronomy rather than open access, which may reduce the number of appropriate funding opportunities. The number of **GPU-focussed workshops in the CfCA training programme should be increased** and they should actively work to increase attendance which has shown signs of plateauing.

4D2U staff: Regarding the career development of 4D2U staff, several core members of the 4D2U project have moved to “age-limit retirement” positions. These staff no longer have a fixed term for

their employment, but the EEC were concerned at the lack of promotion opportunities in such roles. Given the importance of the 4D2U programme, staff retention is an important consideration. While the NAOJ cannot offer salaries at the levels available in industry, the 4D2U team has already lost a member of staff who took up a University role which has a higher salary and is more attractive than age-limited retirement positions. The 4D2U programme risks becoming unsustainable if further staff leave for University position. The EEC also noted that comparable roles in other parts of NAOJ (e.g. Subaru telescope in Hawaii) are tenured positions.

The EEC consider that the 4D2U is a very successful team of highly skilled people who should be rewarded appropriately. The **creation of a number of tenured positions for 4D2U staff** should be considered as a priority in order to make the team sustainable and address concerns about staff retention. At least one of these roles should be **an engineer position**.

The CfCA has been able to attract one member of staff from the games industry, highlighting the benefits of **increasing the breadth of advertising for 4D2U roles** so that they can attract more suitable candidates. This represents another important route to making the programme sustainable for the future.

(3-2) Has sufficient consideration and response been given to feedback from the CfCA Scientific Advisory Committee?

During the review period, the SAC provided several recommendations which the CfCA has responded to, including:

1. Clarification of membership criteria: Faculty members of DoS who conduct numerical simulations and wish to join CfCA now become members. Those who join get access to internal resources and priority queue. This replaces the previous policy that all professors in the Division of Science joined CfCA by default.
2. Support for researchers taking parental leave: researchers can now resume their research as prior to their leave without submitting proposals.
3. Continuous upgrade of the ATERUI supercomputer service.

(3-3) Has sufficient consideration and response been given to feedback from the community, such as through users' meetings?

As previously noted, user satisfaction with the CfCA services is extremely high. The responsiveness of the CfCA to user requests was emphasized as one reason for these high levels of satisfaction. Many of the feedback points we discussed in 3-1 and 3-2 were also raised by users and have been addressed.

According to the annual user survey conducted by the CfCA, 73% of CfCA users currently report that the CfCA system is their primary computing resource. There is a noticeable decline from 93% in 2021, which the CfCA attribute to the availability of the much larger Fugaku supercomputer. It was noted that this reduction could be evidence that people are gaining experience and then using the larger systems and hence that CfCA are playing an important role in the overall computing ecosystem in Japan. It would be useful to confirm this via questions in the User Survey (as recommended in section 2).

Recommendations

1. The CfCA should be proactive in encouraging their user community to engage with the opportunities and challenges of GPU-based computing in order to prepare them for the future.
2. The CfCA should seek to secure external funding to increase the size of its GPU service. Approaches such as a joint deployment with the NINS could be considered to facilitate this.
3. Increase the number of GPU-focussed workshops in the CfCA training programme and explore ways to increase attendance.
4. The NAOJ should consider the creation of a number of tenured positions for 4D2U staff as a priority, in order to address concerns about staff retention. At least one of these roles should be an engineer position.
5. Advertise 4D2U positions more widely (e.g. to communities in industry) in order to increase the pool of suitable applications.

4. Future Plans

(4-1) Does CfCA present a clear future direction (including primary scientific goals and budget prospects for the next period)?

Future computing requirements: The CfCA future plans document (NAOJ-EEC-CfCA-020-A) was developed based on a survey of users. In each research area, the plan presents an estimate of the expected international standard for cutting-edge simulations in 2030. In most cases, this is equivalent to a 10-100x increase in particle number, requiring compute at a level of approximately 10x the performance of the ATERUI-III system.

