# IAU Strategic Plan 2020–2030

# Contents

# Preface

[1] *https://www.iau.org/static/education/strategicplan_2010-2020.pdf*

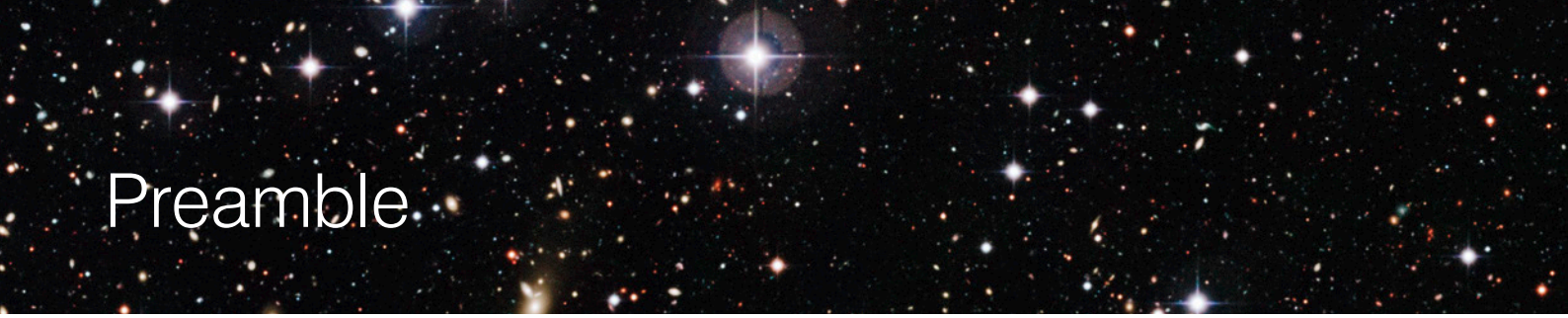
The IAU Strategic Plan 2010–2020[1] primarily describes the Office of Astronomy for Development (OAD), at that time yet to be established. At the 2015 IAU General Assembly (GA) in Honolulu, the GA adopted the following resolution that calls for an updated Strategic Plan by 2018:

1. That the pursuit of the goals of the Strategic Plan: Astronomy for the Developing World should continue until the XXXI General Assembly to be held August 2021.
2. That the Executive Committee should present for approval at the XXX General Assembly to be held in Vienna, Austria in August 2018 an extended Strategic Plan which addresses the future of the OAD and its activities beyond 2021.
3. That the Executive Committee should consult existing and potential stakeholders in the preparation of this Strategic Plan.

As a new decade approaches, the Executive Committee (EC) concluded that an updated document that includes all the activities of the IAU is warranted. Accordingly, the EC, at its EC98 meeting in Mexico City in May 2016, appointed a small working group consisting of Debra Elmegreen, Ewine van Dishoeck, Renée Kraan-Korteweg and Piero Benvenuti, with assistance from Teresa Lago, to start preparing the new IAU Strategic Plan. The working group drafted an overview of all IAU activities and formulated a number of long-term goals and actions. It solicited input from the OAD, OAO and OYA/ISYA, along with the EC, Division Presidents and National Members, and from the IAU membership as a whole via a survey about the draft outline. The plan was approved by the IAU EC on April 18 2018.

The new extended IAU Strategic Plan 2020–2030 provides a comprehensive overview of the IAU, describing how the different IAU activities fit together and how they complement each other, and presents its long-term goals. The actions and activities required to meet these goals are described in the following sections.

The celebrations associated with the 100th anniversary of the IAU in 2019 are an opportunity to reflect on a century of fantastic progress in astronomy. At the same time, they provide inspiration to look forward to the next decade(s), and to take actions such as those described here to further enhance astronomy's impact on society. Working together 'Under one Sky' will make this possible.



# Preamble

The mission of the International Astronomical Union is to promote and safeguard astronomy in all its aspects (including research, communication, education and development) through international cooperation[2].

The International Astronomical Union (IAU) was founded in 1919. Its Individual Members — structured into Divisions, Commissions, and Working Groups — are professional astronomers from all over the world, at the PhD level and beyond, who are active in professional research, education and outreach in astronomy.

A key activity of the IAU is the organisation of scientific meetings and its flagship IAU Symposia publications. Among the tasks of the IAU are: defining fundamental astronomical and physical constants; developing unambiguous astronomical nomenclature; promoting educational activities in astronomy; and hosting informal discussions on the possibilities for future international large-scale facilities. The IAU also serves as the internationally recognised authority for assigning designations to celestial bodies and surface features on them.

The IAU also works to promote astronomical research, education, and public outreach, as well as using astronomy for development. To this end, the IAU has created three offices: (i) the Office of Astronomy for Development (OAD), a joint venture with the South African National Research Foundation; (ii) the Office for Astronomy Outreach (OAO), a joint venture with the National Astronomical Observatory of Japan; and (iii) the Office for Young Astronomers (OYA), a joint venture with the Norwegian Academy of Sciences and Letters. Through the OAD and its regional nodes across the world, astronomy is used to impact the United Nations Sustainable Development Goals (SDGs). Through the OAO and its network of national outreach coordinators, the IAU promotes public awareness of astronomy, coordinates and manages international outreach campaigns, and maintains a relationship with amateur astronomers. Through the OYA, the next generation of astronomers is nurtured. The IAU proposes to create a fourth office, the Office of Astronomy for Education (OAE), to stimulate and develop standards for teaching astronomy at the elementary to high school level worldwide.

### Mission Statement

*[2] The addition of the words in parentheses in this revised mission statement emphasises the expanded scope of the IAU activities.*

### Background

# Preamble

**Priorities**

The IAU's activities centre around 8 main areas (the order does not imply ranking):

I. Stimulation and facilitation of sharing astronomical knowledge among professional astronomers;
II. Coordination of professional tasks and interactions with other fields at the professional level;
III. Recognition of excellence in astronomy through prizes;
IV. Fostering inclusiveness in the advancement of astronomy;
V. Facilitation of the advancement of the next generation of astronomers and scientists;
VI. Stimulation of global development through the use of astronomy;
VII. Engagement with the public in astronomy;
VIII. Use of astronomy to stimulate teaching and education at school level.

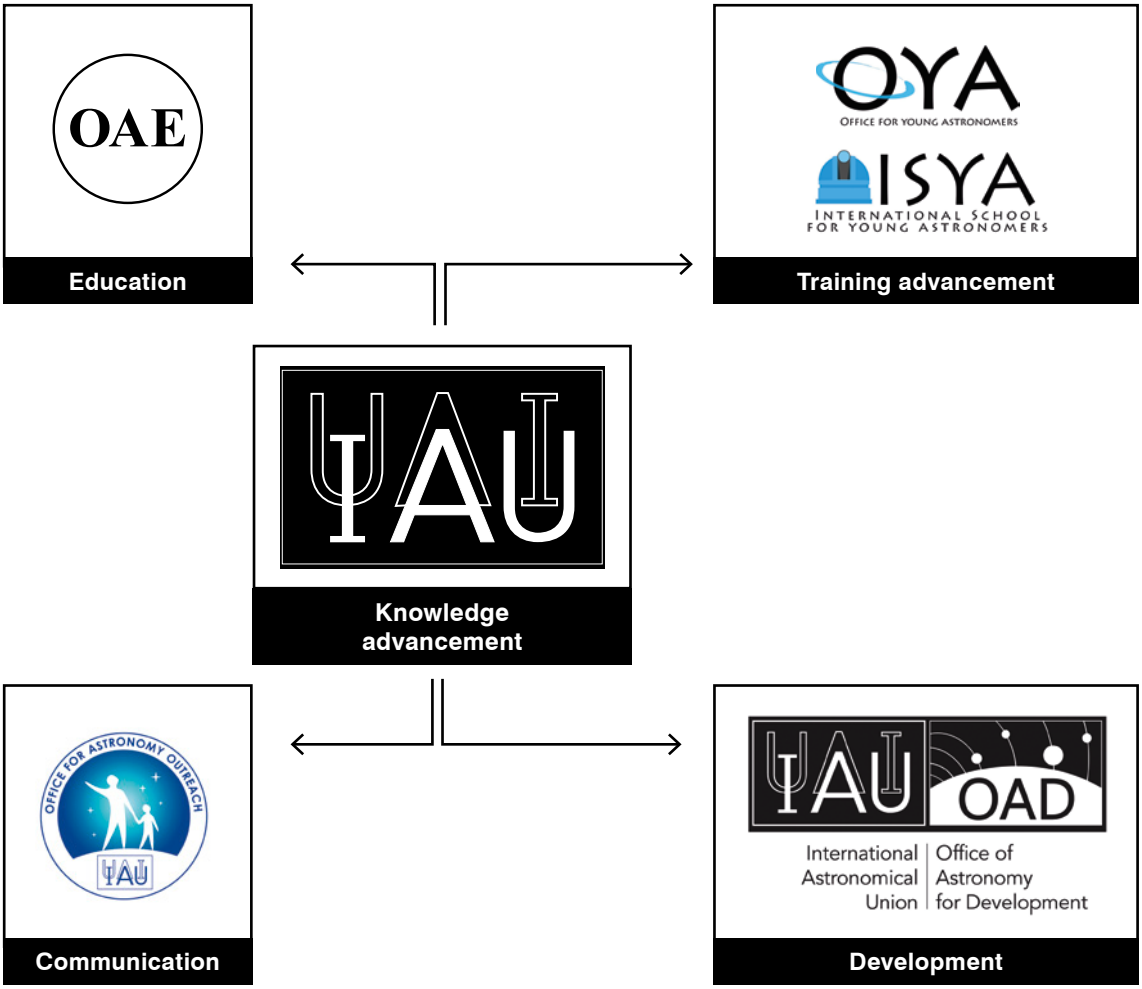
**Mandates**

The proposed responsibilities of the various IAU bodies are as follows:

a. The IAU Executive Committee and Divisions have as their main focus the advancement of the field of astronomy (**advancement of astronomy**), in terms of both stimulating and disseminating astronomical knowledge and producing the next generation of astronomers, while safeguarding the science of astronomy in terms of dark and quiet skies, astronomical standards, etc. They are also the professional interface with other scientific unions, neighbouring fields, industry, culture and society.
b. The IAU Office for Young Astronomers (OYA) focuses on **training young astronomers** at university level.
c. The IAU Office of Astronomy for Development (OAD) focuses on using astronomy to stimulate global development (**astronomy for development**). It seeks to further the use of astronomy as a tool for development by capitalising on the field's scientific, technological and cultural links and impact on society.
d. The IAU Office for Astronomy Outreach (OAO) focuses on engaging with the public, providing access to astronomical information and widely communicating the science of astronomy (**astronomy communication**). It maintains a network of National Outreach Contacts and amateur astronomy groups, which provide an ideal public engagement function for any major astronomical event.
e. The proposed IAU Office of Astronomy for Education (OAE) focuses on providing the training and resources necessary to use astron-

omy to stimulate teaching and education from elementary to high school level (**astronomy and science education**), with a network of National Astronomy Education Coordinators and a database of IAU volunteers.

Obviously, there are various relationships and crosscutting activities between these four branches. Synergy will be essential in implementing the strategic plan. Each office will have a Steering Committee consisting of 4–6 persons, and the EC will liaise with each Office.




*Relationships between the various IAU components and offices. The OAE is still to be established. There will be regular communication between the offices at working and director levels to ensure coordination.*

# 1 Introduction

The International Astronomical Union, whose mission is to promote and safeguard astronomy in all its aspects through international cooperation, has been the worldwide organisation of professional astronomers since 1919. In the last century, the endeavour of astronomy has grown and evolved in ways that could not have been anticipated or predicted at the time of the IAU's founding. In the early 1900s, astronomers had not yet proven that there were other galaxies besides the Milky Way. The expansion of the Universe was unknown. Supernovae had been observed but not recognised as something different from novae. White dwarfs and black holes were not even imagined.

*Hubble Space Telescope image of the Carina nebula. Credit: NASA, ESA, N. Smith (University of California, Berkeley), and The Hubble Heritage Team (STScI/AURA)*

Now, a century later, we know that the Universe is teeming with planets beyond our Solar System; thousands have already been discovered. Supermassive black holes reside in the centres of massive galaxies, and manifest themselves as quasars in the early Universe. Nucleosynthesis is understood to fuel stars. The accelerating Universe is filled with dark energy and dark matter, and the normal baryonic matter of which we are made is an insignificant 4% of the cosmos. Gravitational waves reach us following black hole and neutron star mergers. We are poised to be able to answer the age-old questions of our place in the Universe and whether or not we are alone.

Astronomical discoveries have gone hand in hand with technological advances. The early days of hand-drawn sketches gave way to photographic plates and spectroscopes, which in turn led to photometers, electronic cameras, and spectrographs. The largest telescopes of the early 1900s, whose mirrors were up to 2.5 metres in diameter, have been dwarfed by 10-metre-class telescopes today, and 30-metre-class telescopes are already being constructed. Telescopes in space are common, with wavelength coverage from the gamma-ray and X-ray regimes to the ultraviolet, optical, and infrared. Satellites monitor the Sun up close, have orbited and swept past planets, and have landed on a comet in our Solar System. Ground-based arrays have opened up the radio and sub-millimetre as well as the gravitational-wave Universe.

*The Subaru Telescope, the Keck I and II Telescopes, and the NASA Infrared Telescope Facility on the Mauna Kea Summit, Big Island, Hawaii, United States. Credit: Robert David Linsdell, CC BY 4.0*

The enterprise of astronomy is integral to the human drive to explore and understand the world around us. Society has advanced in part through the development of technology and a growing awareness of physical, chemical, and biological processes. The quest to examine the evolution of the Universe is an endeavour that unites all countries, for we are bound by the

# 1 Introduction

common goal of making sense of our place on Earth. Because of its broad appeal, astronomy is a gateway science that opens the world of possibilities to all, by nurturing inquisitiveness and the pursuit of knowledge using the scientific method. Our collective body of data and theories relies upon collaboration and cooperation among societies and is best advanced through an inclusive and diverse body of astronomers. Astronomical advances in turn help feed economic growth and prosperity through technological advances that positively impact everyday lives.

The activities of the IAU have greatly expanded since its founding. From triennial international General Assemblies to annual IAU symposia and regional IAU meetings, astronomers gather to exchange ideas and plan future endeavours. Astronomers work worldwide to communicate ideas to the public, to help prepare the next generation of astronomers, to educate children at all levels, and to use astronomy as a tool for economic and technological development, innovation and growth. The IAU centenary celebrations in 2019 provide a unique occasion to highlight all of these activities to scientists, policy makers, educators and the public alike.

