Leibniz Gemeinschaft

Der Senat

22. November 2022

Stellungnahme zum
Leibniz-Institut für Astrophysik Potsdam (AIP)

Inhaltsverzeichnis

Anlage A: Darstellung

Anlage B: Bewertungsbericht

Anlage C: Stellungnahme der Einrichtung zum Bewertungsbericht

Vorbemerkung

Die Einrichtungen der Forschung und der wissenschaftlichen Infrastruktur, die sich in der Leibniz-Gemeinschaft zusammengeschlossen haben, werden von Bund und Ländern wegen ihrer überregionalen Bedeutung und eines gesamtstaatlichen wissenschaftspolitischen Interesses gemeinsam gefördert. Turnusmäßig, spätestens alle sieben Jahre, überprüfen Bund und Länder, ob die Voraussetzungen für die gemeinsame Förderung einer Leibniz-Einrichtung noch erfüllt sind.[1]

Die wesentliche Grundlage für die Überprüfung in der Gemeinsamen Wissenschaftskonferenz ist regelmäßig eine unabhängige Evaluierung durch den Senat der Leibniz-Gemeinschaft. Die Stellungnahmen des Senats bereitet der Senatsausschuss Evaluierung vor.

Für die Bewertung einer Einrichtung setzt der Ausschuss Bewertungsgruppen mit unabhängigen, fachlich einschlägigen Sachverständigen ein. Der für das AIP zuständigen Gruppe stand eine von der Einrichtung erstellte Evaluierungsunterlage zur Verfügung. Die wesentlichen Aussagen dieser Unterlage sind in der Darstellung (Anlage A dieser Stellungnahme) zusammengefasst.

Wegen der Corona-Pandemie musste der für den 10. und 11. Februar 2022 vorgesehene Evaluierungsbesuch am AIP in Potsdam entfallen. Die Bewertung erfolgte im Rahmen eines Ersatzverfahrens, das der Senatsausschuss Evaluierung (SAE) in Umsetzung eines Grundsatzbeschlusses des Senats vom 31. März 2020 eingerichtet hat. Der Senat hält in diesem Grundsatzbeschluss fest, dass das Ersatzverfahren ein Notbehelf ist und ausschließlich auf Einrichtungen angewendet wird, die im Regelturnus von sieben Jahren evaluiert werden. Die Bewertungen, auf deren Grundlage der Senat Stellung nimmt, sind auf zentrale Kernfragen der Entwicklung und Perspektive einer Leibniz-Einrichtung fokussiert. Ausführliche Einschätzungen und Schlussvoten zu Teilbereichen und Planungen für „kleine strategische Sondertatbestände“ müssen regelmäßig entfallen.

Die Bewertungsgruppe erstellte den Bewertungsbericht (Anlage B). Das AIP nahm dazu Stellung (Anlage C). Der Senat der Leibniz-Gemeinschaft verabschiedete am 22. November 2022 auf dieser Grundlage die vorliegende Stellungnahme. Der Senat dankt den Mitgliedern der Bewertungsgruppe und des Senatsausschusses Evaluierung für ihre Arbeit.

1. Beurteilung und Empfehlungen

Der Senat schließt sich den Beurteilungen und Empfehlungen der Bewertungsgruppe an.

Das Leibniz-Institut für Astrophysik Potsdam (AIP) führt astrophysikalische Grundlagenforschung durch und entwickelt Instrumente für den Einsatz in Riesenteleskopen und Satelliten. Die Arbeiten umfassen das gesamte Spektrum der Astronomie von der Sonnenphysik bis hin zu hochrotverschobenen Galaxien. Das Institut ist gegliedert in zwei Forschungsbereiche, die von je einem Direktor verantwortet werden, sowie in einen von beiden gemeinsam geleiteten Bereich zur Entwicklung von Instrumenten. Die drei Bereiche sind in insgesamt zwölf Sektionen unterteilt.

[1] Ausführungsvereinbarung zum GWK-Abkommen über die gemeinsame Förderung der Mitgliedseinrichtungen der Wissenschaftsgemeinschaft Gottfried Wilhelm Leibniz e. V.

