Issue 2 | August 3, 2022

Mirinae

미리내 The Milky Way

TABLE OF CONTENTS

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Breaking the limits of telescopes: the GRAVITY revolution

Frank Eisenhauer, Gruber Prize Winner

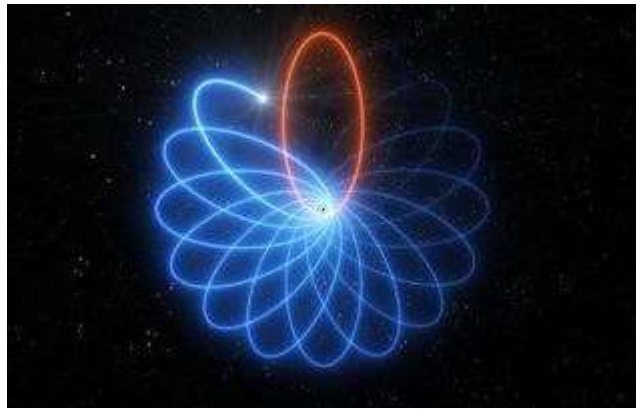
The 2022 Gruber Cosmology Prize recognizes Frank Eisenhauer of the Max Planck Institute for Extraterrestrial Physics for the revolutionary design of instruments that collected seemingly irrefutable evidence for the existence of a black hole at the center of our Galaxy. The citation honors the "unprecedented and exquisite" precision of his instrumentation.

In 2018, the GRAVITY experiment traced the behavior of various phenomena near Sagittarius A*, or Sgr A*, a supermassive and therefore gravitationally voracious, invisible object near the center of our Galaxy. Thanks to Eisenhauer's technical innovations, the GRAVITY team found that the orbit of stars and gas near the Galactic center matches theoretical predictions consistent with the existence of a black hole. Eisenhauer's mentor and longtime collaborator Reinhard Genzel shared the 2020 Nobel Prize in Physics with Andrea Ghez and Roger Penrose for his contributions to work on Sagittarius A* (Sgr A*).

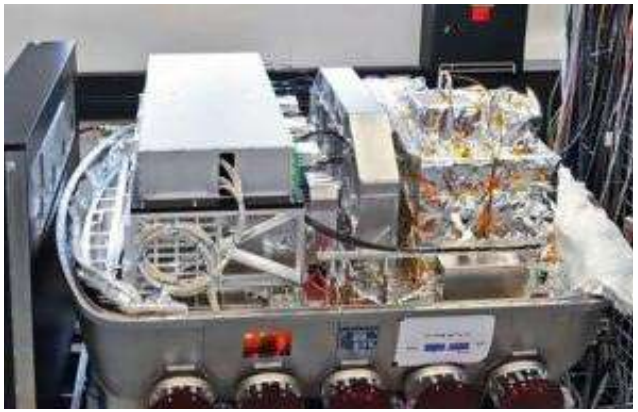
GRAVITY had its basis in an earlier experiment on which Eisenhauer developed breakthrough technology in imaging spectroscopy—the measurements of how matter affects the absorption and emission of light. The instrument is part of the Spectrograph for INtegral Field Observations in the Near Infrared (SINFONI) at the European Southern Observatory's Very Large Telescope on Mount Paranal in Chile. It includes an adaptive optics system to correct the image blur from the Earth's turbulent atmosphere developed under the lead of Henri Bonnet. In 2003, SINFONI began observing stars operating under the great gravitational influence of Sgr A* as they execute their exceedingly rapid, highly eccentric orbits.

Two years later the group of German and French researchers around Eisenhauer and Genzel, Stefan Gillessen, Pierre Lena, Guy Perrin, and Thibaut Paumard began discussing an opportunity to observe an upcoming event involving one of those stars, S2. Having measured a precise orbit of S2 after the first peri-passage in 2002, they could now calculate that in 2018 the star would reach the part of its orbit where it would again pass closest to Sgr A*, a distance of only 17 light-hours. Combining the observing power of all four 8-meter telescopes at Paranal (through a process called interferometry) meant that the experiment could achieve the necessary thousandfold improvement in sensitivity over earlier interferometers necessary to resolve the resulting relativistic effects.

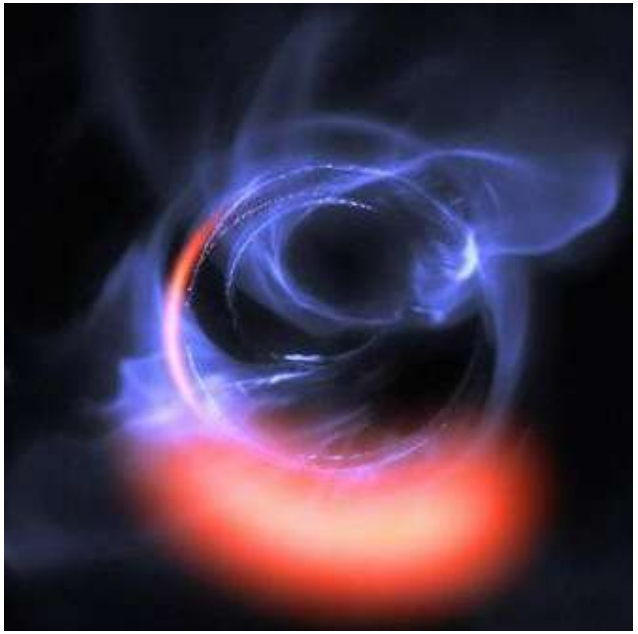
Frank Eisenhauer at the Paranal Observatory in Chile in 2018 when the gravitational redshift in the Galactic Center black hole was discovered. Credit: ESO