Our vision for the coming decade builds on the 2010–2020 plan and incorporates the evolution of the IAU and its many activities into the goals and actions laid out in this strategic plan for 2020–2030.

*IAU GA 2015 Hawaii, with more than 3000 participants from 74 countries.*

# IAU STRATEGIC GOALS 2020–2030

## Goal 1

The IAU leads the worldwide coordination of astronomy and the fostering of communication and dissemination of astronomical knowledge among professional astronomers.

## Goal 2

The IAU promotes the inclusive advancement of the field of astronomy in every country.

## Goal 3

The IAU promotes the use of astronomy as a tool for development in every country.

## Goal 4

The IAU engages the public in astronomy through access to astronomical information and communication of the science of astronomy.

## Goal 5

The IAU stimulates the use of astronomy for teaching and education at school level.

# 2 Outline of strategic actions

In the coming decade, the broad strategic goals for the IAU in the advancement of astronomy, astronomy for development, astronomy communication, and astronomy education will be achieved through the implementation of various activities and proposed action items that encompass the 8 priorities listed in the preamble. Several of these activities and actions are already in place and need to be continued or strengthened, while others are new elements to be implemented in the coming decade.

**Goal 1**
The IAU leads the worldwide coordination of astronomy and the fostering of communication and dissemination of astronomical knowledge among professional astronomers.

**Goal 1: The IAU leads the worldwide coordination of astronomy and the fostering of communication and dissemination of astronomical knowledge among professional astronomers.**

I. **Stimulate and facilitate sharing of astronomical knowledge among professional astronomers**
   a. Host a General Assembly (GA) every 3 years.
   b. Encourage broad membership:
      - National Members;
      - Observers;
      - Individual Members;
      - Junior Members;
      - Associate Members.
   c. Sponsor IAU Meetings:
      - Host 9 Symposia per year (6 GA and 3 non-GA in GA year).
      - Host 12 Focus Meetings at GA.
      - Host additional meetings at GA such as Division meetings.
   d. Sponsor Regional IAU meetings (3 between GAs).
   e. Co-sponsor other meetings (e.g., COSPAR and annual Young Astronomers conference).
   f. Consider and drive systemic changes that would benefit professional astronomy:
      - Aid student supervision (e.g., provide training; best practice guidelines).
      - Inform about career paths (e.g., alternatives to short term postdocs).

- Consider publication practices (e.g., open access; publication of data and simulation codes).
- Advise on hiring practices (e.g., inclusive and unbiased hiring).

g. Publish IAU-related reports:
   - Publish Symposia and Proceedings, Focus Meetings, Transactions, Highlights, GA newspapers.

II. **Coordinate professional tasks and interact with other fields at the professional level**
   a. Represent astronomy at the International Science Council (formed from the ICSU-ISSC merger) and build professional interdisciplinary collaborations where applicable.
   b. Support 9 Divisions.
   c. Support Commissions (35 as of August 2018).
   d. Support Working Groups (51 as of August 2018, under Commissions, inter-Commissions, Divisions, and the Executive Committee):
      - Executive Committee Working Groups (others to be added as deemed appropriate):
        - » Dark and Quiet Sky Protection;
        - » Global Coordination of Ground and Space Astrophysics;
        - » Women in Astronomy.
      - Naming of astronomical objects and surface features.
      - Setting astronomical standards.

III. **Recognise excellence in astronomy through prizes**
   a. Gruber Cosmology and Kavli Astrophysics Prizes;
   b. Gruber Foundation Fellowship in Astrophysics;
   c. IAU PhD prize in each Division.

# 2 Outline of strategic actions

**Goal 2**
The IAU promotes the inclusive advancement of the field of astronomy in every country.

**Goal 2: The IAU promotes the inclusive advancement of the field of astronomy in every country.**

IV. **Foster inclusiveness in the advancement of astronomy**
   a. Encourage gender balance and promote best practices for achieving parity for all.
   b. Encourage more inclusive and diverse IAU-sponsored meetings, symposia, workshops, and schools.
   c. Adopt anti-harassment guidelines for all IAU-sanctioned events.
   d. Develop and promote strategies, tools, and resources for people with special needs.
   e. Ensure that the awarding of prizes reflects a diverse and inclusive body of astronomers.
   f. Broaden the geographical spread of IAU National Members through Observer category.
   g. Broaden geographic and demographic spread of IAU individual membership.

V. **Facilitate the advancement of the next generation of astronomers and scientists**
   a. Support the Office for Young Astronomers (OYA):
      - Help develop the next generation of astronomers and scientists.
      - Coordinate with appropriate IAU commissions and working groups.
      - Provide guidance on diverse career trajectories both within and beyond academia.
      - Host International Schools for Young Astronomers (ISYAs).
   b. Encourage the use of new methods of learning and best practices in pedagogy at university level.

**Goal 3: The IAU promotes the use of astronomy as a tool for development in every country.**

VI. **Stimulate global development through the use of astronomy**

a. Support the Office of Astronomy for Development (OAD):

- Contribute significantly to at least half of all Sustainable Development Goal (SDG) indicators; develop a number of global OAD "signature" projects.
- Establish a sufficient number of regional offices to cover all populated regions of the world.
- Refine OAD project evaluation and feedback loops.
- Use astronomy and its technology to position young people to take advantage of career opportunities throughout society.
- Establish interdisciplinary partnerships around science for development.
- Source the necessary funding to realise the above and assist other related initiatives in fundraising.

**Goal 3**
The IAU promotes the use of astronomy as a tool for development in every country.

**Goal 4: The IAU engages the public in astronomy through access to astronomical information and communication of the science of astronomy.**

VII. **Engage the public in astronomy**

a. Support the Office for Astronomy Outreach (OAO):

- Increase the network of NOCs; restructure them and ensure their effectiveness.
- Facilitate international communication through exchanges and translations.
- Provide open databases and public-friendly access to astronomical information.
- Encourage communication of science and critical thinking through IAU member public engagement, professional-amateur, and citizen science activities.
- Promote dark skies and the pale blue dot message.

**Goal 4**
The IAU engages the public in astronomy through access to astronomical information and communication of the science of astronomy.

# 2 Outline of strategic actions

**Goal 5**
The IAU stimulates the use of astronomy for teaching and education at school level.

**Goal 5: The IAU stimulates the use of astronomy for teaching and education at school level.**

VIII. **Use astronomy for teaching and education at school level**

a. Support the proposed Office of Astronomy for Education (OAE):
   - Establish a network of NAECs.
   - Analyse astronomy teaching in IAU countries and identify accessible materials and astronomy literacy guidelines.
   - Encourage standards for teacher training activities.
   - Organise an annual International School for Astronomy Education (ISAE).
   - Build a database of volunteer IAU members.

Fundraising will be part of the process to advance these goals. The activities and actions of the IAU in support of these goals are detailed in the remainder of this document.

*The VLT in action.*
*Credit: ESO/S. Brunier*

# 3 Goal 1

## The IAU leads the worldwide coordination of astronomy and the fostering of communication and dissemination of astronomical knowledge among professional astronomers.

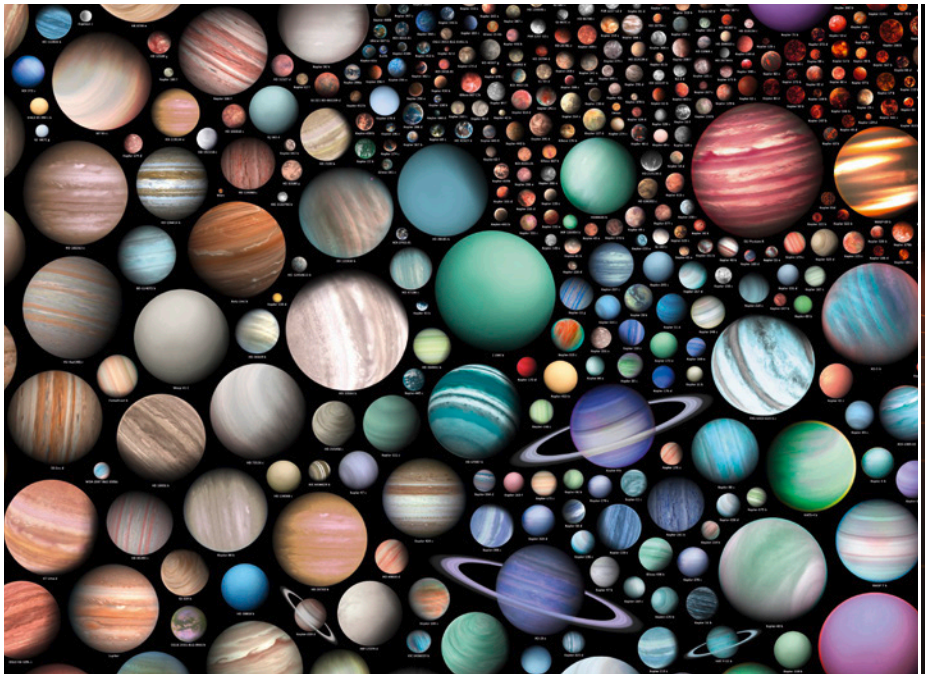
**Stimulate and facilitate sharing of astronomical knowledge among professional astronomers**

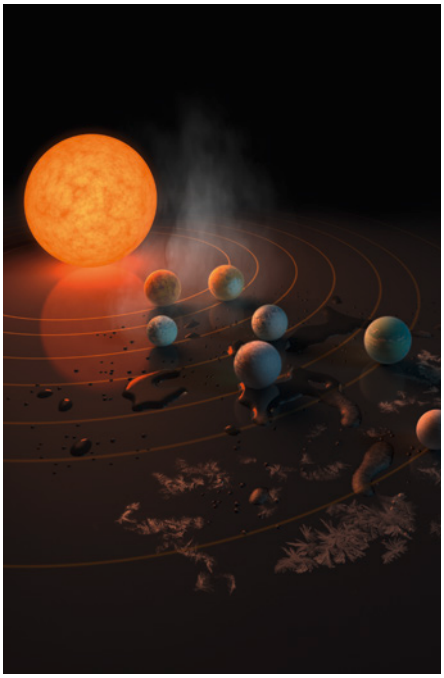
Discussion of astronomical research and the exchange of knowledge are promoted through the nine Divisions of the IAU. The Divisions listed in Appendix A represent a restructuring scheme that was adopted in 2012 at the XXVIII General Assembly in Beijing to reflect the current state of astronomy within the IAU. Each Division includes Commissions that are concerned with more specific themes. The Commissions are not expected to cover all scientific areas of their Division, but are created as necessary for specific areas undergoing significant activity, typically over a decade. Working Groups undertake certain well-defined tasks within Divisions or Commissions, mostly for a limited time period. Some of the Working Groups have ongoing tasks that are institutional, for example the Working Group on fundamental constants in Division A, so they are semi-permanent. Appendix A contains the insights from each Division into the anticipated evolution of their fields in the coming decade, and Appendix B lists the current Commissions and Working Groups. Several of them belong to more than one Division.

The Divisions facilitate interactions between astronomers both within and between their sub-disciplines through IAU symposia and focus meetings at the General Assembly and elsewhere, ensuring worldwide participation at each of the meetings. The current frequency of nine IAU symposia per year and a dozen focus meetings at the General Assembly will be maintained, but a shift is anticipated towards more multidisciplinary symposia involving a larger fraction of speakers from related fields. A new feature will be IAU symposia focusing solely on astronomy-related education, outreach, history or heritage, with the first one taking place in 2018. Regional IAU meetings in Middle East-Africa (MEARIM), Asia-Pacific (APRIM), and Latin America (LARIM), will continue to be crucial to promoting contacts between scientists in these regions, especially young astronomers. Finally, the IAU will continue to co-sponsor other meetings, such as symposia jointly with COSPAR and the biennial Communicating Astronomy with the Public (CAP) meetings. Meetings organised or sponsored by the IAU are open to all scientists.

Membership of the IAU is normally reserved for professional scientists with a PhD degree whose long-term research is directly relevant to some branch of astronomy. National Members are members who represent the national professional organisation adhering to the Union. To encourage the engagement of early career scientists with the IAU, a new category of Junior Member will be created. Moreover, in recognition of the increasingly multidisciplinary nature of astronomy, PhD scientists whose primary research is in other fields but who make important contributions to astronomy will be eligible to become Associate Members, and non-PhDs whose work is relevant to astronomy can occasionally become Associate Members through Divisions, Commissions, and Working Groups.

In the coming decade, the IAU will stimulate discussion of various aspects of the profession of astronomy and provide information and guidelines that can help drive systemic changes in the field. These include advice on student supervision, career paths inside and outside astronomy, publication and refereeing aspects, and hiring practices. The EC will work with Junior Members to develop activities that will help their professional development. In particular, an annual Young Astronomers Meeting (YAM) administered by the EC is envisaged to promote the research and careers of graduate students,





*Left: Zoo of exoplanets discovered by the Kepler mission. Right: Detection of the Trappist-1 exoplanetary system. Credit: Left: Martin Vargic; Right: NASA/R. Hurt/T. Pyle*

# 3 Goal 1

postdoctoral fellows, and IAU Junior Members, and to complement the separate International Schools for Young Astronomers. The YAM would include discussion of hot topics in astronomy and associated technologies, as well as career paths and other items of interest to young astronomers.

## Action

The IAU will expand membership to include the category of Junior Members for early career astronomers, and will stimulate activities fostering their professional development.

The proceedings of the IAU symposia and focus meetings, as well as the transactions and highlights of the General Assembly, will continue to be published in the coming decade, but primarily in electronic form. Updated publication guidelines that stimulate short state-of-the-art reviews will be implemented. Newspapers provide another historic record of activities at the General Assembly. Communications by Divisions, Commissions, and Working Groups will be facilitated by standardised IAU websites. The IAU will implement and recommend to the community changing publication practices such as open access and publication of data, data analysis, and simulation codes.

## Action

The EC will continue IAU-related publications and communications, using and promoting updated methods.

**II**

**Coordinate professional tasks and interact with other fields at the professional level**

Coordination within astronomy and with other fields will receive increased attention in the coming decade. To highlight the importance of coordination and cooperation, the IAU has formed a small number of Working Groups that report directly to the EC and address topics that are of importance for the global astronomy community across all Divisions. Two of these EC

Working Groups and related activities are noted here. More EC Working Groups may be added as necessary.