Alle drei Forschungsbereiche erbringen hervorragende **Leistungen.** Das AIP erarbeitet ausgezeichnete Forschungsergebnisse, die regelmäßig in stark rezipierten Zeitschriften veröffentlicht werden. Die bereits zur Zeit der vergangenen Evaluierung beeindruckende Publikationsleistung wurde noch einmal verbessert. Eine besondere Stärke des AIP liegt in der Entwicklung von Instrumenten, die in den weltweit größten Teleskopen oder in Satelliten-Missionen zum Einsatz kommen. Das AIP nimmt dabei in großen internationalen Verbünden oft führende Positionen ein. So wirkt das AIP gegenwärtig maßgeblich mit an der Entwicklung von zwei wichtigen Instrumenten (ANDES und MOSAIC) für das *Extremely Large Telescope* (ELT) der Europäischen Südsternwarte (ESO) in Chile. Die Inbetriebnahme des ELT und der beiden Geräte wird in etwa zehn Jahren erwartet. Da die Mitwirkung an diesen großen Projekten einen erheblichen Ressourceneinsatz erfordert, ist es unumgänglich, dass das AIP wie geplant seine Beteiligung an anderen Forschungsinstrumenten strategisch gut begründet reduziert. Das AIP betreibt auch erfolgreich Technologietransfer. Es verfügt über mehrere Patente und am AIP entwickelte Instrumente werden in die Anwendung auch außerhalb der Astrophysik überführt, z. B. in den Bereich der Medizintechnik.

Seit der letzten Evaluierung wurden unter anderem die Leitungen von fünf Sektionen neu besetzt. Diese sehr gut gestalteten personellen Veränderungen gingen mit sinnvollen Veränderungen und Anpassungen des AIP-Forschungsprofils einher. In den nächsten Jahren stehen erneut wichtige Wechsel auf der Leitungsebene an. Insbesondere wird im Jahr 2025 einer der beiden wissenschaftlichen Direktoren in den Ruhestand treten. Zudem werden bis 2028 vier weitere leitende Wissenschaftler pensioniert werden.

Das AIP hat mit seinen Gremien eine überzeugende **Zukunftsstrategie** entwickelt, die eng mit den europäischen Entwicklungen verzahnt ist (s. o.). Ziel ist es, das neue, äußerst vielversprechende Thema *Precision Stellar Science* am AIP zu etablieren. Dafür wird ein neuer Forschungsbereich aufgebaut werden. Für die Leitung richtet das AIP aus dem bestehenden Kernhaushalt eine dritte Direktorenstelle ein. Insgesamt plant das AIP für die Finanzierung der vorgesehenen Maßnahmen in erheblichem Maße eigene Mittel umzuverteilen (ca. 1,2 Mio. € p. a.). Darüber hinaus sieht das Institut einen Bedarf von dauerhaft zusätzlichen Mitteln in Höhe von 2 Mio. € p. a. für laufende Maßnahmen sowie von einmalig 2 Mio. € als Beitrag zu den Baukosten für ANDES und MOSAIC. Der Senat begrüßt die Pläne des AIP, eine Erhöhung der institutionellen Bund-Länder-Förderung zu beantragen.

Die Drittmitteleinnahmen des Instituts sind mit etwa 40 % des **Gesamtbudgets** sehr hoch. Wie empfohlen wirbt das AIP nun auch auf europäischer Ebene Mittel ein; hervorzuheben sind dabei sechs *ERC grants*. Die Raumsituation am Institut wird sich durch den Bau eines neuen Gebäudes verbessern, dessen Fertigstellung für 2024 vorgesehen ist.

Das AIP **kooperiert** eng mit der Universität Potsdam. Derzeit sind die beiden Direktoren (W3) und fünf Sektionsleitungen (W2) gemeinsam berufen. Neben der anstehenden ruhestandsbedingten Neubesetzung einiger dieser Positionen (eine W3 und zwei W2) soll eine weitere gemeinsame Berufung (W3) für die Leitung des geplanten neuen Forschungsbereichs erfolgen. Das AIP hat gemeinsam mit der Universität einen Masterstudiengang entwickelt, der sehr stark nachgefragt wird. Auch auf nationaler und internationaler Ebene ist das AIP sehr gut vernetzt und weithin sichtbar.