Based on the internationally competitive projects being led by CfCA full-time staff, examples of projects which CfCA could support on this timeframe include:

- 100 3D Core-collapse supernova explosion simulations
- Disk simulations - developing MHD-SPH code for this
- Planetary ring system simulations with 10^9-10^{10} particles

Potential for shared services: At this point, a number of funding options for the ATERUI TNG system are being explored. This includes the option of a joint procurement with other NINS open-use programmes such as fusion and molecular simulations in order to support a larger, shared machine with pooled budget. The EEC noted that while there are clear benefits to the research community of having access to a larger system, there are organisational challenges and policy alignments (e.g. security, resource allocation, etc.) which must be addressed in order to ensure a successful outcome. One governance model being proposed is to create an umbrella organisation with divisions for each sub-area (e.g. CfCA), as this would allow each division to work with the others while maintaining their own strengths. Partitioning of a shared system would allow each division to operate according to their own models, but could reduce the benefits of shared access to a larger resource. The EEC recognises that these discussions are at an early stage but strongly recommends that the CfCA user community and Rironkon be involved in the discussions about such a move, as community engagement will be critical to the success. One of the key strengths of the CfCA is its connection to the user community and great care must be taken not to jeopardise this.

The CfCA described **a stepwise approach to joint services**, starting from the creation of a budgetary centre, with practical steps such as synchronization of hardware lease dates and

potentially co-location of new resources (e.g. at the NAOJ site). Over time, greater coordination could be discussed leading to shared services being procured and deployed. The EEC supports this approach and encourages the CfCA to explore this option further.

Another option proposed was to submit the CfCA as a frontier project in the MEXT programme. However, while this appears to be an interesting possibility, at this time it was noted that computing programme are not eligible for MEXT frontier project funding.

The CfCA is already engaging with other parts of the NAOJ: for example, they created a movie about the TMT free-of-charge. The EEC encourages the CfCA to **work proactively to increase their levels of collaboration with other parts of the NAOJ**, for example by providing access to CfCA GPUs for the analysis of NAOJ data (already 50% of GPU usage is from observers) and inclusion of SubaruNEXT data in future 4D2U movies. We would also encourage the NAOJ to identify any blockers to collaboration and work to reduce or remove them in order to optimise the use of all available NAOJ resources.

The 2021 creation of the CfCA **Deputy Director** position was a welcome development in terms of providing support for the Director. We recommend that as the potential changes to the nature of CfCA services are being discussed, the Deputy Director should be **more explicitly involved in decision-making processes** along with the CfCA director, as a means to bring in wider range of expertise and opinion and support additional consultation.

The future scale and nature of CfCA computing services represents an important opportunity to review the CfCA's role in the Japanese computing ecosystem. The ATERIU-III service represents a key resource for computational astrophysics which needs to be maintained, and provides an intermediate role for those users who go on to access larger systems such as Fugaku. A number of students that spoke to the EEC expressed the intention of applying for time on larger services in the future. As FugakuNEXT moves to a GPU-based architecture, the CfCA may consider whether part of its future role could be to provide CPU-based computing alongside GPU hardware, for those workflows for which CPUs are more cost effective.

AI adoption: The CfCA team explained that they are still evaluating the role of AI in the future direction of the CfCA, but that the user community has not yet identified this as a requirement. There is a top-down obligation to include AI in the mix of projects running on Fugaku and four CfCA faculty are members of the Fugaku AI group. CfCA plan to organise workshops on AI/ML in the near future, but currently are expecting that the main impact on CfCA services will be an increase level of accelerator-based compute (e.g. GPU) being required, in order to support AI-accelerated workflows.

External collaborations: The CfCA already supports a broad range of computational astrophysics research across the Japanese research community. An increased focus on **developing international partnerships**, as well as exploring interdisciplinary research opportunities, could further solidify the CfCA's position as a global leader in computational astrophysics. Large-scale, collaborative projects represent an important opportunity to increase the visibility and impact of the software and simulation outputs of the Japanese community, as well as providing access to skilled effort which can be leveraged for software support. The CfCA should explore routes within the Japanese funding system to support more external, international visits to encourage such collaborations. **Increased engagement with the HPCI, RIKEN and JICFuS** could provide routes both for developing such partnerships at the organization level and to identify potential funding

sources.

(4-2) Is the development of young human resources being adequately carried out (with regard to past achievements and future plans)?