Observations have revealed for the first time that a star orbiting the supermassive black hole at the centre of the Milky Way moves just as predicted by Einstein's theory of general relativity. Its orbit is shaped like a rosette and not like an ellipse as predicted by Newton's theory of gravity. This effect, known as Schwarzschild precession, had never before been measured for a star around a supermassive black hole. This artist's impression illustrates the precession of the star's orbit, with the effect exaggerated for easier visualisation. Credit: ESO/L. Calçada



View of the GRAVITY instrument during construction. To the left of the image, the connections for the beam lines from the four VLT telescopes are visible. © MPE



Orbital motion of gas around the black hole This visualization uses data from simulations of orbital motions of gas swirling around at about 30% of the speed of light on a circular orbit around the supermassive black hole Sagittarius A*. Credit: ESO/Gravity Consortium/L. Calçada

"This project was seen by some as technically impossible," wrote one nominator for this year's Gruber Cosmology Prize. Advocates for the project, however, argued that even if the experiment didn't reach its goals, any technological advances would have broader benefits. In particular, Tim de Zeeuw and Andreas Kaufer at the European Southern Observatory supported the bold project and the team around Julien Woillez to upgrade the interferometer. Eisenhauer's designs did indeed wind up revolutionizing several kinds of instrumentation, including imaging detectors, laser metrology, and dual-beam operations.

The GRAVITY collaboration consisting of the Max Planck Institute for Extraterrestrial Physics, LESIA at the Paris Observatory, IPAG at the University Grenoble, the Max Planck Institute for Astronomy, the University of Cologne, the Center for Astrophysics and Gravitation in Portugal, and the European Southern Observatory completed the instrument with barely a year to spare, and the initial results, as one nominator wrote, "can only be described as astounding and ground-breaking for many fields of astrophysics."

Those results include: precise measurements of Sgr A*'s general relativistic influence on S2; as well as observations of gas orbiting close to the "last stable orbit"—the point before which it succumbs to the gravitational tug of Sgr A* and disappears from sight forever. Together this data provides enough evidence to satisfy the astronomical community that Sgr A* is indeed a black hole.

Among GRAVITY's other significant contributions to astronomy: A determination of the distance between the Sun and the Galactic center at a level of precision ten times greater than previous measurements (a calibration that other astronomers will use as a reliable first step in tracing the evolution of the universe on the largest scales). A test of Einstein's general relativity using supermassive black holes at the highest level of precision to date.

As GRAVITY's advocates hoped, Eisenhauer's innovations in technology—the ones for which he is receiving the 2022 Gruber Prize in Cosmology—have changed astronomy beyond just the study of Sgr A*. Other astrophysicists have already begun using SINFONI and GRAVITY instrumentation to study distant star-forming galaxies, black holes at the centers of nearby galaxies, and planets orbiting stars within our own Galaxy.

Eisenhauer will receive the $500,000 award as well as a gold laureate pin at a ceremony that will take place on August 2 at the XXXIst General Assembly of the International Astronomical Union in Busan, Korea. Previous honors for Eisenhauer include the Tycho Brahe Medal of the European Astronomical Society for his leadership of the SINFONI and GRAVITY instruments, the Stern-Gerlach Medal of the German Physical Society for his pioneering work in high-resolution infrared astronomy, and the Jackson-Gwilt Medal of the Royal Astronomical Society for the development of astronomical instrumentation. He was elected to the French Academy of Sciences.

The G RAVITY interferometer was installed at the VLTI in 2015, and has been in operation since 2016. © ESO/MPE

Astronomy in Cyberspace

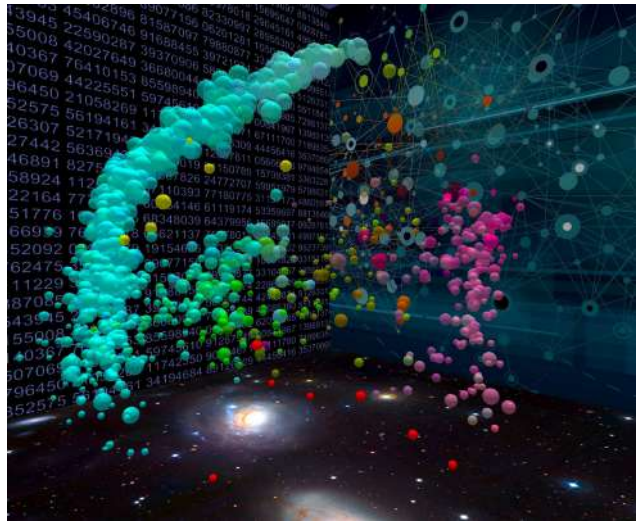
S. G. Djorgovski, S368 plenary speaker

My professional interests started in extragalactic astronomy and cosmology. They included studies of the most distant galaxies known at the time, the first glimpses of galaxy evolution, gravitational lenses and binary quasars, fundamental properties of elliptical galaxies (e.g., the Fundamental Plane correlations and their implications), etc. I also worked on the structure, dynamics, and stellar populations in globular clusters, including the discovery of collapsed cores. Later on, I worked on the studies of gamma-ray burst afterglows and their host galaxies, including the first spectroscopic demonstration of their cosmological nature, properties of the dark energy, and the approach to the reionization era, etc. More recently, I have been working on the exploration of the Time Domain using large synoptic sky surveys, and studies of AGN variability in particular, including the changing look quasars, possible supermassive black hole binaries, and other interesting phenomena. In all of that, I was fortunate to work with many excellent collaborators, too numerous to list in this short contribution, but they deserve most of the credit for these discoveries and results. It was a lot of fun.

Starting in the early 1990s, my attention turned to the advent of 'big data' astronomy, prompted by the first large digital sky surveys. That led to the establishment of Virtual Observatory framework, but also introduced us to the applications of Machine Learning tools for the exploration and analysis of these exponentially growing data sets and data streams. That naturally led to the development of Astroinformatics as a major component of the scientific methodology for the era of growing data abundance.