Das AIP fördert **Promovierende und Postdocs** sehr gut. Ihnen stehen die Angebote der Graduiertenschule der Universität Potsdam offen. Das AIP sollte wie geplant weitere eigene Maßnahmen wie z. B. ein Mentoringprogramm anbieten, um die Karriereentwicklung seiner Mitarbeiterinnen und Mitarbeiter noch zielgerichteter zu unterstützen.

Es wird begrüßt, dass das AIP seit der letzten Evaluierung den Frauenanteil beim wissenschaftlichen Personal von 22 % auf 28 % erhöht hat. Dies gelang vor allem durch eine sehr erfreuliche Erhöhung des Anteils der Doktorandinnen, der von einem Drittel auf über die Hälfte stieg (15 Frauen, 14 Männer). Beim weiteren wissenschaftlichen Personal ist die Situation unverändert: Unter den 70 nicht-leitenden Beschäftigten sind 16 Frauen (23 %). Von den 18 Positionen auf Leitungsebene (2 Direktoren, 12 Sektionen, 4 Gruppen) sind nur zwei mit **Wissenschaftlerinnen** besetzt. Beide wurden im Zuge der fünf Neubesetzungen von Sektionsleitungen in der Zeit seit der letzten Evaluierung eingestellt. Das AIP muss daran anknüpfend auch die anstehenden Wechsel nutzen, um weitere Verbesserungen zu erreichen, insbesondere auf der Ebene der Direktorinnen bzw. Direktoren und der Sektionsleitungen. Der Senat begrüßt, dass das Institut dies aktiv angeht.

Die **Gremien** des AIP begleiten das Institut sehr gut. Der Senat begrüßt, dass das Institut und das zuständige Fachressort des Sitzlands bereits die Empfehlung aufgegriffen haben, die Mitgliedschaft des Vorsitzes des Wissenschaftliches Beirats im Kuratorium ohne Stimmrecht vorzusehen, wie dies an Leibniz-Einrichtungen der Regelfall ist. Es wird erwartet, dass die Verantwortlichen dies zügig in der Stiftungssatzung verankern.

Das AIP führt Forschungen in der gesamten Breite der modernen Astrophysik durch und entwickelt zu diesem Zweck neuartige astrophysikalische Instrumente. Diese Aufgaben lassen sich in dieser Form nicht an einer Hochschule erfüllen. Eine Eingliederung des AIP in eine Hochschule wird daher nicht empfohlen. Das AIP erfüllt die Anforderungen, die an eine Einrichtung von überregionaler Bedeutung und gesamtstaatlichem wissenschaftspolitischem Interesse zu stellen sind.

2. Zur Stellungnahme des AIP

Der Senat begrüßt, dass das AIP beabsichtigt, die Empfehlungen und Hinweise aus dem Bewertungsbericht bei seiner weiteren Arbeit zu berücksichtigen.

3. Förderempfehlung

Der Senat der Leibniz-Gemeinschaft empfiehlt Bund und Ländern, das AIP als Einrichtung der Forschung und der wissenschaftlichen Infrastruktur auf der Grundlage der Ausführungsvereinbarung WGL weiter zu fördern.

20 January 2022

Annex A: Status report

Leibniz Institute for Astrophysics Potsdam (AIP)

Contents

1. Key data, structure and tasks

Key data

Year established:	1700
Admission to joint funding by Federal and *Länder* Governments:	1992
Admission to the Leibniz Association:	1992
Last statement by the Leibniz Senate:	2015

Legal form:	Foundation under civil law
Responsible department at *Länder* level:	Ministry of Science, Research and Culture of the State of Brandenburg (MWFK)
Responsible department at Federal level:	Federal Ministry of Education and Research (BMBF)

Total budget (2020)

€ 13.1 m institutional funding

€ 9.0 m revenue from project grants

Number of staff (2020)

117 individuals in research and scientific services

51 individuals in science supporting staff (laboratories, technical support etc.)

23 individuals in administration

Mission and structure

According to its statutes, AIP is a foundation with the mission to conduct scientific research in the area of astrophysics. The institute participates in education and training as well as in the dissemination of knowledge and transfer.

The science programme of the institute is organized in the two research areas *Cosmic Magnetic Fields* and *Extragalactic Astrophysics*, each headed by a director. They are complemented by the research & development area *Development of Research Technology and Infrastructure*, which is supervised by both directors. All three areas are further divided into sections (see organisational chart in annex 1).