ECR access to resources: The CfCA actively seeks to support early career researchers in the use of their services. In particular, ECRs are able to apply for their own CfCA computing resources and approximately 30% of proposals now come from PhD students. Support for publication costs is also provided for ECRs.

Within the CfCA, attention is paid to staff research ratios. For example, staff in Project Researcher positions each have a budget of 500k yen per annum to support their research. In addition, they are only required to work 30% of their time on CfCA activity (the maximum level would be 50%) and the remaining 70% is allocated to their own research. The EEC considers this to be a valuable model which clearly contributes to the thriving research programme within the CfCA.

Training: The CfCA training programme is extensive and user feedback about the training provision, for example the N-body school, is very positive. The EEC strongly supports the existing activites which should be continued as a high priority, due to their benefits to the community. We have identified some areas for potential improvement, which the CfCA should consider as they plan for their future training programme:

1. Increased provision of courses on GPU programming and MPI parallelization would be beneficial.
2. Additional basic training and documentation for new users, for example summary documents on code development and data analysis.
3. Development of training courses and activities in key areas such as fluid dynamics (e.g. particle-in-cell methods), equivalent to the N-body school.
4. Creation of a seedcorn access programme to allow familiarization and code testing on CfCA services.
5. Consider the expansion of the training programme to include some training aimed at undergraduate level as a means to increase the diversity of ECRs entering the community.

Overall, we would encourage the CfCA to continue to identify **gaps in the training programme for new users and explore ways to meet these needs.**

Mentoring: Within the CfCA, there is an informal mentoring system for young researchers which includes annual review meetings and provides guidance with future career plans. The scheme has been running for 10 years and its success is indicated by the fact that all PDRAs that had to leave the CfCA have found new PDRA positions. The EEC also noted that the CfCA no longer hires research oriented junior staff as “Research Supporters” as these roles are part-time and therefore not suitable for staff intending to pursue a research career.

The EEC understands that the mentoring scheme is essentially a supervision programme. While this is very valuable and is clearly of benefit to the ECR staff members, the EEC would recommend that **a mentoring programme** is also initiated, where the mentor is independent of the supervisor. As part of this programme, we recommend that **more structured guidance be provided to ECRs regarding industry career pathways**. It is widely understood that the majority of PDRAs will work in industry for at least part of their careers, and it is important to support them in exploring the various options available. We recommend the **collection of data about the career pathways of CfCA staff**

outside academia, as well as those within academia, as a means to provide greater awareness of the many career trajectories which can be followed. A scheme of regular presentations from people who have moved to industry could also be valuable.

Equality, Diversity and Inclusivity: The EEC noted that the CfCA does not have its own EDI policies, but adheres to the guidance of the NAOJ, including the target of 18% women at PDRA level. It was noted that the NAOJ advertising of positions which were only open to women did not attract suitable applicants for the CfCA. The EEC welcomed the **compulsory EDI training** for everyone in NAOJ, annually as well as talks from the NAOJ EDI team which aim to increase awareness of EDI issues. The EEC also welcomed the fact that out of the four early career researchers which were interviewed for this report, two were female.

Nevertheless, the EEC noted that the CfCA has only 1 tenured female member of staff and she is only 0.1 FTE for CfCA. There are two female staff on non-fixed-term appointment, and a total of 4 female staff with either tenured or age-limited retirement. We are concerned about the lack of EDI data for applicants for CfCA roles, which makes it more difficult to identify and address potential issues and recommend that the NAOJ ensures that this information is provided to the CfCA in future, in accordance with **ASJ guidance**. In addition, the EEC recommends that the CfCA begin formally monitoring EDI statistics for their user community, staff members and attendees at public events in order to develop a detailed picture of the demographics of the communities they work with.

Once these data are available and baselined, the CfCA should explore ways to improve the gender balance among faculty members, as well as to address any imbalances identified in the user community. In particular, they should introduce additional EDI training as part of the mandatory staff training programme.