**Global Coordination of Ground and Space Astrophysics**

International efforts play a key role in driving all areas of astrophysics, and involve access to data and facilities as well as joint partnerships on large-scale instruments, observatories, and missions. Global cooperation and collaboration are increasingly important as the costs and preparation to build forefront facilities and missions escalate. International strategic planning is essential to explore how partnerships can be built and joint projects developed that could otherwise not be afforded, and to maximise the scientific return from these efforts.

For these reasons, in 2016 the IAU established the Working Group on Global Coordination of Ground and Space Astrophysics, reporting directly to the EC, following an IAU GA 2015 focus meeting by the precursor Division B Working Group on Large Scale Facilities. A key aspect of the Working Group's activities is to organise meetings to foster international planning. The IAU facilitates discussions, but does not endorse any particular mission or facility over any other. The aim of the Working Group is to have one focus meeting at each General Assembly covering a broad range of issues, and one focused workshop between GAs.

## Action

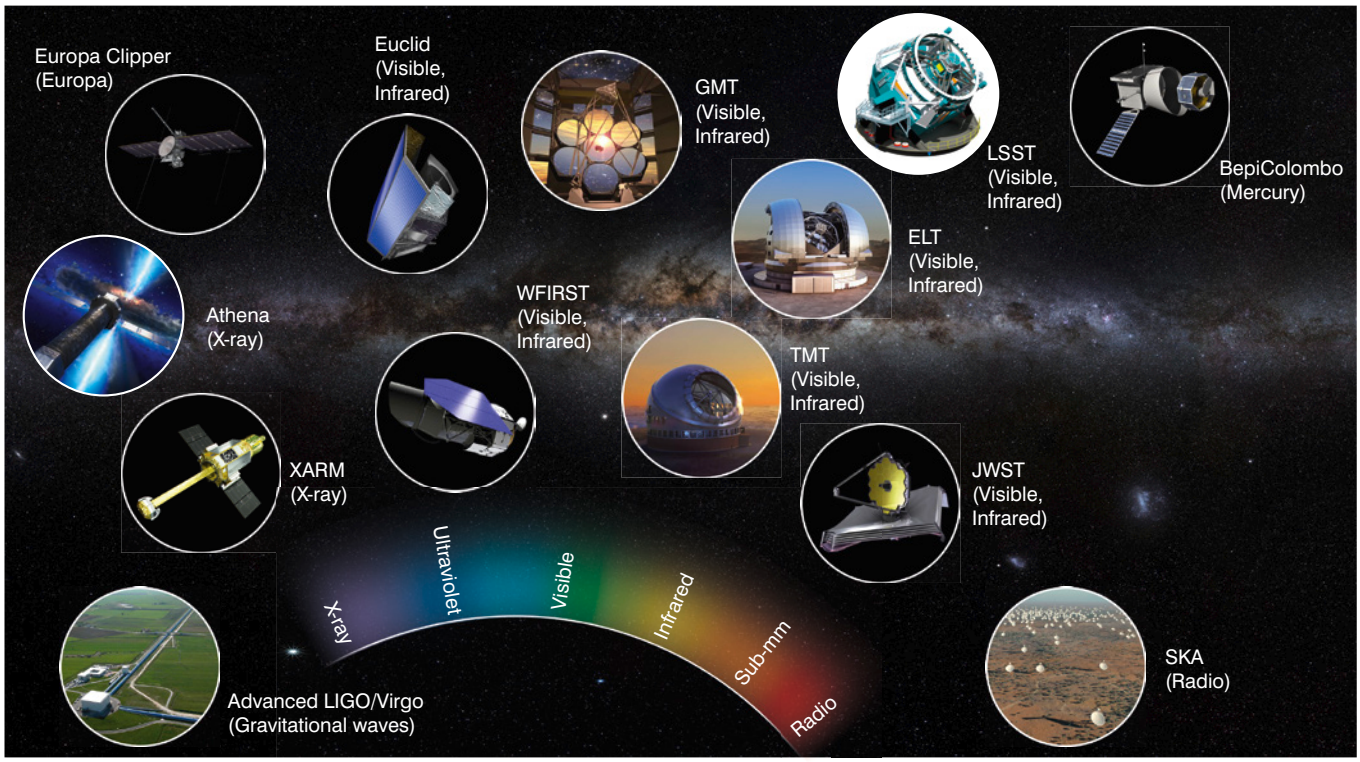
The Working Group on Global Coordination will have a focus meeting at the GAs and a focused workshop between GAs.

An IAU Workshop on "Global Coordination: Future Space-Based Ultraviolet-Optical-Infrared Telescopes," sponsored by the Kavli Foundation, was the first such meeting, and it was held in Leiden in July 2017. The goal was to highlight the unique science to be accomplished by a large UV-Optical-IR space telescope, to outline in broad terms the necessary technology and instrumentation capabilities, and to foster further international discussions.

**Dark and Quiet Sky Protection**

Astronomical observations across the electromagnetic spectrum require protection of the sky. The reduction and prevention of artificial sky glow and radio interference are priorities for the IAU, through its EC Working Group

# 3 Goal 1




*Major new facilities planned to come online in the 2020–2030 time frame.*

on the subject. Its goals are to make progress in restricting light and radio pollution near astronomical observatories, to raise public awareness of the problem, and to work with relevant national and international authorities to set up legal policies and guidelines for protection of the skies. The Working Group coordinates its activities with several Commission-level Working Groups.

The problem of the protection of the dark and quiet sky has been brought to the attention of the UN Committee on the Peaceful Uses of Outer Space (COPUOS), on which the IAU has permanent observer status, to gain further political support. The IAU will organise a conference in cooperation with COPUOS and UNESCO as part of the IAU centenary celebration activities, aimed at defining a number of measures that can mitigate interference with astronomical observations by artificial illumination and radio wavelength emissions. The conference will also propose measures to protect the areas on which major observing facilities have been installed and are operational. Follow-up meetings and individual observatory actions to enforce local measures are envisaged in the coming decade. Dark sky protection

should also involve the International Union for the Conservation of Nature (IUCN), which has a Dark Skies Advisory Group.

## Action

The IAU will organise an international conference on dark and quiet sky protection, in cooperation with COPUOS and UNESCO, as well as follow-up meetings and interactions with IUCN, to raise awareness at all levels.

**Coordination with other fields**

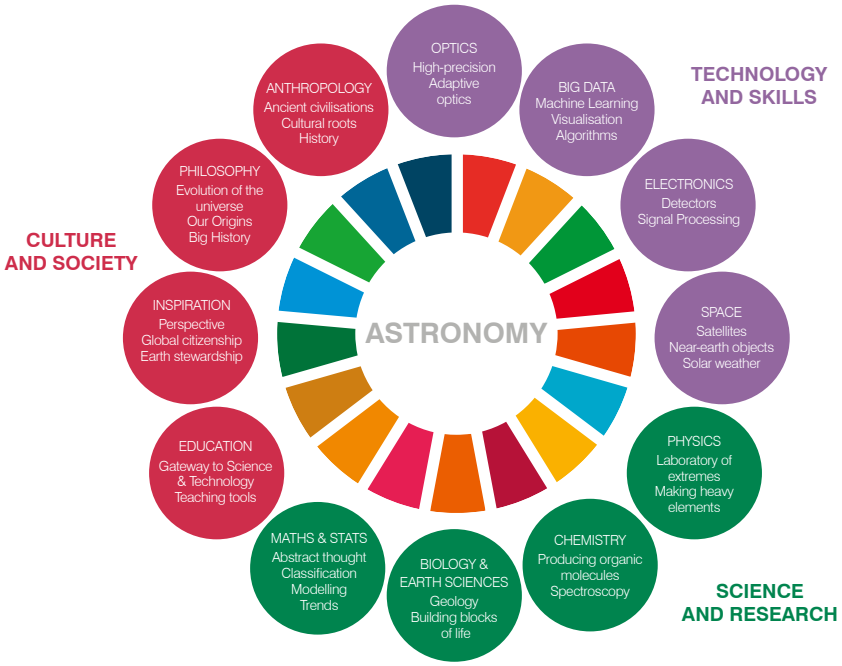
The IAU belongs to the International Science Council (ISC), recently formed by the merger of the International Council for Science (ICSU) and the International Social Science Council (ISSC). The ISC has membership from a large number of national scientific bodies and international scientific unions like the IAU. Its mission is to strengthen international science for the benefit of society. The IAU follows the ISC's statutes on the Principles of Universality (Freedom and Responsibility) of Science and its Conduct. The ISC provides a platform for joint activities with other unions, including social sciences, such as the Gender Gap in Science study (see Section IV) and OAD activities (see Section VI).

The IAU also has close connections with the Committee on Space Research (COSPAR), with which it co-sponsors scientific meetings and capacity-building workshops in developing countries. Similarly, the IAU interacts with the International Union of Radio Science (URSI), most notably on the protection of radio frequencies for astronomy. The SPIE International Society for Optics and Photonics organises worldwide meetings on Astronomical Telescopes and Instrumentation every two years, bringing together scientists, engineers and industry, with symposia often co-chaired by members of IAU Division B.

The IAU is also connected with many other professional organisations, and sits on their respective committees. These are listed on the IAU administration web page[3] and include organisations on space research, units, measures, time, weather, communications, and other astronomy-related groups. The connections of astronomy with other fields are highlighted in the wheel shown in the following figure.

[3] *https://www.iau.org/administration/international_org_relations/other_organizations/*

# 3 Goal 1




*Connections of astronomy with other disciplines. The colours in the inner ring represent the colours of the UN Sustainable Development Goals (SDGs) to which astronomy can contribute (this "wheel" is a re-envisioning of the wheel on the cover of the Strategic Plan 2010–2020).*

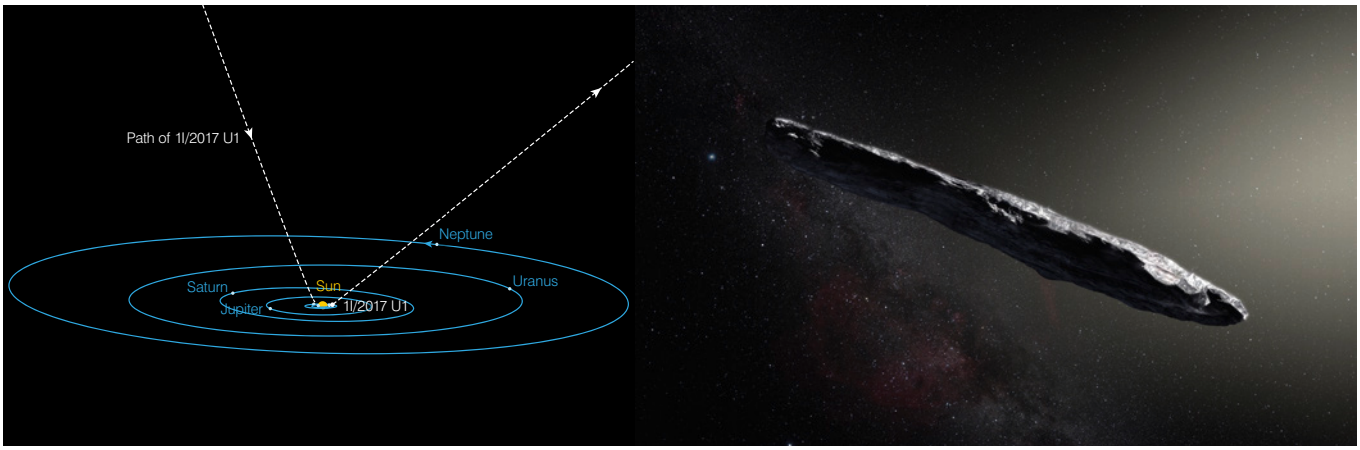
## Action

The IAU will continue to foster connections with relevant professional organisations to help advance science.

**Naming of astronomical objects and surface features**

The IAU serves as the internationally recognised authority for assigning designations to celestial bodies and their surface features. To do so, the IAU has a number of Working Groups on various topics, most notably on the nomenclature of small bodies in the Solar System and planetary systems under Division F and on Star Names under Division C. The Working Groups usually have a multidisciplinary composition, including astronomical, historical, and cultural expertise. The IAU maintains web pages with detailed rules and guidelines for the designation of various types of celestial bodies. The IAU supports the involvement of the general public in naming astronomical objects, whether directly or through an independently

organised vote. For example, the IAU organised the public exoplanet naming competition in 2015–2016. The IAU will continue these important activities in the coming decade.




*The IAU approved a new type of designation, 1I/2017 U1, for the recently discovered object Óumuamua, which has a hyperbolic trajectory with an unusually high eccentricity, unlike anything seen for asteroids or comets. The letter I indicates that the object is of 'Interstellar' origin. Left: Trajectory of the object. Right: Artist's impression. Credit: ESO/M. Kornmesser*

## Action

The IAU will continue to oversee official assigning of names for celestial bodies and their features.

**Setting astronomical standards**

Both the astronomical community and society in general require services that provide high-accuracy data on positions and dynamics of Solar System objects and other celestial bodies, Earth orientation, current best estimates for astronomical constants, etc. Division A and its functional Working Groups will continue to provide this key information (see also Appendix A).

## Action

The IAU will continue to oversee the definition, determination, and use of astronomical standards.

# 3 Goal 1

**III**

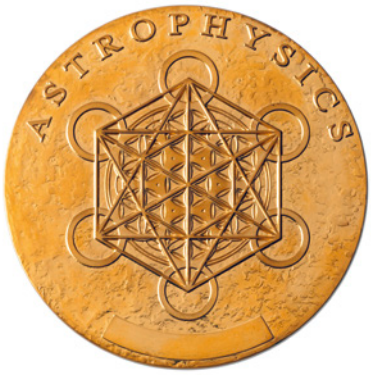
**Recognise excellence in astronomy through prizes**

An important function of the IAU is to recognise excellence in astrophysics through the award of annual prizes and awards. These highlight forefront research and encourage continued commitment to the field. In the coming decade, the IAU will continue to enhance and diversify its portfolio of prizes to reflect changes in its own priorities and targets.

**Gruber Cosmology and Kavli Astrophysics Prizes**

The highest accolades involving the IAU are the prizes generously sponsored by the Gruber and Kavli foundations. The Gruber Cosmology Prize, consisting of a gold medal and $500 000 cash, has been awarded annually since 2001 to a leading astronomer whose theoretical or observational work has led to a significant breakthrough in our understanding of the Universe. The Cosmology Selection Advisory Board includes members of the IAU and other international scientific unions in fields relevant to cosmology.