In my presentation, I will provide a brief overview of the use of Machine Learning tools in astronomy, starting from the early applications for star-galaxy separation in sky surveys and photometric redshifts, to a remarkable and growing spectrum of other applications and use cases today, with the number of publications growing exponentially. Machine Learning and other aspects of AI are now necessary tools for data-rich astronomy, as well as in any other scientific discipline. I will also review some of the currently promising and/or fashionable methods, mostly based on Deep Learning. Finally, I will address the rise of the AI tools and methods that are leading us to a genuine human-computer collaborative discovery and offer some speculations about the future.

My key scientific interests are now in understanding how computing and information technologies are changing science, scholarship, and education. These technologies have profoundly changed the world and just about any human endeavor. This poses some interesting sociological challenges for academia as well since our institutions and traditional ways of doing research and teaching are developing much more slowly than these enabling technologies. Our present is interesting and challenging, and the future will be even more so.



A schematic illustration of the intersection of astronomy, big data, and machine learning. Credit: S. G. Djorgovski, Caltech.

A roller coaster into the IAU's second century:

reflections by the IAU Past-President

Ewine F. van Dishoeck, Former IAU President

On August 26 2021, I stepped down as your IAU President at what was the first-ever virtual GA Business session. Now, nearly a year later, we are finally here together at the actual GA in beautiful Busan and have the pleasure of seeing and hearing each other in person again. Annyeonghaseyo, mannaseo bangabseubnida! I have been asked to briefly reflect on the 2018-2021 period. What a rollercoaster triennium it was, plunging from the peak of the IAU 100 years celebrations in 2019 down to the onset of the global pandemic in early 2020, and finding a new equilibrium and way of working together ever since.

The overarching guide for the IAU's activities is the Strategic Plan 2020-2030, written together with now President Debra Elmegreen and approved at the GA 2018 in Vienna. Significant progress has been made on its implementation, thanks also to the hard and capable work by past general secretaries Teresa Lago and Piero Benvenuti. Most notably, the IAU now has four well-functioning Offices, those for young astronomers (OYA), development (OAD), outreach (OAO), and education (OAE), with each of them having their Regional Offices and national contacts. This family of Offices is proving to be an increasingly strong and global network. Other achievements include the revival of the global coordination of ground and space astronomy working group, the establishment of the junior member category, and the strengthening of actions to make our field more diverse and inclusive.

To deliver on its mission and the ambitions set out in the Strategic Plan, the IAU needs to reach new audiences who can support it beyond what the annual resources from its member states enable it to do. Fundraising has therefore become a growing activity with a number of significant successes in this triennium. Most notably, new funding has enabled the annual Shaw-IAU education workshops, the new IAU Hands-On workshops to train young astronomers in the use of large and complex data sets, an annual multidisciplinary Kavli-IAU symposium, support for the CAP conference, and coordination of the annual Women and Girls in Astronomy week.

Undoubtedly, the 2019 IAU 100th anniversary celebrations were the highlight of the triennium. As President, it was my privilege to help develop and experience them. A goal of IAU100 was to show not just to our fellow scientists, but also to policy makers, teachers, educators and the general public what a century of astronomical discoveries has brought to society. It also allowed to reflect on its future. The IAU100 theme "Under One Sky" emphasized the global nature and the role that the IAU plays in bringing people together. It was a very busy year: IAU100 hosted over 5000 activities that engaged over 100 million people in 143 countries. High points included the Flagship meeting in Brussels on "Astronomy with and for society", the "Above and Beyond" exhibition in 75 countries, the "NameExoWorld" contest across the world, and two books describing the IAU's history. I highly recommend browsing through the beautifully conceived IAU100 Final Report to get an impression. IAU100 ended with the 30 year celebration of the iconic "Pale Blue Dot" picture, driving home the message to society, especially children, that

Opening of the IAU100 exhibition "Above and Beyond" at the GA 2018 in Vienna (credit IAU/M. Zamani).

Alternative: Group photo from the 100 years Under One Sky Celebration Flagship Ceremony in Brussels April 11-12 2019 (credit IAU/Babak Tafreshi).

IAU meetings in Covid times: IAU symposium 367 took place fully online in December 2020 (Credit: IAU/B. Garcia).

our planet is small and fragile in space and that we should take well care of it.

Just weeks later, the pandemic hit, turning everyone's life upside down and causing hardships across the globe. Office and scientific meetings moved online, with the advantage that researchers from around the world could join and present their work at almost no cost. Indeed, some IAU Commissions held very successful virtual meetings: they have the right size (few hundred people) and focus to do so. My strong recommendation is that Commissions continue such virtual meetings regularly, especially to give young scientists a platform. However, most IAU-sponsored symposia chose to postpone until they can be in-person, offering the benefits of people getting to know each other and triggering new ideas and collaborations through unstructured discussions. Hybrid meetings now seem the new norm, also for environmental reasons, but how well they will work for large intercontinental meetings like the GA with thousands of participants is yet to be explored.

As with any organization, new challenges emerge at any time. The IAU's mission includes protection of the dark and radio-quiet skies. During 2019, it became clear that our skies are now being threatened not just by huge increases in urban lighting and radio interference due to telecommunication, but notably by the launch of swarms of small satellites. The IAU and its partners organized major online workshops in 2020 and 2021 resulting in a detailed report that describes the impact of human activities and makes recommendations for mitigating actions. This includes pushing the issue at the UN Committee on the Peaceful Uses of Outer Space (COPUOS). The IAU subsequently issued a call to establish a new "Centre for the Protection of the Dark Sky from Satellite Constellation Interference" to coordinate actions internationally; the selection of the Centre was announced in early 2022.