Recommendations

1. The CfCA should continue to lead on discussions about possible shared computing services in the future. A stepwise approach to the development of joint services appears to represent a good compromise between seizing the opportunity of deploying larger, shared systems while bearing in mind the potential risks associated with providing services in this way.
2. Work with the user community to explore potential roles for the CfCA computing services in the Japanese computing ecosystem beyond 2030.
3. The CfCA should continue to work proactively to increase their levels of collaboration with other parts of the NAOJ; the NAOJ should also work to remove any barriers to such collaboration.
4. Increase the involvement of the Deputy Director in the decision-making process within the CfCA.
5. Explore routes to increasing the levels of international collaboration across the Japanese computational astronomy community in order to enhance the visibility of Japanese software and simulations and make the support of these tools more sustainable.
6. Consider the expansion of the training programme to include some training aimed at undergraduate level as a means to increase the diversity of ECRs entering the community.
7. Identify gaps in the training programme for ECRs and new users and develop appropriate material to meet these needs.
8. Establish an independent mentoring programme for ECRs to complement the existing supervision programme. This programme should include more guidance regarding career pathways in industry.

9. Collect of data about the career pathways of CfCA staff outside academia.
10. Following the ASJ guidance, the NAOJ should allow the CfCA to access and monitor EDI data on both applicants and appointments on an annual basis in order to establish a baseline of such data and identify any issues.
11. Explore ways to improve the gender balance among CfCA faculty members.
12. The CfCA should introduce additional EDI training as part of the mandatory staff training programme.

Other comments from the EEC

The EEC is pleased to note that the CfCA receives good support from the NAOJ leadership, who understand the value of open-use computing for the astronomy community and have protected the CfCA from some of the recent budget cuts.

The structure of the NAOJ explicitly separates science delivery within the Division of Science (DoS) from the support of open-use computing systems within the CfCA. Given the importance of the CfCA computing systems for the science programme, as evidenced by the high numbers of publications generated, the EEC discussed whether this separation is beneficial for the science programme. In particular, the apparent reduction in the number of simulators in the DoS means that the theoretical astronomy programme is being weakened, relative to the time when there was a separate division of theoretical astronomy. As a mitigation, to maintain current levels of scientific outputs and to strengthen the theoretical astronomy programme, the EEC proposes that the NAOJ increase the proportion of research time for CfCA members.

The EEC is conscious that several of our recommendations would require the allocation of additional funding for the CfCA, in order to increase the number of positions (e.g. to create a dedicated CfCA engineer position) and to allow a greater proportion of research time for CfCA members. However, we consider that the high levels of productivity delivered by the CfCA team strongly justifies an increased share of the available NAOJ budget. The NAOJ also needs to continue making efforts to obtain external funding, including sources such as donations, that could support CfCA activities.

Summary of recommendations for future actions

Review Item 1. Achievement of Establishment Objectives

Recommendations 1-1:

1. Consider allowing joint applications for computing resources as well as individual applications, as a means to encourage larger groups to work together.
2. Continue to solicit, and listen to, feedback from the community and reflect it in future service improvements.
3. The CfCA should begin a programme of engagement with industry partners as soon as possible, to allow for good working relationships to be built up with multiple potential suppliers in advance of the design and deployment of the ATERUI-IV service.
4. The NAOJ should approve the creation of a full-time engineer position whose primary responsibility is for the CfCA systems. This would support both the operation of current services, planning for future services and the development of the industrial engagement programme.

5. The NAOJ should underwrite the risk of energy price increases in order to maintain full operations of ATERUI-III.
6. The CfCA should create and maintain a live risk register for the organization, covering all areas of risk, which can be used for monitoring and planning purposes.

Recommendations 1-2:

1. Explore more open-sourcing of code as a means to increase the international adoption and impact of Japanese-developed software.
2. Consider the creation of a CfCA software hub to support specific codes which would be pre-installed on CfCA services and leverage community effort for support and maintenance.

Recommendations 1-3:

1. The NAOJ should encourage CfCA staff to participate in the delivery of movie presentations by including outreach in CfCA members' formal activities.
2. The CfCA should request the PR division to provide demographic data for audiences at the monthly movie presentations in order to monitor engagement levels from different sectors of society.