Since 2010 the IAU has collaborated with the Norwegian Academy of Science and Letters in choosing the members of the Kavli Prize selection committee. The Kavli Prize for Astrophysics, consisting of a medal and $1 000 000 cash, is awarded every two years for outstanding achievements in advancing our knowledge and understanding of the origin, evolution, and properties of the Universe.





*Left: Kavli Astrophysics medal. Right: Gruber Cosmology medal.*

**Gruber Foundation Fellowship in Astrophysics**

The Gruber Foundation (TGF) Fellowship, created by the Gruber Foundation, is awarded annually by the IAU to a promising early career astronomer who is beginning, or in the early stages of, a postdoctoral appointment in any field of astrophysics. The $50 000 award (which may be split into two equal prizes) is a supplemental research grant. The selection committee is a subset of the IAU Executive Committee. Outstanding science is the primary

criterion, but preference will be given to applicants from countries experiencing difficult economic conditions.

**IAU PhD prize**

The IAU established PhD Prizes in 2017 following a proposal by Division Presidents to highlight excellence by early career astronomers and to introduce them to IAU activities. Each of the 9 Divisions may recognise annually the most outstanding dissertation research by a promising graduate student. The competition is open to every PhD graduate in that year. Award winners are selected by the Division Presidents and their steering committees, and approved by the IAU EC. Award winners receive travel grants to attend the General Assembly, where they are presented with certificates at their Division Days and may have the opportunity to present their thesis work. Focusing on early career astronomers, who are an increasingly more diverse group than in earlier generations, will help foster inclusivity within the IAU.

## Action

The IAU will continue to enhance and diversify its portfolio of prizes to reflect changes in its priorities.

# 4 Goal 2

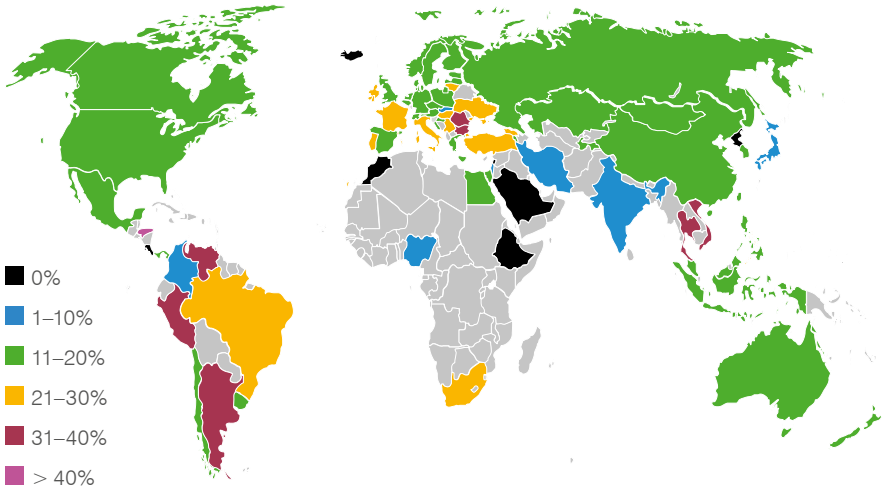
**IV**

**Foster inclusiveness in the advancement of astronomy**

## The IAU promotes the inclusive development of the field of astronomy in every country.

The IAU, as the worldwide astronomy organisation with 79 member nations and members from 101 countries, has naturally been the focal point for astronomers from across the world to come together and exchange ideas. The IAU has stimulated this interaction through travel grants for IAU symposia, GAs, and regional meetings, and will continue to do so. The IAU strives to be an inclusive organisation within which all astronomers, regardless of nationality, ethnicity, religion, gender, sexuality, or disability, are welcome at all activities. Astronomy as a whole is enriched when there is a diverse body of astronomers, who bring a variety of perspectives, ideas, and approaches to the field.

Gender equality is a particular focus of the IAU, since men have largely dominated the field of astronomy. Within the IAU membership, the percentage of women was 16% worldwide as of 2016; from 1939 to 1987, the percentage was about 10%. There has evidently been some slow growth, but not nearly at a rate that would achieve a percentage reflecting the general population. However, among younger astronomers (30–40 years old) in the IAU, the percentage is greater than 30%. Accordingly, the new Junior membership category (see Section II) should help to improve the gender balance across the membership. The ultimate goal is to achieve equity in gender among IAU members, with a first step to match the proportions in the incoming student population. The IAU will continue to promote gender parity in astronomy across the world (see figure below).




*IAU membership by gender and geography. The colour coding indicates the fraction of female IAU members.*

The Women in Astronomy (WiA) Working Group is an EC-level group established in 2003 at the XXV General Assembly. Its mandate is to collect information, propose measures, and initiate actions to advance equality of opportunity for women and men in astronomy, in the IAU, and in the world at large. It acts as a federation of national Women in Astronomy organisations, creating links and facilitating information exchange worldwide.

At each GA, the Working Group co-sponsors a Women in Astronomy lunch to help facilitate interaction and discussion. In addition, it hosts 1-on-1 mentoring sessions (for both men and women) and lunch talks at the GA.

The Working Group has joined with the ICSU (now ISC) to undertake the project "Gender Gap in Science – A Global Approach to the Gender Gap in Mathematical and Natural Sciences: How to Measure It, How to Reduce It?"[4]. The 3-year project, to be completed by 2020, will carry out a joint global survey, complete a data-backed study of publications, and develop a database of good practices. The information provided in the database will also be useful for career guidance. Special attention will be paid to actions that not only stimulate women and minorities to enter the field, but also retain them.

[4] *https://icsugendergapinscience.org/*

*Attendees at the Inclusive Astronomy 2015 conference at Vanderbilt University in Nashville, Tennessee, June 2015. Courtesy of IA 2015 organisers.*

# 4 Goal 2

Besides promoting gender parity, the IAU is concerned with broadening astronomy to be more inclusive in all respects. Commission C1 on Astronomy Education and Development has a Working Group on Astronomy for Equity and Inclusion that examines and develops strategies, tools, and resources for people with special educational needs or those with disabilities and impairments, such as visual, hearing or motor disabilities. It also supports efforts for inclusiveness of all minorities, including ethnic, racial, and religious minorities and the LGBTIQA community. All these other aspects of inclusiveness will receive increased attention in the coming decade, and training sessions may be incorporated at ISYAs, schools, and IAU events.

*Astronomical words in sign languages, an example of a recent project of the Working Group on Astronomy for Equity under Commission C1. Credit: https://www.iau.org/news/pressreleases/detail/iau1706/*

In order to enable productive, inclusive meetings that are conducive to a civil and welcoming exchange of ideas, the IAU has approved and adopted anti-harassment guidelines intended to prevent any form of harassment during IAU-sanctioned events[5].

To further encourage diversity in the selection of speakers for focus meetings and symposia, the IAU will introduce searchable keywords for members in its directory (entered on a voluntary basis) that allow them to be found when searching for experts on particular topics.

[5] *https://www.iau.org/news/announcements/detail/ann16007/*

## Action

- The IAU will continue to increase the level of actions to promote diversity, encourage and retain women and minorities in astronomy, and support astronomers with special needs.
- WiA and ICSU will cooperate on the Gender Gap in Science study and similar future studies to promote best practices for achieving gender parity.
- IAU-sanctioned events will follow anti-harassment guidelines.

Training and educational activities are a vital task of the IAU. The Office for Young Astronomers (OYA) is a virtual office established in 2015 by the Norwegian Academy of Science and Letters (NASL) and the IAU to run the IAU programme on International Schools for Young Astronomers (ISYA), a project that was established by the IAU in 1967. The ISYAs are run by the ISYA Director and overseen by the OYA Steering Committee. The ISYAs are 3-week international postgraduate schools held mainly in astronomically developing countries and taught by experts from around the world. The curriculum is meant to cover theory as well as hands-on observations, data reduction and analysis, and often takes place at an observatory or using remote robotic telescopes. Many astronomers in currently or formerly developing countries have participated in ISYA schools.

As of spring 2017, 39 ISYAs have been held, in 25 countries. A new formal agreement between the NASL and the IAU was signed in October 2016. An increased IAU contribution will permit holding as many as four schools in every 2-year period, one of which is joint with the OAD, as a goal in the coming decade.

**V**

**Facilitate the advancement of the next generation of astronomers and scientists**

**Office for Young Astronomers (OYA)**

# 4 Goal 2

*ISYA held in Addis Ababa, Ethiopia, in 2017.*

## Action

The OYA will hold as many as 4 ISYA schools every 2-year period.

While the ISYAs will remain the IAU's top-level educational and training programme at university level, additional Schools and Training seminars are being organised within the activities of the Regional Offices of Astronomy for Development (ROADs) or selected and supported as OAD Projects. In preparing the programmes of both the ISYAs and the other schools, the educational situation of the regions in which they are organised, as well as the average level of the prospective participants, must be taken into account. The OYA, in coordination with the OAE (Section VIII), will consider

having a lectureship programme combining a lecture given at university level with lectures at local high schools. “North-South” and “South-South” collaborations will also be encouraged, through institute twinning, mobility, and joint student supervision. In the coming decade, the OYA will extend its oversight to all the Schools and Training seminars at university level that are supported directly, or indirectly, by the IAU.

Another new initiative will be an annual IAU Advanced School for students at MSc and PhD level, where top scientists will present lectures on an exciting topic during a week-long meeting, the topic changing each year. The lectures will be recorded and posted on the internet so that students from across the world can benefit from them.

The President of Division C, who is an ex-officio member of the OYA Steering Committee, represents the natural link between the OYA and the other educational activities. Division C Working Groups also undertake other educational initiatives that encourage the use of new, engaging methods of learning, e.g., Massive Open Online Courses (MOOCs). Working Group goals include identifying best practices in pedagogy at university level, fostering the involvement of students from related fields (e.g., physics/mathematics/computer science) in research projects, and providing curricular support and training for university lecturers. Hence, this training also prepares students for careers outside astronomy.

# 5 Goal 3

**VI**

**Stimulate global development through the use of astronomy**

**Office of Astronomy for Development (OAD)**

## The IAU promotes the use of astronomy as a tool for development in every country.

The Office of Astronomy for Development (OAD) was established in 2011 by the IAU together with the South African government, with a vision of "Astronomy for a better world." This vision has been effective in communicating the purpose of the OAD's work and that of the IAU's Strategic Plan 2010–2020, and should be continued into the next decade.

The OAD uses the UN Sustainable Development Goals (SDGs) as the global definition of development in calling annually for proposals. The figure below illustrates some potential contributions of astronomy to the SDGs. A goal for the 2020–2030 strategic plan is that — depending on the region — about half of the 232 UN Strategic Development Goals (SDG) should have been positively affected by OAD projects on all of the populated continents.


*Some potential contributions of astronomy to the Sustainable Development Goals.*

As of 2018, the OAD had administered IAU grant funds awarded to 122 projects that reached over 85 countries around the world, and had negotiated the establishment of nine regional offices ("ROADs") around the world (based in Armenia, China, Colombia, Ethiopia, Jordan, Nigeria, Portugal, Thailand and Zambia) with two of these offices serving as joint language centres (Chinese and Arabic), and one serving as a dedicated language centre ("LOAD") (Portuguese). The OAD has registered over 600 volunteers

and formed nine partnerships with organisations sharing the OAD vision. A global snapshot of the OAD's footprint is given in the figure below. A goal for the next decade is to further solidify and expand this network.


*The global footprint of OAD activities during its first 5 years.*

The ROADs and LOADs form the global core structure of the OAD, and interactions between them stimulate synergies among different geographic and cultural regions. For example, offices in Africa are learning from offices in Asia, and vice versa — making the whole greater than the sum of its parts. It is clear from the OAD's experience thus far that diversity is a strength, with numerous ideas and best practices spreading across language and geographic boundaries. The establishment of a European ROAD in 2018 adds a dynamic to the family of regional offices, given the advanced level of astronomical activities in Europe. Other ROADs in developed countries should be established in the coming decade to effectively cover all populated regions of the world. The OAD aims to identify a number of global "signature" projects that can be expanded and regularly carried out worldwide in the next decade.

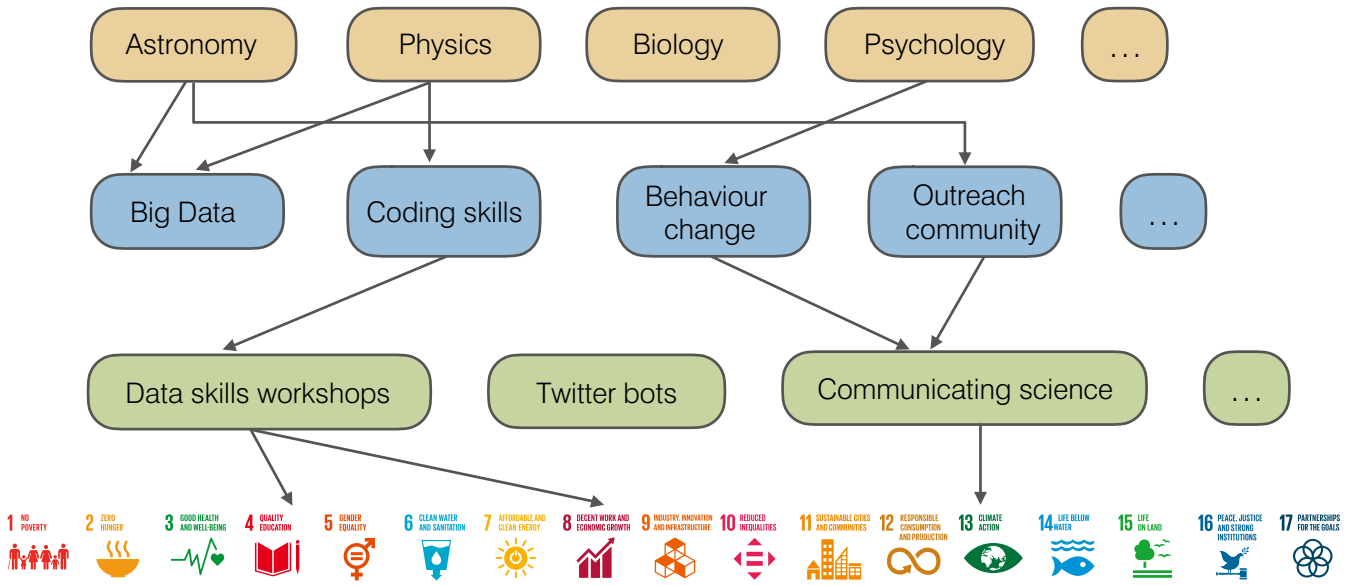
There is also a clear potential for close synergies between the ROADs, the OAO National Outreach Contacts (NOCs; see Section VII), and the IAU EC and Divisions. For example, the regional offices can be used to stimulate

# 5 Goal 3

research collaborations with countries where astronomy researchers may be isolated. Partners from fields other than astronomy should also be included in this scheme. Indeed, an important goal of the OAD is to position young people for non-academic job opportunities in which they can apply the skills they have acquired in their career so far, as they are often in high demand.