I ended my online speech last year with bubbles. Thanks to Covid, everyone is familiar with the concept of bubbles: small groups of people that only interact with each other but not with rest of the world. Alas, they are becoming more common in science and society, whether at the national, regional and/or scientific topic level. The importance of the IAU, and especially its General Assembly, is that it takes you outside your bubble, giving you the full perspective of the field and letting you make worldwide connections. With an increasing number of conflicts around the world, such international relations are more important than ever to build respect, trust and support for each other.

Hence, let's uncork some bubbles to the IAU as it embarks on its next century, and let me quote the African-American abolitionist and activist Harriet Tubman (1822-1913): "Every great dream begins with a dreamer. Always remember, you have within you the strength, the patience and the passion to reach for the stars to change the world." Unlocking this strength in everyone through "Astronomy for All" (the GA 2022 motto!) is exactly what the IAU aims to do.

A million thanks to my fellow Officers, Office, Vice and Division Presidents, IAU100 team, and IAU family of Offices for a great triennium!

The IAU, a vibrant organisation

Teresa Lago, Former IAU General Secretary

My tenure as General Secretary (September 2018-2021) was very exciting. It covered the implementation of the IAU's first global Strategic Plan 2020-2030 and included notable events in the life of the Union such as: - Centennial celebrations through more than 5,000 activities involving several million people in 140 countries; - The creation of the new IAU Office of Astronomy for Education (OAE) - the enthusiastic response to the international call for partnership (October 2018) led to the agreement with the Max Planck Society for the Advancement of Science signed within one year, and to the start of the OAE activities in January 2020. This three-year period was also marked by the consolidation of the IAU's international collaboration through its other offices, namely - The revision of the agreement with the Norwegian Academy of Science and Letters (2019) which resulted in a substantial update of the Office of Young Astronomers (OYA); - The revision of the agreement with the National Astronomical Observatory of Japan, leading to a profound restructuring and improvement of the Office of Astronomy Outreach (OAO); - The review of the agreement with the National Research Foundation of South Africa for the Office of Astronomy for Development (OAD).Regardless of whether they pursue ambitious programmes tailored to their specific missions, the four IAU Offices now have a similar structure and coordinate an incredible worldwide network of regional nodes and hundreds of national teams in over 100 countries. Another major achievement in the triennium was the creation of Catalyst (2019), a new concept for the IAU Bulletin revived after a long hiatus. Catalyst is intended to be a tool for direct communication between the various structures and members of the IAU, and with other international scientific organisations. The period 2018-2021 was also an intense period for key management initiatives essential in an international organisation. Relevant missing policy documents were prepared, and others completely revised: - The Rules and Guidelines for Scientific Meetings, a concise document that replaces an earlier set of rules with many gaps and duplications; - Rules and Procedures for IAU missions; - The IAU Code of Conduct, including hectics and anti-harassment; - The IAU Communication Policy guidelines. Other successes include: - The exhaustive review of the IAU Website (structure and contents) valuing the institutional brand; - An agreement with the CNRS-INSU resulted in the free hosting of the IAU Office by the Institut d'Astrophysique de Paris; - Changing the application process for individual members that have become annual since 2019. The triennium was also very successful in the relationship with sponsoring organisations: the Kavli Foundation, the Gruber Foundation and the Shaw Prize Foundation, which since 2019 has financed the annual Shaw-IAU Workshop on "Astronomy for Education" organised by the OAE. Of course, this triennium was also unique due to the pandemic and its impact on our lives and practices. For the IAU, which is all about cooperation, networking, knowledge-sharing and public engagement, it was a huge challenge: the Paris Office was closed for some time, most scientific meetings and other activities planned for 2020 were postponed, or cancelled, including the XXXI General Assembly, with the exception of the business sessions held in virtual format (August 2021). Even so, the IAU did not stop and reacted to the circumstances in order to fulfil its mission. We know that the IAU was created in difficult times. We also know now that it is capable of continuing and even making great strides in very difficult and unusual circumstances. The IAU is indeed an impressive and vibrant organisation!

Cover of 1st Catalyst (The IAU Catalyst — a Revival of the IAU Bulletin)

A group photo of signing the agreement for hosting the IAU OAE by the Max Planck Institute for Astronomy, during the 1st IAU-Shaw Workshop in Paris, December 2019 (see IAU Office of Astronomy for Education Agreement Signed during the 1st IAU–Shaw Workshop)

Focus Meeting 8

Planetary Astronomy via Telescopic and Microscopic Approaches

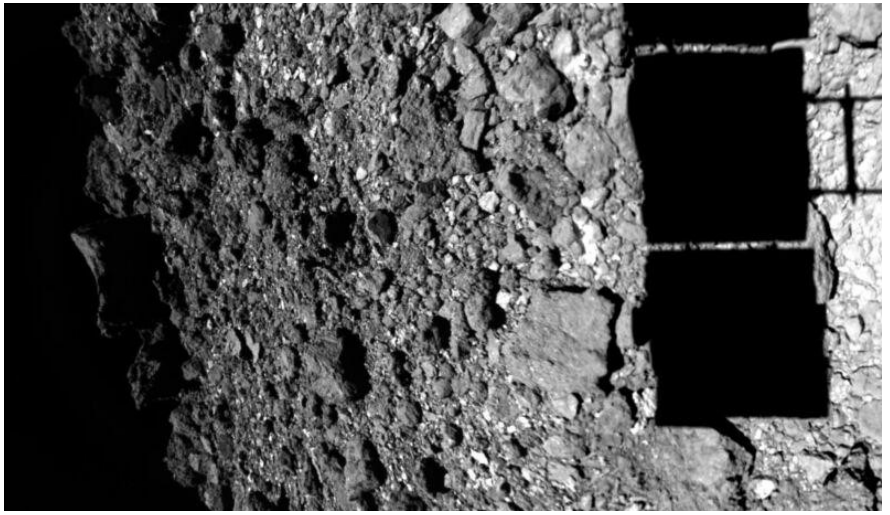
Focus Meeting 8: Planetary Astronomy via Telescopic and Microscopic Approaches	
START DATE	Tuesday, 2 August
END DATE	Wednesday, 3 August
ORAL SESSIONS	Room 106, Convention Hall, 1st Floor
POSTERS	e-Poster Zone, Convention Hall, 3rd Floor