Review Item 2. Benchmarking Against Similar Projects

1. Include additional questions in the user survey to understand why user choose CfCA resources as their primary computational service.

Review Item 3. Response to External Feedback

1. The CfCA should be proactive in encouraging their user community to engage with the opportunities and challenges of GPU-based computing in order to prepare them for the future.
2. The CfCA should seek to secure external funding to increase the size of its GPU service. Approaches such as a joint deployment with the NINS could be considered to facilitate this.
3. Increase the number of GPU-focussed workshops in the CfCA training programme and explore ways to increase attendance.
4. The NAOJ should consider the creation of a number of tenured positions for 4D2U staff as a priority, in order to address concerns about staff retention. At least one of these roles should be an engineer position.
5. Advertise 4D2U positions more widely (e.g. to communities in industry) in order to increase the pool of suitable applications.

Review Item 4. Future Plans

1. The CfCA should continue to lead on discussions about possible shared computing services in the future. A stepwise approach to the development of joint services appears to represent a good compromise between seizing the opportunity of deploying larger, shared systems while bearing in mind the potential risks associated with providing services in this way.
2. Work with the user community to explore potential roles for the CfCA computing services in the Japanese computing ecosystem beyond 2030.
3. The CfCA should continue to work proactively to increase their levels of collaboration with other parts of the NAOJ; the NAOJ should also work to remove any barriers to such collaboration.

4. Increase the involvement of the Deputy Director in the decision-making process within the CfCA.
5. Explore routes to increasing the levels of international collaboration across the Japanese computational astronomy community in order to enhance the visibility of Japanese software and simulations and make the support of these tools more sustainable.
6. Consider the expansion of the training programme to include some training aimed at undergraduate level as a means to increase the diversity of ECRs entering the community.
7. Identify gaps in the training programme for ECRs and new users and develop appropriate material to meet these needs.
8. Establish an independent mentoring programme for ECRs to complement the existing supervision programme. This programme should include more guidance regarding career pathways in industry.
9. Collect of data about the career pathways of CfCA staff outside academia.
10. Following the ASJ guidance, the NAOJ should allow the CfCA to access and monitor EDI data on both applicants and appointments on an annual basis in order to establish a baseline of such data and identify any issues.
11. Explore ways to improve the gender balance among CfCA faculty members.
12. The CfCA should introduce additional EDI training as part of the mandatory staff training programme.

Appendix A: List of CfCA Review Documents

From the NAOJ Secretariat:

Applicable **D**ocuments:				
ID	Doc #	Doc Title	File Name	# of Pages
AD01	NAOJ-EEC-CfCA-001-A	List of the External Evaluation Committee (EEC) Members	[AD01] EEC_Members_List_ FY2024_CfCA_Review..pdf	1
AD02	NAOJ-PROJECT-30-A	Scientific Goals and Missions – Center for Computational Astrophysics (20220819)	[AD02] NAOJ-PROJECT-030-A_CfCA_2022-08-19.pdf	4
AD03	NAOJ-EEC-CfCA-002-A	FY2024 NAOJ Project Review: Review Charges of the CfCA	[AD03] ReviewCharges_CfCA_20250114.pdf	3
AD04	NAOJ-EEC-CfCA-003-B	External Evaluation of Center for Computational Astrophysics (CfCA), NAOJ- kick-off meeting -	[AD04] CfCA Reivew overview (20250114 kick-off meeting)_rev.pdf	21
AD05	NAOJ-EEC-CFCA-009-A	2024 JFY NAOJ Project Review Plan for CfCA	[AD05]EEC-CfCA_Review_Plan.pdf	11

Reference **D**ocuments				
ID	Doc #	Doc Title	File Name	# of Pages
RD01	NAOJ-RESO-0009-A	国立天文台平成29年度プロジェクト評価報告書　天文シミュレーションプロジェクト（平成30年2月）	[RD01] FY2017 NAOJ Project Review Report - CFCA - NAOJ-RESO-0009-A(20180726).pdf	9
RD02	NAOJ-EEC-CfCA-004-A	FY2017 NAOJ Project Review Report - Center for Computational Astrophysics (English Version) February 2018	[RD02] FY2017 NAOJ Project Review Report - CFCA - NAOJ-RESO-0009-A(20180726)-E.pdf	10
RD03	NAOJ-EEC-CfCA-006-A	Source: Annual Report of the National Astronomical Observatory of Japan FY2018-2023	[RD03] Annual_Report_of_CfCA_2018-2023e.pdf	18
RD04	NAOJ-EEC-CfCA-007-A	出典：国立天文台年次報告 2018-2023年度	[RD04] Annual_Report_of_CfCA_2018-2023j.pdf	19