Within the broad astronomy community the OAD will aim to engage with astronomers and other related professionals both from the perspective of "borrowing" their skills (e.g., applying data skills/computing resources to development challenges), and in terms of educating them about development matters.

Astronomy is an interdisciplinary field. In addition to the natural sciences (especially physics), astronomy connects with the space sector, branches of social sciences, relevant industries and NGOs, art and cultural organisations, and other "4dev" initiatives such as ICT for Development and Data for Development. With astronomy continuing to push the limits of technology in terms of instrumentation (including precision engineering, large infrastructures, systems engineering, etc.) and data (including large data sets, machine learning, data analytics and visualisation, etc.) the OAD must




*Example of multidisciplinary connections. All scientific disciplines have tools that they use in their fields. There are many overlaps, with similar tools being used in different sciences. These tools in turn can be used to drive various actions, borrowing other relevant tools from other science disciplines in order to optimise the actions. The actions in turn will influence one or several of the SDGs.*

engage with this important potential of astronomy and help influence society in the midst of the 4th industrial revolution.

The IAU is well positioned to lead this global conversation on science for development. The field of astronomy can lead other sciences in terms of the societal benefits of blue skies research, and also with regard to the value that science brings to challenges facing humanity. The OAD can be a "working space" for collaborations across sciences. The recent merger of the ICSU and ISSC clearly promotes such an approach. The diagram illustrates how various disciplines can come together to impact the SDGs, with astronomy being one part of a bigger "science-for-development" landscape.

## Actions for the OAD for the decade 2020–2030

– Contribute significantly to at least half of all SDG indicators; develop a number of global OAD "signature" projects.

– Establish enough regional offices to cover all populated regions of the world.

– Refine the OAD project evaluation and feedback loop.

– Use astronomy and its technology to position young people for career opportunities throughout society.

– Establish interdisciplinary partnerships around science for development.

– Source the necessary funding to realise the above and assist other related initiatives in fundraising.

# 6 Goal 4

The IAU engages the public in astronomy through access to astronomical information and communication of the science of astronomy.

**VII**
**Engage the public in astronomy**

**Office for Astronomy Outreach (OAO)**

The Office for Astronomy Outreach (OAO) coordinates public outreach activities and communication of science to the public. It was established in cooperation with the National Astronomical Observatory of Japan in 2012 to facilitate access of astronomical information to the public. Its long-term vision is: that all people throughout the world will have access to knowledge of frontline astronomy; that all countries will have good access to astronomical research, culture and experiences to help build a literate society; and that astronomers are a strong part of the global citizenship.

The central OAO function is "accessibility". The OAO generally does not create outreach material itself, but works with the IAU and other organisations to increase the impact of its activities. Outreach is a strong component of many different units within the IAU, and the OAO interfaces with all of them. For example, Commission C2, "Communicating Astronomy with the Public" (CAP), addresses astronomy communication and outreach issues, with the OAO editing the CAP journal as well as an Astronomy Outreach Newsletter. Also, the OAD conducts numerous actions related to public outreach in order to achieve SDGs (Section VI). By working together, both offices can maximise their synergies in the same area but with different goals. The OAO also takes part in EPO-like (Education and Public Outreach) activities, thus providing an interface with the newly proposed Office of Astronomy for Education (OAE; Section VIII).

Within the broader sense of "accessibilities," one of the primary directives of the OAO is to communicate astronomical results and make them more accessible to the general public in a larger number of countries than at present. It will do this through websites, emails and social media. Professional astronomers will be strongly encouraged to continue communicating astronomy to the public of all ages. To help reach larger audiences, the OAO will expand its translation network in the coming decade to manage and distribute astronomical results in several different languages.

To reach its long-term goals, OAO activities will include the provision of easily accessible public-friendly information on astronomical terminologies and objects in the Universe. Activities to connect professional and

amateur astronomers will be strengthened in the coming decade. The OAO also coordinates some of the worldwide citizen-science projects and campaigns, such as the public exoplanet naming competition in 2015–2016[6]. Taken together, the OAO activities contribute to providing inclusive resources globally and achieving a more diverse astronomical community.

The OAO coordinates and supports global outreach projects at the national level by maintaining a network of National Outreach Coordinators (NOCs), who can coordinate and advance projects in their country, as was done with great success during the 2009 International Year of Astronomy (IYA2009). Similarly, the NOCs are being mobilised for the IAU100 activities in 2019.

[6] *http://nameexoworlds.iau.org/*


*The Mitaka Solar System Walk in Japan, where each planet within the Solar System is introduced on a scale of one-14 billionth of its actual size.*

# 6 Goal 4

The NOCs are also the formal point of contact for engagement with amateur astronomy groups within each country. Furthermore, NOCs can play a role in helping to spread the word about the dark and quiet sky initiatives and to promote citizen science projects. In the coming years, the NOC system will be redefined, restructured and enlarged to ensure its effectiveness across the world.

## Actions for the OAO for the decade 2020–2030

– Increase the network of NOCs; restructure and ensure their effectiveness.

– Facilitate international communication through exchanges and translations.

– Provide open databases and public-friendly access to astronomical information.

– Encourage communication of science and critical thinking through IAU member public engagement, professional-amateur, and citizen science activities.

– Promote dark skies and the pale blue dot message.

*Credit: TWAN/Babak Tafreshi*

# 7 Goal 5

**VIII**

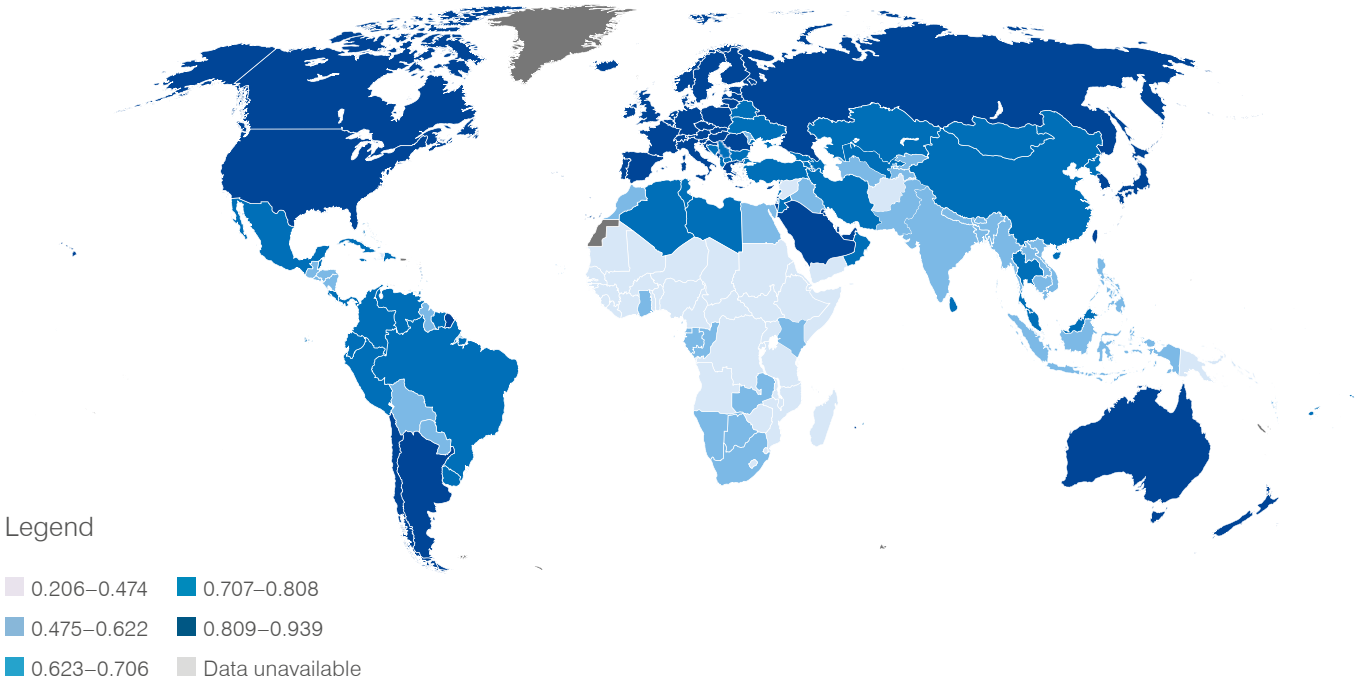
**Use astronomy for teaching and education at school level**

**Office of Astronomy for Education (OAE)**

## The IAU stimulates the use of astronomy for teaching and education at school level.

The International Schools for Young Astronomers (ISYAs) and the other schools and training seminars that are under the responsibility of the OYA are devoted to university students who are already pursuing an astronomical educational career. Equally important is the astronomical education available at lower levels, from elementary to high schools, not just to attract young people to astronomy but more broadly to encourage them to pursue a science career. The IAU's strategic vision from the 2010–2020 plan urged that astronomy be included, at the appropriate level, in the schools' syllabi of all countries. However, this is a much more complex challenge than that which is addressed by the more advanced astronomy schools successfully tackled by the OYA. While university educational programmes are highly uniform across the world, the teaching of STEM subjects in schools may vary considerably from country to country. Moreover, the ISYAs are directly offered to a limited number of selected students, while an educational action at levels below university potentially incorporates a huge target audience, a problem that cannot be addressed directly and centrally by the IAU.


*Galileomobile is an education initiative that brings astronomy to young people in areas with limited access to outreach programmes. Its constellation project involved 21 schools in 7 countries (Peru, Brazil, Bolivia, Colombia, Ecuador, Chile and Argentina), directly reaching at least 100 teachers and 6 000 students.*




*Global distribution of Education Index.*

Under the coordination of Commission 46 (until 2015), now commission C1 "Astronomy Education and Development," various educational activities at national level have been developed, such as the Network for Astronomy School Education (NASE), the Galileo Teacher Training Program (a legacy of IYA2009), Universe Awareness, and AstroEDU. The material produced under the auspices of AstroEDU has been tested and peer-reviewed by both astronomers and educators. These programmes, largely supported by volunteers and national funding, have built an extensive expertise on the challenges that a global astronomy education is facing. So far, teaching materials produced by IAU members have been translated from English to Spanish, Portuguese, Chinese Mandarin, Romanian, Indonesian, and French, with expansion to other languages anticipated in the future.

In order to provide more structured support to astronomy education in all countries, and to further encourage the use of astronomy as a stimulus for teaching in diverse areas, it is proposed to constitute the IAU Office of Astronomy for Education (OAE). The OAE will be established following a Call for Proposals and will have the following main objectives:

# 7 Goal 5

- Establish a network of National Astronomy Education Coordinators (NAECs). Similarly to the National Outreach Coordinator, the NAEC will represent the interface between the OAE and the community of teachers in his/her country who are potentially interested in astronomy teaching.
- Analyse, with the support of the NAECs, the use of astronomy in teaching in all the IAU countries and identify relevant actions: e.g., proposing modifications to school syllabi, organising teacher training and identifying adequate teaching material that is readily accessible and can be translated into the local language.
  - » Liaise with education ministries and curriculum experts to develop educational material tailored to needs of specific countries or groups.
- Encourage standards to be followed in the organisation of teacher training activities.
- Organise an annual International School for Astronomy Education (ISAE) adhering to these standards.
- Build a database of volunteer IAU members who are willing to contribute to the teacher training programme.

## Action

Create an Office of Astronomy for Education, which will
– establish a network of NAECs;
– analyse the use of astronomy in teaching in IAU countries and identify accessible materials and astronomy literacy guidelines;
– encourage standards for teacher training activities;
– organise an annual International School for Astronomy Education (ISAE);
– build a database of volunteer IAU members.

*ALMA and the centre of the Milky Way.*
*Credit: ESO/B. Tafreshi (twanight.org)*

# 8 Concluding thoughts

Astronomy combines top science, cutting-edge technology and education, while naturally inspiring and exciting the general public both young and old. As such, it can be an effective tool for furthering sustainable global development and addressing global societal challenges, drawing in scientists and experts from different domains. This strategic plan demonstrates that the IAU has evolved from an organisation focused primarily on scientific activities to one that stimulates, promotes and coordinates all of these aspects worldwide. In the coming decade, the IAU will further strengthen these activities and introduce new elements into its portfolio, aimed also at ensuring a younger, more diverse and inclusive astronomical community. The actions highlighted in this strategic plan span an enormous range, however, and can only be accomplished with the dedicated commitment and efforts of its members. New avenues for raising funds to enable several of these ambitions will also be needed.

"You can't cross the sea by merely standing and staring at the water" is an appropriate quote by the Indian philosopher Rabindranath Tagore to address these challenges. The IAU looks forward to working with its membership to make our dreams and vision into a reality, constructing the ships to cross the sea, and building bridges with other disciplines, thereby positioning our beautiful field to flourish for decades to come.

*The Milky Way as seen from Earth. Credit: Flickr/Peter Ozdzynski, CC BY-SA*

*Stellar nursery called Sharpless 29.
Credit: ESO*

*Laguna Miñiques in the Chilean Atacama Desert.*
*Credit: A. Duro/ESO*

# APPENDIX A Astronomy 2020–2030 — visions of the divisions

The Division Presidents and their Steering Committees have provided the following insights into the anticipated evolution of their scientific fields in the coming decade.