For details on presenters, topics, and times see the online program on the GA website

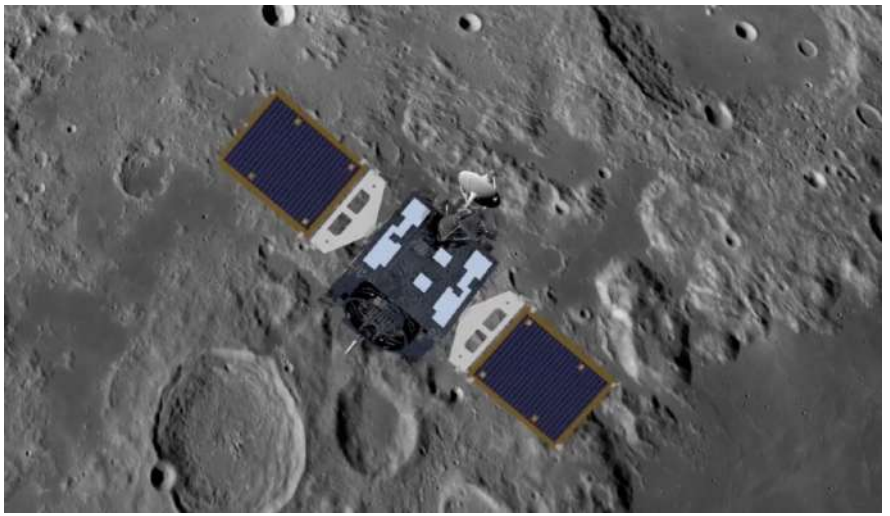
The Solar System research is on course to a new frontier with cutting-edge technologies lifting its sophistication to unprecedented levels. Advanced telescopes and microscopes have presented a closer-than-ever look at distant celestial bodies that are still shrouded in mystery. And we are now seeing a layer of the mystery peel off when materials brought by sample-return missions are analyzed.

The Focus Meeting 8 (FM8), set to take place as part of the IAU GA 2022 in the Republic of Korea, will review recent achievements and findings in this field and discuss issues that need to be explored in the coming decades. It will put together planetary astronomers around the world who study their targets with a wide range of sizescales using various techniques. They will share their latest findings and ideas for future missions, setting the stage for young researchers in related fields and students to think about the uniqueness of our planetary system and the origin of life as we know it.

Broadening the lens and studying other solar systems are critical to construct 'comprehensive references for distant worlds.' And doing so is getting easier and technically guided thanks to increasingly sophisticated instruments. In other words, we are making progress and growing sophisticated in Solar System research with telescopes and microscopes, and we are about to establish a new frontier in research linking the Solar System, exoplanets, planet-forming regions, and astrobiology. It was



The surface of Ryugu as Hayabusa2 made its approach (ISAS)



An artist's impression of the Korean Pathfinder Lunar Orbiter at the Moon (KARI)

something unthinkable five decades ago when the first human landed on the Moon. But it's no longer the case. The planetary science community has grown tremendously, surveying small Solar System bodies by telescope, sending spacecraft to all major planets, and sending spacecraft to some smaller Solar System bodies. These celestial bodies, once considered unreachable, are now visited and investigated by spacecrafts and their onboard instruments. The research targets in planetary science have downsized significantly from kilometer to submicron, or even smaller. Theoretical approaches such as light scattering models for understanding the observational data have similarly improved in sophistication.

In addition, a series of sample return projects will enable us to build a link between telescopic and microscopic approaches. Starting with the Stardust and Hayabusa missions, planetary scientists are now analyzing extraterrestrial materials in the laboratory, under the microscope and at nanoscale. While Hayabusa2 brought collected samples to the Earth in 2022, OSIRIS-Rex will return with carbonaceous materials from their target asteroids in 2023. They will provide the first opportunity to analyze pristine minerals and organic materials in the laboratory.

The sessions of the Focus Meeting will focus on the following:

- Planetary science with ground-based and spaceborne surveys, Hayabusa2 and OSIRIS-REx
- Remote sensing observations, Rosetta, Dawn, and other missions
- Celestial bodies under the microscope, sample analyses for space missions, laboratory studies with microscopes, and organic matter in small bodies
- Interdisciplinary science, extrasolar planetary systems, and future projects

HONG-KYU MOON, is a planetary astronomer at Korea Astronomy and Space Science Institute, South Korea and the Chair of IAU Focus Meeting 8.

MASATERU ISHIGURO, is a professor at Seoul National University, South Korea and the Co-Chair of IAU Focus Meeting 8.

ANTONELLA BARUCCI, President of Division F Planetary Systems and Astrobiology, is an astronomer at Paris Observatory involved in many space mission and at present PI of the MIRS instrument of the JAXA MMX mission.

RICARDO GIL-HUTTON, is a professor at San Juan National University, Argentina, and Vice-president of IAU Commission F4.