From the CfCA

Deliverable **D**ocuments				
ID	Doc #	Doc Title	File Name	# of Pages
DD01	NAOJ-EEC-CfCA-005-A	Exploring the Universe by the Next-Generation Simulations (From NAOJ Future Planning Symposium 2024; 2024.12.06)	[DD01] NAOJFutureSympo2024-Kokubo.pdf	35
DD02	NAOJ-EEC-CfCA-008-A	CfCA FY2023-2024 Overview (From FY2024 CfCA Users' meeting; 2024.11.25)	[DD02] CfCAUM2024-Kokubo.pdf	16
DD03	NAOJ-EEC-CfCA-010-B	2nd version CfCA Publication List as of Feb 17, 2025	[DD03] CfCA_publication_list_v2.pdf	2
DD04	NAOJ-EEC-CfCA-011-C	2nd version CfCA Members List as of Feb 17, 2025	[DD04] CfCA_members_v3.pdf	2
DD05	NAOJ-EEC-CfCA-012-B	CfCA Budget Report as of Feb 15, 2025	[DD05] CfCA_budget_v2.pdf	6
DD06	NAOJ-EEC-CfCA-013-B	CfCA Open-Use Computer System	[DD06] CfCA_computer_system_v2.pdf	39
DD07	NAOJ-EEC-CfCA-014-A	CfCA School Meeting as of Feb 17, 2025	[DD07] CfCA_school_meeting.pdf	1
DD08	NAOJ-EEC-CfCA-015-A	International Visitors of CfCA as of Feb., 2025	[DD08] CfCA_visitors.pdf	2
DD09	NAOJ-EEC-CfCA-016-B	Four-Dimensional Digital Universe (4D2U) Project	[DD09] CfCA_4D2U_v2.pdf	18
DD10	NAOJ-EEC-CfCA-017-B	Human Resources of CfCA as of Feb., 2025	[DD10] CfCA_HR_v2.pdf	4
DD11	NAOJ-EEC-CfCA-018-B	External Evaluation: Center for Computational Astrophysics National Astronomical Observatory of Japan / National Institutes of Natural Sciences Review Data Package 27-28 February 2025	[DD11] CfCA_review_v2.pdf	36
DD12	NAOJ-EEC-CfCA-019-A	The World's Largest Simulated Universe	[DD12]CfCA_press_release.pdf	5
DD13	NAOJ-EEC-CfCA-020-A	Proposal for NAOJ Science Roadmap	[DD13] research_plan_proposal_cfca.pdf	12
DD14	NAOJ-EEC-CfCA-021-A	Summary of User Survey (FY2024)	[DD14]CfCA_user_survey.pdf	16

Presentation Slides				
ID	Doc #	Doc Title	File Name	# of Pages
PS01	NAOJ-EEC-CfCA-022-A	Center for Computational Astrophysics External Evaluation for FY2018-2024	[PS01] External_Evaluation_FY2024.pdf	69
PS02	NAOJ-EEC-CfCA-023-A	Four-Dimensional Digital Universe (4D2U) Project	[PS02] 4d2u.pdf	22