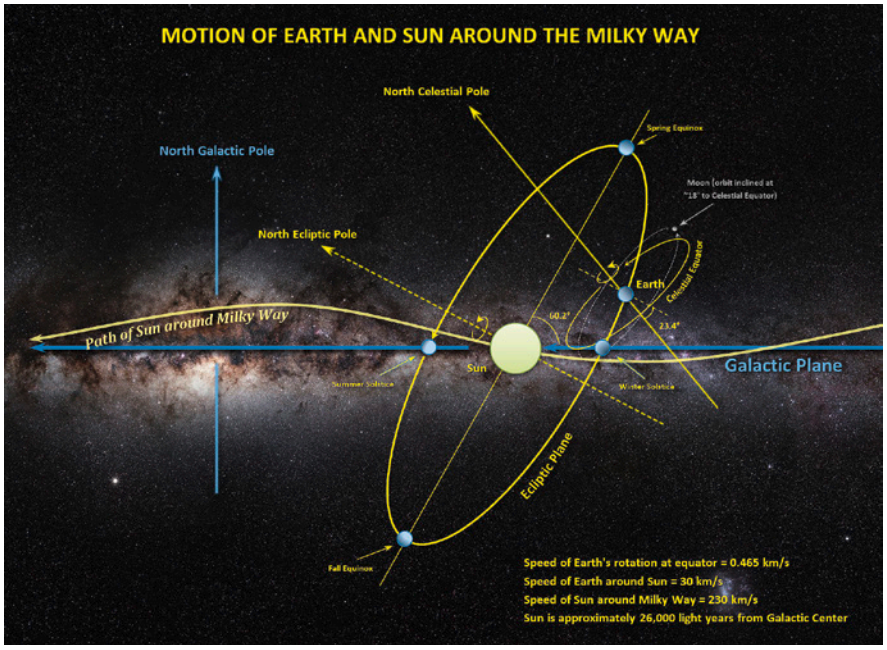
**Division A: Fundamental Astronomy**

Division A is concerned with fundamental astronomy: providing definitions and models that describe reference systems and frames used to determine positions and motions of celestial objects in space and time; investigating the dynamical behavior of celestial bodies; and testing physical laws using the methods of astrometry and celestial mechanics. It offers services that provide data and ephemerides of Solar System bodies, Earth orientation data, time scales, astronomical constants, and models including relevant software procedures, etc. for users within the astronomical community as well as within society. These basic questions themselves and the goals of Division A do not change over time, but they are being addressed with different insights and a continuous flow of new data.

The next decade will bring a huge quantity of new data, thanks to space missions such as *Gaia*. The main challenges will be: to confirm or dispute existing theories such as General Relativity or alternative theories; to determine precisely the numerical values of some of the Physics of Particles and Nuclei parameters, or a possible variation of the constant of gravitation; and to develop consistent and numerous reference systems, for time and positions. A related challenge is to connect all the new celestial and terrestrial reference frames and to include improvements in our knowledge of the Earth's rotation. A new astrometry system has to be designed, allowing a combination of past and future data.

Progress in fundamental physics, such as testing the universality of free fall, is expected to come from several space missions. The confirmation of the existence of gravitational waves has reopened discussions about the structure of the Universe and existence of the graviton.

Division A interacts with other Divisions on the availability of observations and the (re)calculation of the standards. The topics of interest for Division A are quite often connected to those of Division F. For example, for the Solar System, the dynamics of new populations of small bodies, like Earth crossers, is connected to our knowledge of their physical properties. The recent discussions about the presence of a ninth planet, a potential massive body perturbing the Kuiper Belt objects, have reopened a huge field of future investigations, with observations and theories going hand-in-hand.




*Motion of the Earth and the Sun around the Galactic Centre. Diagram not to scale.*
*Credit: Jim Slater, Background image: ESO/S. Brunier*

## Division B: Facilities, Technologies, and Data Science

Division B activities centre around the effective exchange of information and fostering of international collaboration on existing and future facilities, technologies and the methodologies for astrophysical inference from astronomical data. It involves scientists and engineers who design, develop, deploy, and operate the ground- and space-based hardware and software tools and systems necessary to advance our knowledge of the cosmos. The Division promotes contacts between astronomy and the commercial, technical and scientific world at large and its professional societies, including highlighting the benefit of astronomical innovation to society and as a driver for the high-tech industry. In the coming decade, Division B will foster enhanced cross-fertilisation with related science fields such as physics, informatics, data science, mathematics, technology and industry (through SPIE, Section III). Particular attention will be given in the next decade to future large-scale facilities and their ground-space synergy (see Section III).

Key technical initiatives of the coming decade include: (i) the development of instrumentation beyond the first-light complement for the extremely large telescopes; (ii) the development of next-generation space-based observatories beyond the current planned complement for NASA, ESA, JAXA, etc., including the technologies required for real performance advances in X-ray, UV, IR/sub-mm and gravitational waves — evolving CubeSat technology

# APPENDIX A Astronomy 2020–2030 — visions of the divisions

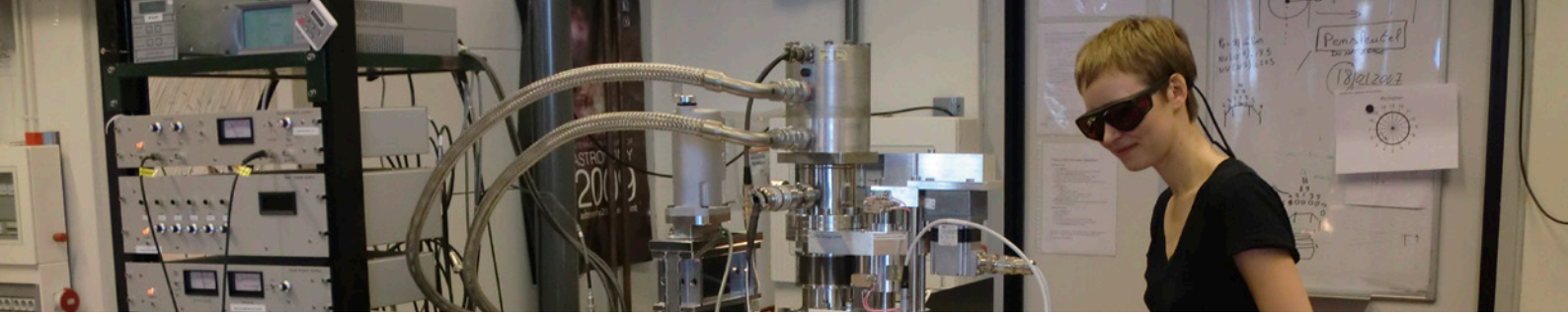
*The mechanical structure for the filter wheel of the MIRI instrument aboard the James Webb Space Telescope, developed at MPIA. Credit: MPIA*

is also directly relevant, and has key synergies with larger missions; (iii) the development of more sophisticated computational and statistical approaches for analysing data, particularly for Big Data instruments such as LSST, new solar telescopes, and radio interferometers; (iv) improvements in operational standards and infrastructure, particularly for appropriately prioritised prompt follow-up of time-domain alerts and coverage of needed cadences on variable sources; (v) the stimulation of basic laboratory studies to provide data needed to interpret and understand astronomical observations.

Division B recognises the IAU commitment to dark and quiet sky protection and helps to enable those goals through its Commission B7 in order to protect existing and potential observing sites (with Division C). The Commission plans to provide enhanced support for national and local efforts through web-based resources and links to related professional societies, thereby complementing the global efforts of the EC Working Group on dark and quiet skies (see Section III).

**Division C: Education, Outreach, and Heritage**

Division C seeks to further the development and improvement of all aspects of astronomy education, outreach, history and heritage. Education ranges from primary to tertiary level including both formal and informal education, and is informed by astronomy education research. The Division also promotes astronomy in developing countries. Outreach communicates with the public through a wide range of media and formats. Heritage includes the



*From the European Task Force on Laboratory Astrophysics. Credit: Leiden Observatory*

legacy of astronomical artefacts and structures as well as the astronomical attributes of mankind's cultural history, and benefits from close interactions with UNESCO. The history of astronomy is an active area. Division C has an interest in maintaining dark skies (with Division B, see Section III), as this has an impact on education and outreach as well as research.

The involvement of the IAU in education and history goes back about 50 years, but its involvement in outreach and heritage is much more recent and has been strong in just the last decade. Promoting all of these activities is important in order for astronomy to be appreciated and supported by the public. All four of these non-scientific aspects of the IAU mission will be strengthened in the coming decade, especially since Division C activities are closely aligned and coordinated with the OAD, OAO and OYA, as well as with the proposed OAE. Division C will provide the knowledge and act as a "think tank" for the offices.

*Stargazing with small telescopes at Mt. John Observatory, New Zealand, promotes education for young students and outreach for the public; both are core activities of Division C. Credit: Photo by Fraser Gunn, Lake Tekapo, NZ*

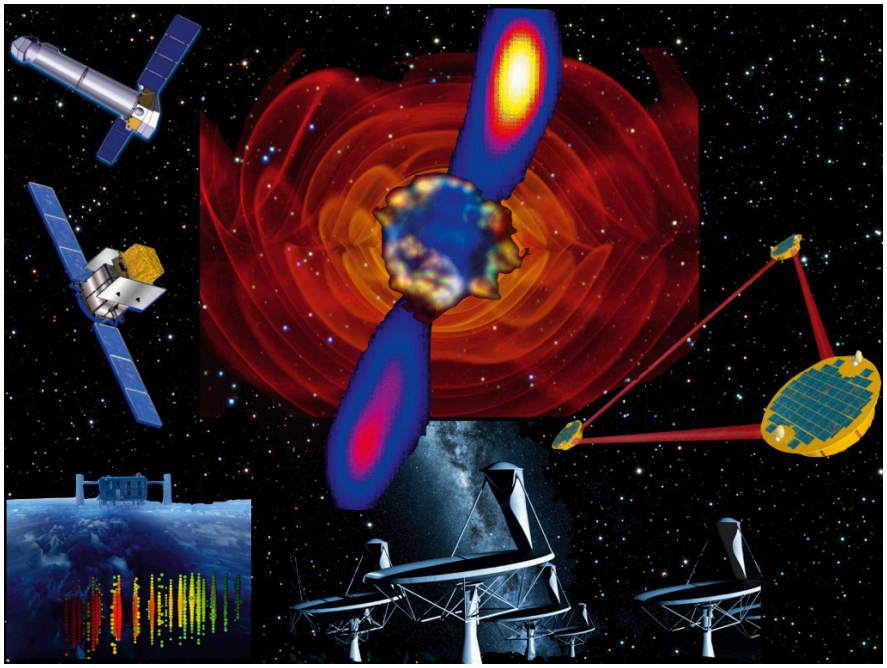
# APPENDIX A Astronomy 2020–2030 — visions of the divisions

## Division D: High Energy Phenomena and Fundamental Physics

Division D encompasses high-energy astrophysics including the components of multi-messenger astronomy, such as neutrinos and gravitational waves. In the last few years, gravitational astrophysics has taken off, new X-ray missions are flying — several are scheduled to launch soon — and its flagships and smaller missions are going strong, and ground-based observatories are constantly improving. Multi-messenger astrophysics is certainly coming of age. A Commission on gravitational waves and a supernovae standing Working Group are active and a new Commission on nuclear astrophysics/dense matter physics to link these disciplines together is being considered.

The next decade will see several facilities (ground- and space-based) coming online, devoted to multiple manifestations of strong gravity and high-energy astrophysics on various scales. New satellites will follow the legacy of past or present missions by continuing the detection and rapid follow-up of transients, in particular gamma-ray bursts. Others will: tackle fundamental properties of stellar and supermassive black holes, including the role of their spin in determining the motion and radiation from matter in the close vicinity of the black hole horizon; address the equation of state of neutron stars; and usher in a new era of gravitational wave signal detections. The need for a future wide-field observatory in the MeV-GeV range has also been recognised and promoted by the international gamma-ray community to make progress on, e.g., nucleosynthesis, particle acceleration, the effect of cosmic-ray feedback on galaxy evolution and the activity of the earliest AGN, and to complement multi-messenger studies.

On the ground, new gravitational wave interferometers will join the current network, making source localisations increasingly more accurate and facilitating fast follow-ups and identifications of multi-wavelength counterparts. Wide-field, high-cadence transient surveys in the optical and at high energy, and radio wavelengths, will return hundreds of variable source detections per night, thereby establishing the next decade as the era of multi-messenger time domain astrophysics. Observations combined with theoretical interpretations, numerical simulations, and modeling will, for example: address the nature of the progenitors of the most powerful explosions — core-collapse, thermonuclear, and superluminous supernovae and gamma-ray bursts; investigate relativistic jets on scales from stellar to megaparsec; study the nucleosynthesis of all elements in various regimes; and clarify the role of magnetic fields on many scales.



*In the next decade, several ground- and space-based facilities will be devoted to multi-messenger high-energy astrophysics, from gamma rays to gravitational waves and neutrinos. From top left to bottom right, ATHENA, e-ASTROGAM AMEGO, IceCube-Gen2+KM3NeT, SKA and LISA are shown. The central part of the figure illustrates different facets of high-energy astronomy such as the powering of relativistic jets, supernovae and kilonovae, and the production of gravitational waves when compact objects coalesce. Credit: Isabelle Grenier*

## Division E: Sun and Heliosphere

Division E encompasses the study of the Sun, its variability, activity and dynamics, as well as its impact on the Earth and other bodies located within the heliosphere. This field will have a great variety of opportunities in the next decade as a result of new generations of observations from ground- and space-based facilities across the electromagnetic spectrum, either fully or partly dedicated to solar/heliospheric physics. For example, a new mission will approach to within 8.5 solar radii of the surface of the Sun to help to solve the longstanding mysteries of solar-wind acceleration and coronal heating; another will provide close-up, high-latitude observations of the Sun to examine how it creates and controls the heliosphere; and the world's largest ground-based solar telescope will image the surface of the Sun in unprecedented detail.