Focus Meeting 9

Stellar Synthetic Spectra to Study Stellar Populations in the Era of Gaia

The goal is to assemble the community that has made significant advances in the last ten years in the field of model atmospheres, in the modeling of stellar spectra and the use of synthetic spectra to interpret the observations of stars in the Galaxy and in the Local Group galaxies. Our focus meeting is particularly timely since our community will be involved in the analysis of a plethora of upcoming ground and space-based observations obtained using sophisticated instruments such as the next generation ESO instruments 4MOST and MOONS or NIRSpec on board of the James Webb Space Telescope.

Focus Meeting 9: Stellar Synthetic Spectra to Study Stellar Populations in the Gaia Era	
START DATE	Tuesday, 2 August
END DATE	Wednesday, 3 August
ORAL SESSIONS	Room 109, Convention Hall, 1st Floor
POSTERS	e-Poster Zone, Convention Hall, 3rd Floor

For details on presenters, topics, and times see the online program on the GA website

The meeting is in memory of Fiorella Castelli who greatly contributed to the field.

Among the questions that we wish to tackle are: What developments do we need for non-LTE modeling? What developments do we need for 3D model atmospheres? What are the best ways to scale up these methods and compute large grids of model atmospheres and synthetic spectra, to meet the needs of modern stellar surveys ? What are the best ways to validate the realism of synthetic spectra and colors? What is the role of relatively small samples of stars with extremely high quality observations, in the era of large surveys? What are the best ways to extract astrophysical information from extremely large collections of data?

One of the peculiarities of this focus meeting is that there are no invited talks. We decided to experiment this format since we felt that too often younger scientists are not given enough space in international meetings, given the small fraction of time often reserved to contributed talks. We consider our experiment has been a success, we have 25 talks, two e-talks and seven e-posters. Of the 25 talks 10 will be delivered by PhD candidates. We do not have the data “years after PhD” to make a proper statistics, but from personal acquaintance we can say that the younger scientists are well represented, quite likely more than they would have been if we had decided to invite speakers, several of which would have been “not-so-young”.

The topics covered are very diverse and stimulating ranging from the recent efforts in 3D simulations of stellar atmospheres and related spectrum synthesis to kinetic equilibrium computations (non-local thermodynamical equilibrium) to the use of stellar spectra in a cosmological context to the results of large spectroscopic surveys. The talks provide a good sample of theory and practice and we hope they will provoke interesting discussions and spin off new collaborations. We hope to see many people drop by and follow the talks of FM 09!

Piercarlo Bonifacio is Research Director of CNRS at GEPI department of Observatoire de Paris (PSL University) and French PI of the WEAVE multi-object instrument on the WHT.

Swetlana Hubrig is an emeritus researcher at the Leibniz-Institut für Astrophysik Potsdam (AIP) and the former head of its Stellar Physics and Stellar Activity section.

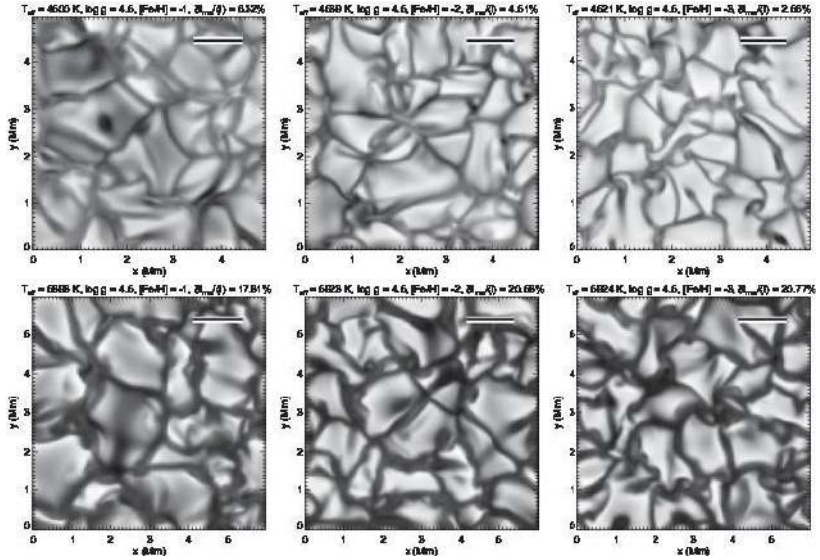


Figure 1
Tremblay et al. 2013, A&A 557, A7. Emergent bolometric intensity for dwarfs at different metallicities. In the first row, Teff = 4500 K, log g = 4.5, and [Fe/H] = – 1, – 2 and – 3 (from left to right). In the second row, Teff = 5900 K, log g = 4.5, and [Fe/H] varies again from – 1 to – 3. © Astronomy & Astrophysics

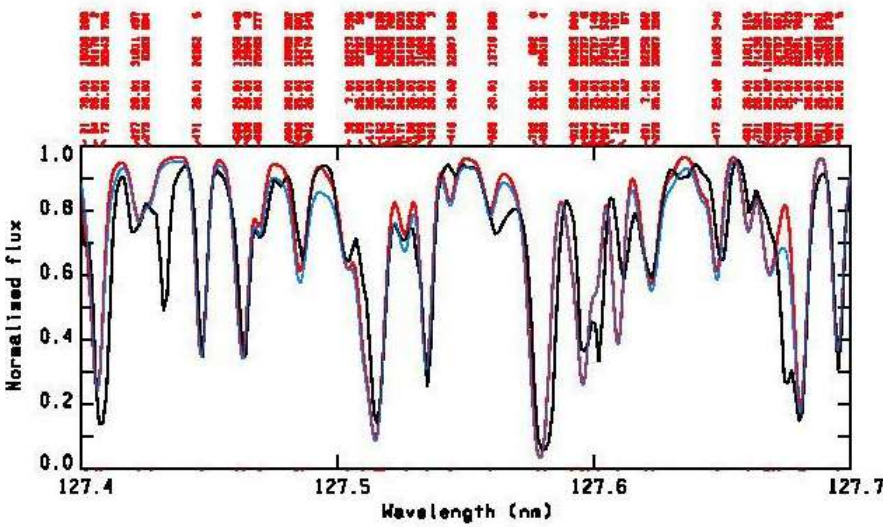


Figure 2
Castelli et al. 2017, A&A 601, A119. A portion of the STIS-HST spectrum of the Bp star HR6000, N I lines of UV mult. 4 at λλ 1492.625, 1492.820, and 1494.675 Å (black), compared to a spectrum synthesis (red). © Astronomy & Astrophysics