Appendix B: CfCA Review Meeting timetable

Day 1 Date: Thursday, 27 February 2025 9:00-17:20 Place: Large conference room, Mitaka Campus at NAOJ	
◆Advance Meeting (closed)	
09:00 - 09:30	EEC meeting
◆Mutual Introductions (open)	
09:40 - 10:00	Introduction of the project members to the EEC; Introduction of the EEC members to the attendees and of the agenda of this Review meeting.
◆Presentation from CfCA (1) (open)	
10:00 - 11:05	Presentation from the project: CfCA Overview +Q&A
11:05 - 11:15	(Break)
11:15 – 12:00	Presentation from the project: CfCA Overview +Q&A (continued)
12:00 – 13:00	(Lunch Break)
◆Presentation from CfCA (2) (open)	
13:00 - 14:22	Presentation from the project for Review Item **[1]** , **[2]** +Q&A
14:22 - 14:32	(Break)
14:32 - 15:20	Presentation from the project for Review Item **[2]** , **[3]** +Q&A
15:20 - 15:30	(Break)
◆Interview with CfCA Users (Closed)	
15:30 - 16:00	Group Interview with early career users (4 PhD students)
16:00 – 16:10	(Break)
16:10 - 16:50	Personal Interview with 2 senior users
◆Discussion (Closed)	
16:50 – 17:20	EEC discussion

Day 2 Date: Friday, 28 February, 2025 9:00-17:00 Place: NAOJ Mizusawa Campus, Main Building, Conference Room 309 (3F)

◆Presentation from CfCA (3) (open)	
09:00 - 10:35	Presentation from the project for Review Item **[3], [4],** 4D2U +Q&A
10:35 - 10:45	(Break)
10:45 – 11:15	EEC discussion (Closed)
11:15 - 12:00	Presentation from the project for **EDI** report +Q&A
12:00 - 13:00	(Lunch Break)
◆Campus Tour	
13:00 – 14:30	CfCA Mitaka Computer Room and the 4D2U Theatre
14:30 – 14:35	Group Photo (in front of the 4D2U Theatre)
◆Interview with CfCA (Closed)	
14:40 - 14:55	Interview with System Astronomer
14:55 – 15:00	(Break)
15:00 – 16:00	Interview with Director
◆Discussion (Closed)	
16:00 - 16:45	EEC discussion
◆Closing (Open)	
16:45 - 17:00	Executive Summary (Briefing to the project members)

Note:
*Review Style: “open” all members of the project are welcome; “closed” invitation-only (by EEC).

Review Items
[1] Achievement of Establishment Objectives
[2] Benchmarking Against Similar Projects
[3] Response to External Feedback
[4] Future Plans

Appendix C: Questions asked to interviewees during panel meeting

In order to absorb the opinions of a wide range of interested parties on the current status and future direction of the project, the EEC conducted interviews with a group of four ECRs via Zoom and in-person during the first day of the in-person meeting. The questions asked were:

1. Please describe your experience of using CfCA computing resources and/or working with CfCA colleagues. What have been the highlights (scientific or technical) of this engagement?
2. Have there been any challenges in accessing resources (either hardware/software or expertise/people)?
3. What are the key strengths of the CfCA?
4. Are there areas in which you think the CfCA could be improved?
5. What activities and services do you think the CfCA should focus on over the next five years?
6. Why do you choose CfCA computer resources among a variety of Japanese resources like HPCI?
7. Do you get all the time you ask for?
8. Do you write proposals yourself?

Appendix D: Questions asked to external stakeholders

The following questions were asked to a set of external stakeholders by e-mail:

1. Please describe your experience of using CfCA computing resources and/or working with CfCA colleagues. What have been the highlights (scientific or technical) of this engagement?
2. If you have used CfCA resources for your research:
   a. why did you choose CfCA computer resources among a variety of Japanese and international resources?
   b. Have there been any challenges in accessing resources (either hardware/software or expertise/people)?
3. If you have not, was there a reason why you chose not to?
4. What are the key strengths of the CfCA and how does it compare with similar organisations internationally?
5. Are there areas in which you think the CfCA could be improved?
6. What activities and services do you think the CfCA should focus on over the next five years?

Appendix E: Names of stakeholders consulted

The EEC would like to thank the following colleagues for their time and input to this review process:

Shun Hatano - GUAS
Dr. Tomoaki Ishiyama - Chiba University
Koki Kin - Tohoku University
Ayano Komaki – Tokyo University
Prof. Tomoaki Matsumoto - Hosei University
Erika Nishio - Tohoku University
Prof. Simon Portegies-Zwart – Leiden University
Dr. Yuki Yoshida - Kobe University