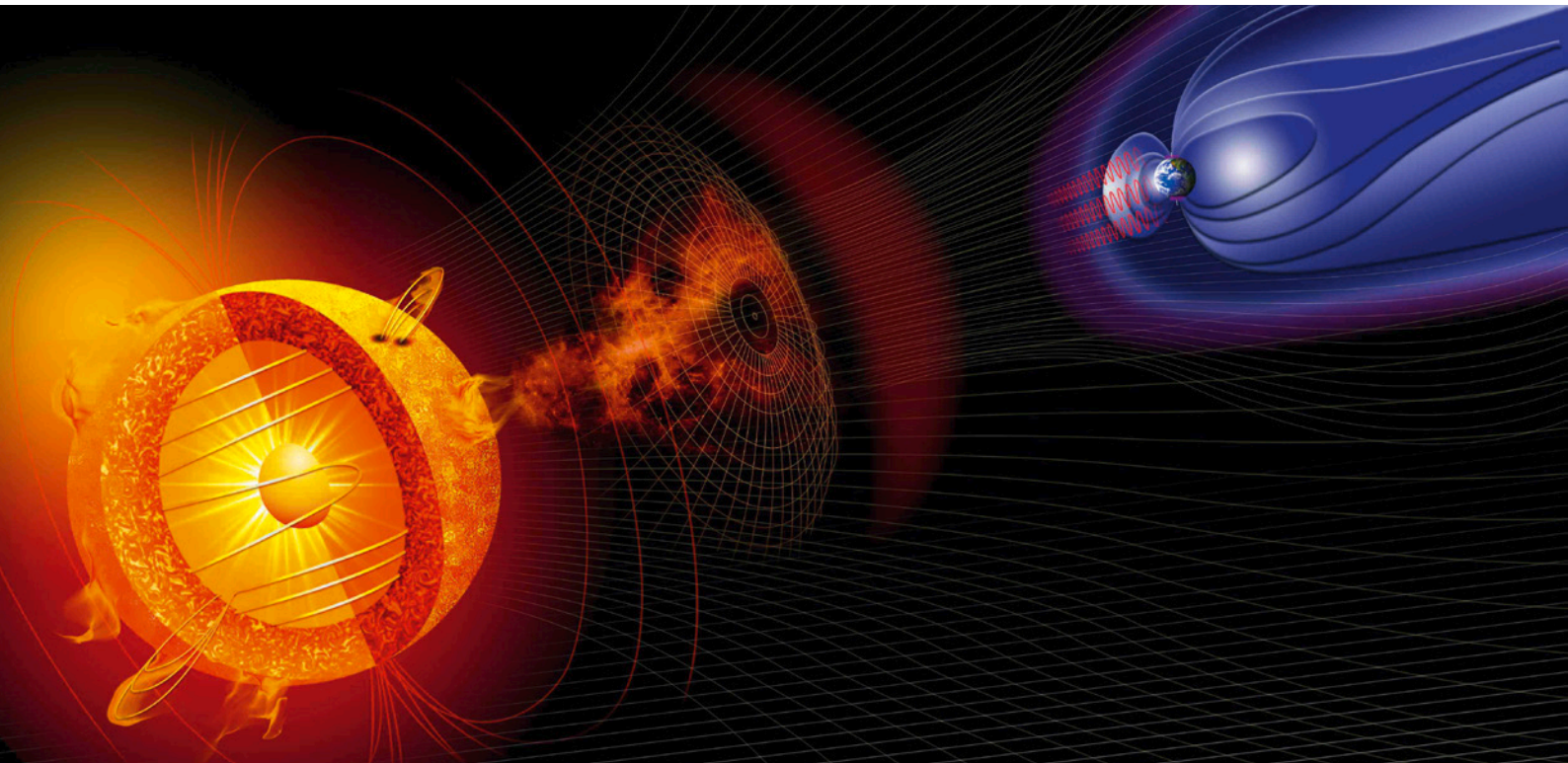
High-performance computing will enable the analysis of as-yet-unexplored physical regimes and help tackle Grand Challenge problems by bringing together multidisciplinary teams of theorists, observers, and data scientists. Specifically, connections between solar/heliospheric science and geospace/atmospheric science will aid in systematically understanding the

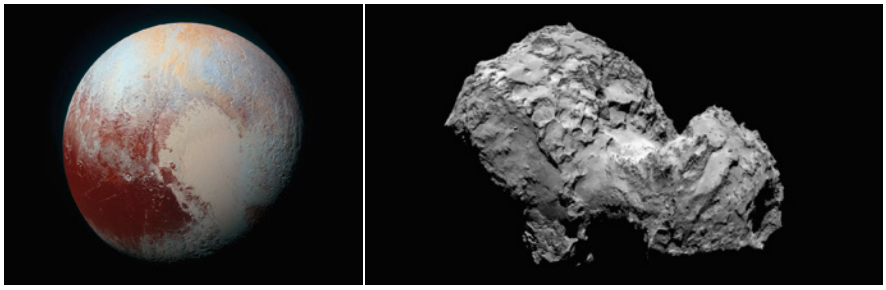
# APPENDIX A Astronomy 2020–2030 — visions of the divisions

basic processes of space weather and space climate. Connections with stellar physics will help understand the stellar dynamos and the importance of the host star's behaviour for planetary habitability. The new generation of observational data will stimulate theoretical developments aimed at answering fundamental questions of astrophysics and plasma physics such as the origin of solar and stellar magnetic activity cycles, the triggering mechanism for solar and stellar eruptions, the processes underlying magnetic reconnection, the heating mechanisms of the chromosphere and corona, the acceleration and propagation of energetic particles, and the potentially disastrous impacts that solar disturbances may have on the solar-terrestrial space environment.

The challenges include: ensuring continuity of solar and heliospheric observations, and the preservation and accessibility of archival data; developing new methods for using heterogeneous and high-volume data in driving and optimising models; enhancing the dialogue between astrophysicists and other Divisions challenged by the similar basic physics problems; and building bridges between basic and applied science, industry and the general public for the common benefit. In particular, the Sun via its activity influences the Earth's environment and human activity in space and on the ground, requiring the Division to work more closely with the space-weather operations community to better understand both the physics and the risks of extreme space weather events.

*The Sun's flares interact with Earth. Credit: NASA*





*New Horizon image of Pluto (left) and Rosetta image of comet 67 P/Churyumov-Gerasimenko. Credit: Left: NASA/JHUAPL/SwRI; Right: ESA/Rosetta/MPS for OSIRIS Team MPS/UPD/LAM/IAA/SSO/INTA/UPM/DASP/IDA*

## Division F: Planetary Systems and Bioastronomy

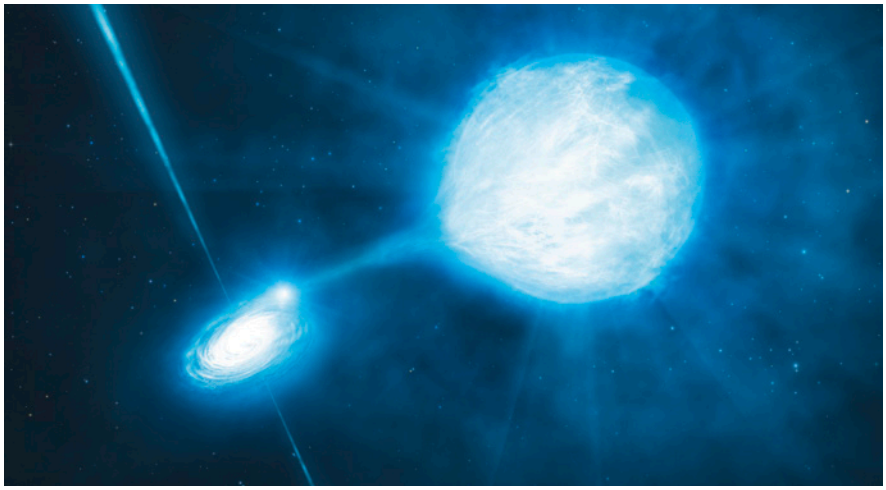
Division F deals with our Solar System, extrasolar planetary systems, and astrobiology. The Division promotes studies concerning planetary systems, including our own, aimed at the understanding of their formation and evolution, from the point of view of both their dynamics and physics and the occurrence of conditions favourable to the development of life in the Universe. Technological advances in observational astronomy during the past decade have revolutionised this field. These advancements can, in general, be divided into Solar System astronomy and extrasolar planetary science. Recent space missions such as Rosetta and New Horizons have provided a wealth of data on the physical characteristics of asteroids, comets and the outer Solar System. The success of the Kepler space telescope in discovering more than 4000 planetary systems has opened a new direction for research in planetary astronomy and habitability.

The goal of planetary astronomy is now to develop a much deeper understanding of the formation and evolution of our Solar System, and to extend those ideas to extrasolar planets by carrying out statistical analyses of these objects. It is towards the latter that the field is progressing. The construction and operation of large ground-based observatories combined with the operation of dedicated and multi-purpose space observatories will allow complementary observations of Solar System bodies and the discovery of more extrasolar planets. That will enable astronomers to characterise their atmospheric composition, a crucial step toward identifying potentially habitable planets. Ground-based radio and submillimetre telescope arrays will enable us to study the original environments where these planetary systems formed. Astrobiology, as an umbrella discipline, will continue to facilitate connections between these efforts and other areas of science related to habitability, and will become even more relevant and fundamental to the goals and mission of planetary astronomy.

# APPENDIX A Astronomy 2020–2030 — visions of the divisions

## Division G: Stars and Stellar Physics

Stars are the fundamental building blocks of the baryonic Universe. They produce energy, radiation, and chemical elements that shape the structures of the Universe from small to very large scales in both space and time. Understanding how they form, evolve, die, and interact with their environments is a fundamental challenge with deep implications for the proper description of the assembly and evolution of exoplanetary systems, of galaxies over cosmic time, and of the Universe as a whole. This requires multi-disciplinary developments in fundamental physics, including nuclear and particle physics, and cosmology.



*Artist's impression of a stellar-mass black hole stripping matter away from a Wolf-Rayet star. Credit: ESO/L. Calçada/M.Kornmesser*

Stellar astrophysics is in the midst of a revolution sparked by the large amounts of unprecedentedly detailed data being gathered for the first time with complementary multi-messenger techniques. Large high-resolution spectroscopic and photometric surveys coupled to ultra-high precision astrometry are providing chrono-chemo-kinematical information on the different stellar populations in the Milky Way and beyond. The maturing field of asteroseismology brings unrivaled information on stellar interiors together with constraints on fundamental stellar parameters and evolutionary clocks that are independent of the classical methods, for very large samples of stars over the entire Hertzsprung-Russell diagram. Interferometry and adaptive optics reveal details of stellar surfaces that it was until now only possible to see on the Sun, while spectropolarimetric observations coupled to tomographic techniques reveal the large-scale magnetic topologies of stars. Finally, the recent detection of gravitational waves brings a new means to study stars and their remnants using observational clues beyond

the electromagnetic spectrum. The coming decade will see the explosion of these techniques, thanks to the advent of extremely large telescopes and of dedicated instruments and space missions.

On the theoretical side, the challenges are significant and are at the frontiers of fundamental physics. Magnetohydrodynamical processes, as typically manifested through convection, mixing, rotation, magnetic activity, winds, interactions in multiple systems and interplay with interstellar surroundings, remain the largest uncertainty in modern stellar astrophysics. The crucial implications of this area of study range from cosmic re-ionisation and distance ladders to galactic evolution and exoplanet habitability. The growth of computational resources to simulate stellar magnetohydrodynamics, from the formation of stars to the explosions of supernovae, holds promise for substantial improvements in the next decade, in synergy with astrostatistics and big data science.

**Division H: Interstellar Matter and Local Universe**

Division H centres on the study of the interstellar medium (ISM) and the stars in our Milky Way and in nearby galaxies (out to ~ 15 Mpc). The ISM and stars, the two major visible components of a galaxy, are coupled to each other through star formation, stellar feedback, and their gravitational potential. Many key topics in Division H will be among the fastest growing research areas in astronomy in the next decade. New millimetre-wave telescopes will map local star-forming regions and protoplanetary discs in the Milky Way and Local Group galaxies with unprecedented detail using molecular emission lines that trace the dynamical and physical state of the gas, chemistry and dust. New arrays will revolutionise centimetre-wave and metre-wave radio astronomy by discovering and studying pulsars and mapping magnetic fields, ionisation regions, and supernova remnants, as well as monitoring activity in the Galactic Centre. These new facilities will also map neutral hydrogen and diffuse-phase molecules at new levels of sensitivity in nearby galaxies. Large ground-based surveys will study variable stars and discover transient and lensed optical sources in our Local Group, and map the Local Universe to extreme depth in optical bands using long accumulated exposure times. Spectral survey instruments will determine the abundances and velocities of millions of stars.

The *Gaia* satellite will map the structure and dynamics of stars over more than half of the Milky Way disc, revealing the thick and thin disc components along with the extent of the bulge and halo, and determining the activity of density waves and stellar dispersal after birth. Wide-field infra-

# APPENDIX A Astronomy 2020–2030 — visions of the divisions

red survey satellites will map the Local Group and discover small extrasolar planets through microlensing. The JWST will observe the Galactic disc and nearby galaxies at high resolution in the infrared, showing the formation, internal structure and dispersal of OB associations, star clusters, and individual stars. Galactic X-ray sources will be studied with high-energy satellites, while the highest energy messengers, cosmic rays and gamma rays, will be studied by ground-based arrays. These and other instruments will map the main components of the Milky Way and Local Group with unprecedented depth, spectral range, and time coverage.

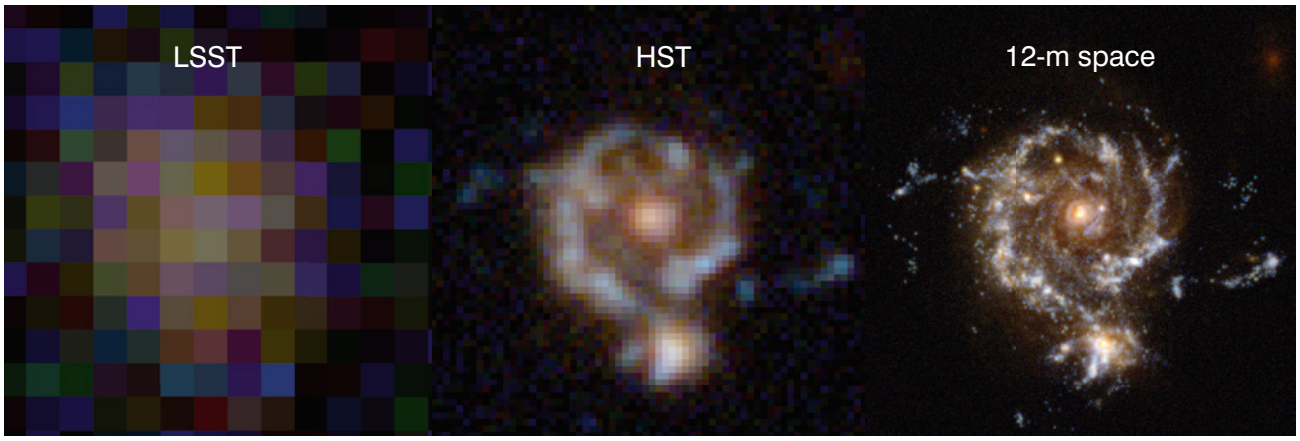
The next generation of extremely large optical telescopes that will become operational in the second half of the next decade will enable observations of even finer detail, e.g., of protostellar discs and the dense cores of star clusters. Laboratory astrophysics combined with quantum computational chemistry and chemical models will provide better information on gas- and dust-phase chemical processes and opacities, the formation of the ever more complex molecules being detected in star-forming regions, and their use as physical diagnostics. Continued improvements in computational power will allow numerical studies to simulate most of these observations over a wide range of scales, aiding our understanding of how the Milky Way and Local Group galaxies assemble and evolve.