Symposium 368

Machine Learning - Possibilities and Pitfalls

Symposium 368 of the IAU GA in Busan from Aug 2 to 4 2022 revolves around machine learning in astronomy, in particular the potential it has created to solve many problems in astronomy, but also the possible problems that can be encountered when applying these often black-boxy techniques without proper care.

We received overwhelming support with close to 450 astronomers wanting to attend the symposium in person, and about 100 submitting abstracts for presentations. We have tried to select representative presentations from across the spectrum, and the talks cover theory, simulations, applications, interpretations and are on datasets from the Solar System to Galactic to extragalactic astronomy to cosmology.

There were many more deserving abstracts that had to be converted to e-talks and e-posters. The e-talks will be available throughout, and the e-poster presenters will have short windows during the main conference to advertise their posters. We have ensured that we have kept ample time for discussion through various panels on topics like GW/MMA, broader ML, and fusion of large datasets in which all attendees will be able to participate.

The invited talks cover several related topics going into more details of aspects like existing datasets for machine learning in astronomy (Renee Hlozek), physics informed ML for exoplanet surveys (Eric Ford), tools for outreach and education (Ivy Wong), as well as overviews like ML in astronomy (Michelle Lochner), and more generic tutorials on ML for the broader community (Sara Webb), and classic ML techniques (Guillermo Cabrera-Vivas).

The plenary talks will address the trends and challenges in deep learning (Ofer Lahav), and the path to collaborative Human-AI learning (George Djorgovski).

The challenges that ML is facing include the lack of interpretability and explainability. On another level not many techniques allow for proper uncertainty quantification. While we do not expect the symposium to solve these big problems, even if a larger set of users and practitioners become aware of the issues, we will see better ML practices in the future and more applications.

The broad hope and expectation is that attendees get the breadth of available datasets and techniques, and the expertise on display during the symposium allows them to step out of their comfort zone to take on bigger problems in a safe manner. In particular, we hope to see more population studies incorporating more publicly available datasets (including transfer learning across datasets) rather than specialized studies involving smaller private and proprietary datasets, and we believe the symposium will help us move in that direction.

The SOC of the symposium includes: Ashish Mahabal (Co-Chair, Co-Editor), Christopher Fluke (Co-Chair, Co-Editor), Tara Murphy (Co-Chair), Jessica McIver (Co-Editor), G C Anupama, Dalya Baron, Nadia Blagorodnova, Andrew Connolly, Gwendolyn Eadie, Francisco Forster, Vanessa McBride, David Parkinson, Kai Polsterer, Pavlos Protopapas, Arman Shafieloo.

IAU Symposium 368: Machine Learning in Astronomy - Possibilities and Pitfalls	
START DATE	Tuesday, 2 August
END DATE	Thursday, 4 August
ORAL SESSIONS	Room 205, Convention Hall, 2nd Floor
POSTERS	e-Poster Zone, Convention Hall, 3rd Floor

For details on presenters, topics, and times see the online program on the GA website

Ashish Mahabal is an astronomer and lead computational scientist at Caltech's Center for Data Driven Discovery. He is interested in discovering and interpreting unusual objects in large astronomical datasets.

IAU Office for Astronomy Outreach: building bridges through access, communication and international cooperation

The IAU Office for Astronomy Outreach (OAO) is a joint project of the International Astronomical Union (IAU) and the National Astronomical Observatory of Japan (NAOJ), based in Tokyo, Japan. Our work builds bridges between the IAU and the global astronomy community of amateur astronomers, outreach practitioners, educators, communicators, and the general public. Through this and our international collaborations, we aim to make the science of astronomy accessible to all.

Office Meeting: IAU Office for Astronomy Outreach	
START DATE	Tuesday, 2 August
END DATE	Monday, 8 August
ORAL SESSIONS	Room 108 (8/2), 101 (8/8), Convention Hall, 1st Floor
POSTERS	e-Poster Zone, Convention Hall, 3rd Floor

For details on presenters, topics, and times see the online program on the GA website

The goal of the OAO is to engage the public in astronomy through access to astronomical information and communication of the science of astronomy. We accomplish this through our network of IAU National Outreach Coordinators (NOCs) and the IAU's engagement initiatives with the public.

During the XXXI IAU General Assembly in Busan, our team is looking forward to meeting the IAU members and other participating astronomy professionals. During these two weeks, we hope to engage with you as much as possible. We, therefore, issue an open invitation for all to drop by our booth in person, if you are joining us face-to-face, or online, if you are attending virtually. We have prepared an exciting and engaging programme that will hopefully foster future collaborations between you and our IAU Outreach programmes, and inspire you to share the wonders of the universe with your communities.

Meet the IAU Astronomers!
Bring IAU members into astronomy clubs, classrooms, museums, or out-of-school-time initiatives.

100 Hours of Astronomy
An event of 100 hours of continuous astronomy outreach events in October.

Women and Girls in Astronomy
A project to honour the contribution of women and girls to astronomy. Most events run throughout February and March centred around the International Day of Women and Girls in Science (11 February) and International Women's Day (8 March).

Dark and Quiet Skies Awareness
A project to raise awareness of the need for dark and quiet skies centred around the month of May and the International Day of Light (16 May).

NameExoWorlds
A programme that offers the public the opportunity to give a name to one exoplanet and its host star.

Inclusive Outreach Astronomy
A programme that aggregates best practices in diversity, equity, and inclusion, collected from practitioners from around the world. These resources help create astronomy outreach events or programming that are accessible to audiences of all abilities.

Communicating Astronomy with the Public
A collection of programmes to support the professional development of astronomy communicators, including CAP Conferences, CAPjournal and CAP Public Engagement Training.

In addition to welcoming you to our OAO booth, we are looking forward to seeing you in our workshop on August 9th, and at OAO sessions throughout the General Assembly.

You can access our programme here:
https://www.iau.org/public/oao/gabusan2022/

Overall, our programmes help build relations between professional astronomers, amateurs, and the public, creating fairer societies that are able to think critically and make informed decisions using science.

The OAO team wishes you a fruitful and inspiring General Assembly. We are looking forward to engaging with you!

Lina Canas, on behalf of the OAO Team

LINA CANAS is the Director of the IAU Office for Astronomy Outreach. The OAO is a joint venture between the International Astronomical Union (IAU) and the National Astronomical Observatory of Japan (NAOJ) with the goal of making astronomy accessible to all.

The Office of Astronomy for Development

OFFICE OF ASTRONOMY FOR DEVELOPMENT

The International Astronomical Union's Office of Astronomy for Development (OAD) was established in 2011 and aims to use the skills, methods and techniques of astronomy to impact socio-economic development. The Office is based in Cape Town, South Africa, and is a joint venture between the International Astronomical Union and South Africa's National Research Foundation, with strong support from South Africa's Department of Science and Innovation.

The OAD advances development through an annual call for proposals that is open to anyone, anywhere in the world, and provides seed funding for innovative "astronomy for development" projects. The OAD also had three flagship projects along the themes of "Astronomy for stimulating economies", "Astronomy in science diplomacy" and "Knowledge & skills from astronomy". Central to the OAD's effectiveness is its family of eleven regional and language centres, along with a broad network of volunteers and fellows.

The OAD institutional meeting will take place at GA2022 in 5 sessions on the 3rd and 8th of August. The key discussion topics are:

- OAD Flagship Projects
- Global structure in astronomy-for-development – OAD's Regional Offices
- OAD Projects – evaluation and future directions; impact of COVID-19 and related projects
- Interdisciplinary imperatives: synergies between natural and social sciences for the UN Sustainable Development Goals
- Reviewing the OAD: Past, present and future of Astronomy-for-Development
- Synergies between IAU structures (OAD, OAO, OYA, OAE, IAU Divisions, etc)

Office Meeting: IAU Office for Astronomy Development	
START DATE	Wednesday, 3 August
END DATE	Monday, 8 August
ORAL SESSIONS	Room 108 (8/3), 205 (8/8), Convention Hall, 1st and 2nd Floor
POSTERS	e-Poster Zone, Convention Hall, 3rd Floor

For details on presenters, topics, and times see the online program on the GA website

The mission of the OAD is driven, in large part, by the global astronomy community. In his talk at the virtual business sessions of the IAU organised in 2021, OAD Director Kevin Govender appealed to the IAU membership, communicators, educators, and the larger astronomy community to join hands with the OAD, contributing their skills and time to create a better world for all. He said, "The global pandemic has highlighted the great challenges of our time and the inequalities that persist. The OAD is a place for people to come together and tackle these challenges by applying the sophistication and grandeur of astronomy." Chat to us online (info@astro4dev.org), at the OAD institutional session at GA2022, or at the IAU exhibition booth at BEXCO about how we can collaborate to use astronomy towards a better world!

www.astro4dev.org

Astronomy for Development at the IAU General Assembly 2022: https://www.astro4dev.org/iauga2022/



This article is written by Kevin Govender, Vanessa McBride and Ramasamy Venugopal for the Office of Astronomy for Development.

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SET SYSTEM
Space and Earth Technology

SETsystem Inc. is a research based small business firm established in 2006. Most of the members have their academic background in Astronomy and Space science. As you can guess from the company name, we deal with scientific projects related to space and earth. More specifically, we are specialized in the field of Space Situational Awareness (SSA) including space weather and radar based space surveillance and tracking (SST).

For the Korean Space Weather Center, a government agency responsible for space weather research and operation of the Republic of Korea since 2011, we have developed algorithms for 1) solar absolute radio flux calculation, 2) automatic classification of solar radio burst type II and III, 3) digital beamforming routine for low frequency InterPlanetary Scintillation (IPS) array, 4) algorithm for Geomagnetic Induced Current (GIC) calculation, 5) analysis and visualization of various space weather data etc. In the field of instrumentation, we have developed several space weather oriented equipment including 1) Solar 2.8 GHz absolute flux receiver, 2) Multi frequency solar radio flux receiver, 3) IPS array radio telescope for solar wind imaging, 4) GIC monitoring system.

Based on experience from space weather projects, we expanded our business area which develop both software and hardware of remote sensing instrument for scientific and civil usage. The first remote sensing instrument was High Frequency Surface wave Radar. HF ocean radars are efficient to monitor wide areas of ocean at low cost, and are used to measure ocean currents and waves in many countries. You can find specification/features and performance verification of developed HF ocean radar, called "SEODAE" on the company website, www.setsystem.co.kr. The same technique was applied to X-band patch array radar we have been developing recently, the X-band FMCW radar together with digital beam forming process allows various applications in real day like 1) basic testbed for the Space Surveillance Radar 2) detecting low RCS (radar cross section) targets, Drones, micro-UAVs.

www.setsystem.co.kr

Opening Ceremony at the IAUGA 2022

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