**Division J: Galaxies and Cosmology**

Division J covers all themes dealing with the physics of the distant Universe, and the physics of galaxies composing it. This includes the physics and content of the (early) Universe, the evolution of structure, the formation and evolution of galaxies, and spatially resolved galaxies. Major advances are expected in key areas in the coming decade, driven by powerful new facili-

*Spitzer Space Telescope GLIMPSE image measuring 2 degrees in latitude and 3 degrees in longitude around the galactic centre, with starlight at 3.6 μm (blue), PAH emission at 8.0 μm (green) and warm thermal dust emission at 24 μm (red), illustrating the different components of a galaxy. Credit: Edward Churchwell, Bob Benjamin, Brian Babler, Marilyn Meade, Barbara Whitney and the GLIMPSE team, 2017*

ties, progress in theory, and in Big Data science. The new facilities include space observatories such as the JWST, wide-field infrared telescopes, X-ray telescopes, ground-based wide-field observatories, extremely large optical telescopes, and radio and submillimetre arrays. The synergy between these observatories will enable a multi-frequency approach, which will provide an unprecedented wealth of data. The road ahead will be shaped by Big Data science.




*Three-colour composite images of a distant Milky Way-mass galaxy at redshift $z = 2$ in a high-resolution cosmological simulation, demonstrating the spatial resolving power of LSST, HST, and a 12-m space telescope mission. Credit: G. Snyder*

These facilities will allow astronomers to tackle the nature of the dark sector: dark matter and dark energy. Deep fields will unveil the large-scale structure of the Universe, with a detailed chronology of its history back to the epoch of reionisation. Future centimetre-wave arrays are expected to measure the fluctuations and evolution in the 21-cm signature of the epoch of reionisation, which will be a major boost to the study of early galaxy formation, from the perspective of both observations and cosmological simulations and theory.

The new generation of instruments, from the X-ray to radio, with much improved sensitivity in the infrared, will provide a census of galaxies at any epoch. Together with the large statistical value of large surveys, this will enable us to determine how a galaxy forms and evolves and how its star formation is quenched, in the field as well as in rich environments such as galaxy clusters. This will allow a detailed understanding of the cosmic star formation density and its history across the Hubble time, as well as the cosmic growth of supermassive black holes.

# APPENDIX B List of commissions and working groups

## Commissions

| | Commission Name | Parent Division(s) |
|---|---|---|
| A1 | Astrometry | A |
| A2 | Rotation of the Earth | A |
| A3 | Fundamental Standards | A |
| B1 | Computational Astrophysics | B |
| B2 | Data and Documentation | B |
| B3 | Astroinformatics and Astrostatistics | B |
| B4 | Radio Astronomy | B |
| B5 | Laboratory Astrophysics | B |
| B6 | Astronomical Photometry and Polarimetry | B |
| C1 | Astronomy Education and Development | C |
| C2 | Communicating Astronomy with the Public | C |
| C3 | History of Astronomy | C |
| C4 | World Heritage and Astronomy | C |
| D1 | Gravitational Wave Astrophysics | D |
| E1 | Solar Radiation and Structure | E |
| E2 | Solar Activity | E |
| E3 | Solar Impact Throughout the Heliosphere | E |
| F1 | Meteors, Meteorites and Interplanetary Dust | F |
| F2 | Exoplanets and the Solar system | F |
| F3 | Astrobiology | F |
| G1 | Binary and Multiple Star Systems | G |
| G2 | Massive Stars | G |
| G3 | Stellar Evolution | G |
| G4 | Pulsating Stars | G |
| G5 | Stellar and Planetary Atmospheres | G |
| H1 | The Local Universe | H |
| H2 | Astrochemistry | H |
| H3 | Planetary Nebulae | H |

## Inter-Division Commissions

| | Commission Name | Primary Division | Parent Division(s) |
|---|---|---|---|
| A4 | Celestial Mechanics and Dynamical Astronomy | A | A, F |
| B7 | Protection of Existing and Potential Observatory Sites | B | B, C |
| H4 | Stellar Clusters through-out Cosmic Space and Time | H | G, H, J |
| J1 | Galaxy Spectral Energy Distributions | J | D, G, H, J |
| J2 | Intergalactic Medium | J | B, H, J |

## Cross-Division Commissions

| | Commission Name | Parent Division(s) |
|---|---|---|
| X1 | Supermassive Black Holes, Feedback and Galaxy Evolution | D, J |
| X2 | Solar System Ephemerides | A, F |

## Working Groups

| Commission Working Group | Parent Commission |
|---|---|
| Theory of Earth Rotation and Validation (IAU / IAG Joint WG) | A2 |
| Historic Radio Astronomy | B4 |
| High-Accuracy Stellar Spectroscopy | B5 |
| Spectroscopic and Radiative Data for Molecules | B5 |
| Site Protection | B7 |
| Technical Working Group | B7 |
| Astronomy for Equity and Inclusion | C1 |
| Network for Astronomy School Education (NASE) | C1 |
| Theory and Methods in Astronomy Education | C1 |
| CAP Conferences | C2 |
| CAP Journal | C2 |
| Outreach Professionalization & Accreditation | C2 |
| Public Outreach Information Management | C2 |
| Science Communication Research in Astronomy | C2 |
| Johannes Kepler | C3 |
| Astronomical Heritage in Danger | C4 |
| Classical Observatories from the Renaissance to the 20th Century | C4 |
| Heritage of Space Exploration | C4 |
| Solar Irradiance | E1 |
| Meteor Shower Nomenclature (MSN-WG) | F1 |
| Stellar Spectral Libraries | G1 |
| Reference Library of Galaxy Spectral Energy Distributions (RELIGAS) | J1 |

# APPENDIX B List of commissions and working groups

| Division Working Group | Parent Division | |
|---|---|---|
| Astrometry by Small Ground-Based Telescopes | A | |
| Multi-waveband Realisations of International Celestial Reference System | A | |
| Numerical Standards in Fundamental Astronomy (NSFA) | A | Functional |
| Standards of Fundamental Astronomy (SOFA) | A | Functional |
| Third Realisation of International Celestial Reference Frame | A | |
| Time Metrology Standards | A | Functional |
| Information Professionals | B | |
| Time Domain Astronomy | B | |
| UV Astronomy | B | |
| Star Names | C | |
| Supernovae | D | Functional |
| Impact of Magnetic Activity on Solar and Stellar Environments | E | |
| Near Earth Objects | F | |
| Planetary System Nomenclature (WGPSN) | F | Functional |
| Small Bodies Nomenclature (SBN) | F | Functional |
| Abundances in Red Giants | G | |
| Active B Stars | G | |
| Ap & Related Stars | G | |
| The Galactic Center | H | |

| Executive Committee Working Group | Parent body |
|---|---|
| Dark and Quiet Sky Protection | Executive Committee |
| Global Coordination of Ground and Space Astrophysics | Executive Committee |
| Women in Astronomy | Executive Committee |

| Inter-Commission Working Group | Parent Commissions |
|---|---|
| Data Driven Astronomy Education and Public Outreach (DAEPO) | B2, C1, C2 |
| From Databases to Spectral Energy Distributions (DB2SED) | B2, J1 |
| Achieving Sustainable Development within a Quality Lighting Framework | B7, C1 |
| Windows to the Universe: High-Mountain Observatories, and Other Astronomical Sites of the Late 20th and Early 21st Centuries | B7, C4 |
| Intangible Astronomical Heritage | C1, C4 |
| Education and Training in Astrobiology | C1, F2, F3, H2 |
| Archaeoastronomy and Astronomy in Culture | C3, C4 |

| Inter-Division Working Group | Parent Divisions | |
|---|---|---|
| Cartographic Coordinates & Rotational Elements | A, F | Functional |
| Coordination of Synoptic Observations of the Sun | B, E | Functional |
| Solar Eclipses | C, E | Functional |

# APPENDIX C Acronyms

**APRIM**: Asian-Pacific Regional IAU Meeting
**ATHENA**: Advanced Telescope for High ENergy Astrophysics
**CAP**: Communicating Astronomy with the Public
**COPUOS**: Committee on the Peaceful Uses of Outer Space
**COSPAR**: Committee on Space Research
**CUP**: Cambridge University Press
**EC**: Executive Committee
**ESA**: European Space Agency
**FM**: Focus Meeting
**GA**: General Assembly
**GeV**: Billion electron volts
**JAXA**: Japan Aerospace Exploration Agency
**JWST**: James Webb Space Telescope
**IAU**: International Astronomical Union
**ICSU**: International Council for Science
**ISAE**: International School for Astronomy Education
**ISC**: International Science Council
**ISSC**: International Social Science Council
**ISYA**: International School for Young Astronomers
**IUCN**: International Union for the Conservation of Nature
**IYA**: International Year of Astronomy
**LARIM**: Latin-American Regional IAU Meeting
**LISA**: Laser Interferometer Space Antenna
**LOAD**: Language expertise centre for the Office of Astronomy for Development
**MEARIM**: Middle-East and Africa Regional IAU Meeting
**MeV**: Million electron volts
**MOU**: Memorandum Of Understanding
**Mpc**: Megaparsec
**NASA**: National Aeronautics and Space Administration
**NASE**: Network for Astronomy School Education
**NAOJ**: National Astronomical Observatory of Japan
**NAEC**: National Astronomy Education Coordinator
**NOC**: National Outreach Contact
**OAD**: Office of Astronomy for Development
**OAE**: Office of Astronomy Education
**OAO**: Office of Astronomy for Outreach
**OYA**: Office for Young Astronomers
**ROAD**: Regional Office for Astronomy Development
**SDG**: UN Sustainable Development Goals

**SKA**: Square Kilometre Array
**SPIE**: International society for optics and photonics (originally called the Society of Photographic Instrumentation Engineers)
**STEM**: Science, Technology, Engineering, Mathematics
**Sub-mm**: sub-millimetre
**TGF**: The Gruber Foundation
**UNESCO**: United Nations Educational, Scientific and Cultural Organization
**URSI**: International Union of Radio Science
**UV**: UltraViolet
**WG**: Working Group
**WiA**: Women in Astronomy
**YAM**: Young Astronomers Meeting

# APPENDIX D IAU Executive Committee 2015–2018

**President:**
Silvia Torres-Peimbert (Mexico)

**President-Elect:**
Ewine F. van Dishoeck (Netherlands)

**General Secretary:**
Piero Benvenuti (Italy)

**Assistant General Secretary:**
Maria T. V. T. Lago (Portugal)

**Vice-Presidents:**
Debra M. Elmegreen (USA)
Ajit K. Kembhavi (India)
Renée C. Kraan-Korteweg (South Africa)
Xiaowei Liu (China)
Dina K. Prialnik (Israel)
Boris M. Shustov (Russian Federation)

**Advisor:**
Past President Norio Kaifu (Japan)

*The VLT and the radiant Milky Way.*
*Credit: G. Hüdepohl (atacamaphoto.com)/ESO*

# APPENDIX E IAU Division Presidents 2015–2018

A. **Fundamental Astronomy:**
Anne Lemaître

B. **Facilities, Technologies and Data Science:**
Pietro Ubertini

C. **Education, Outreach, and Heritage:**
John Hearnshaw

D. **High Energy Phenomena and Fundamental Physics:**
Chryssa Kouveliotou

E. **Sun and Heliosphere:**
Yan Yihua

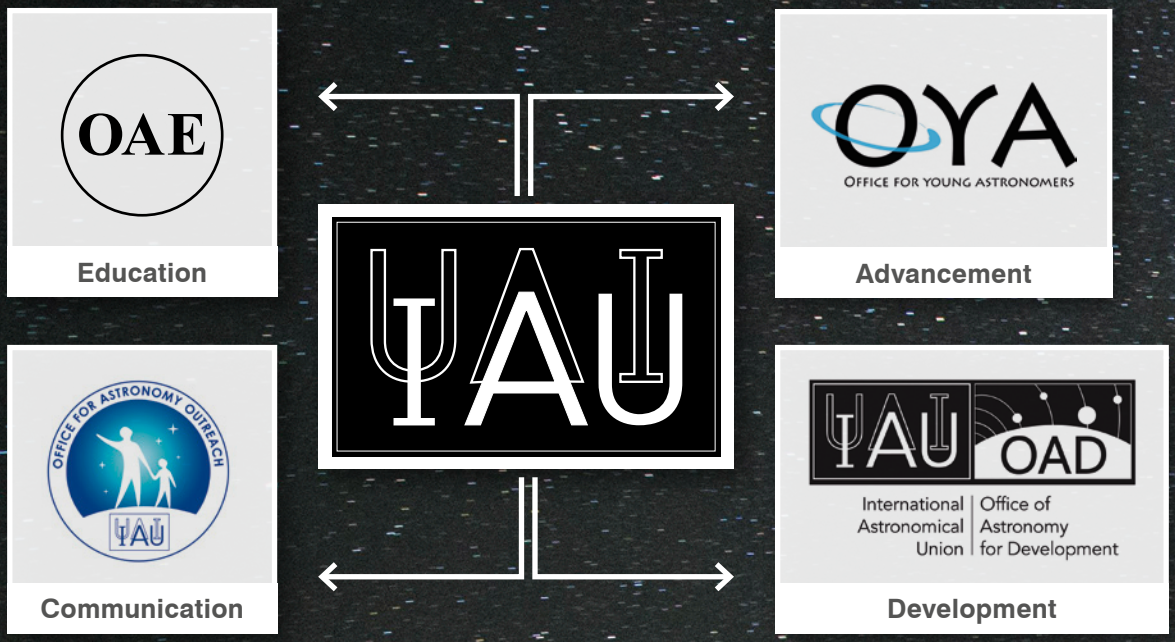
F. **Planetary Systems and Bioastronomy:**
Nader Haghighipour

G. **Stars and Stellar Physics:**
Corinne Charbonnel

H. **Interstellar Matter and the Local Universe:**
Bruce Elmegreen

I. **Galaxies and Cosmology:**
Claus Leitherer

*The Omega Nebula. Credit: ESO*




*Credit cover image: Billy Rudiger*