2. Overall concept and core results

Overall concept

AIP is a non-university research institution dedicated to fundamental research in astrophysics. Its primary research objectives are i) to disentangle the structure, formation, and evolution of objects in our cosmos from the Sun and individual stars and their exoplanets over the Milky Way and other galaxies to the Universe as a whole and ii) to understand the underlying physical processes acting on these scales, such as magnetic dynamos, turbulence, feedback by stars, supermassive black holes, and cosmic rays, and the effects of dark matter and dark energy.

Research at the institute is aligned along the following nine strategic themes (three per research area, connecting the work within the different sections):

1.1. Understanding the Dynamos in the Sun and Stars

1.2. Observing the Surfaces of the Sun and Stars

1.3. Understanding the Environments of Exoplanets, the Sun, and Stars

2.1 The Milky Way System as a Galaxy Prototype

2.2 Constituents and Habitats of Galaxies

2.3 The Physics of Galaxy Formation: from Kinetic to Cosmological Scales

3.1 Spectroscopic Instrumentation for the Facilities of the 21st Century

3.2 Surveys and Monitoring

3.3 Technology Development and Transfer

In its research approach, the institute aims at a well-balanced system involving observations and data mining, theory and simulations, and the development of research infrastructure necessary to promote research. A common denominator for the research and development area is its focus on optical spectroscopy, comprising high-resolution Echelle spectrographs, imaging spectroscopy with integral-field spectrographs and Fabry-Pérot imagers, and multi-object spectrographs.

A typical research cycle consists of (i) the analysis of data drawn from an existing instrument and its confrontation with theoretical models; (ii) the design of new facilities capable of addressing key science questions left open by the previous step; (iii) the construction and commissioning of such facilities, and (iv) the science exploitation of these facilities, ideally by usage of guaranteed observing time awarded with providing the facility, (v) re-entering the first stage of the next cycle. Considering the large sizes and considerable investment budget of state-of-the art facilities in astronomy, such a research cycle typically extends over 15 years and longer. Typical current examples of such a research cycle are the analysis of stellar atmospheres as well as the detection and characterization of exoplanets (SES@STELLA → PEPSI → ELT HIRES), the reconstruction of the formation history of the Milky Way (RAVE → 4MOST), and the crowded field spectroscopy of galaxies and spectroscopic tomography of the circumgalactic and intergalactic medium (PMAS → MUSE → ELT MOSAIC). These major development paths are complemented by engagements in complementary facilities, e.g., satellite missions or radio observatories.

Besides its contributions to large international observatories and satellite missions, AIP also operates scientific infrastructure like the STELLA robotic observatory on Tenerife and participates in or cooperates with major research facilities such as the Large Binocular Telescope in Arizona, the GREGOR solar telescope on Tenerife, and the Potsdam-Bornim Station of the LOFAR radio interferometer. Furthermore, AIP operates several database services of astronomical surveys (e.g., RAVE, Gaia, MUSE-Wide) and simulation projects (e.g., HESTIA, MultiDark). It participates in the National Research Data Infrastructure (NFDI) in a leading function.

Results

Research

Scientists at the AIP regularly publish and present their scientific results to the academic community, resulting in an average of 269 peer-reviewed journal publications per year between 2018 and 2020 (see Appendix 2). AIP names the following ten research highlights:

1. The influence of magnetic instabilities on the interior structure of stars was quantified by theoretically predicting the ensuing transport coefficients, subsequently incorporating these insights into stellar evolution models.
2. Solar LOFAR observations confirmed that electrons in flares are predominantly accelerated at nearly perpendicular shocks, as theoretically predicted by AIP researchers.
3. The age-rotation-activity relationship has been measured and extended for cool stars. AIP's work on open stellar clusters as calibration objects has shown that gyrochronology is valid even for stars with ages similar to our Sun.
4. A starspot decay law was inferred from time series STELLA Doppler-imaging observations and allowed the determination of the magnetic diffusivity on a star other than the Sun.
5. Precise distances, extinctions, ages, and kinematical parameters were obtained to build multi-dimensional maps of the Milky Way using mainly RAVE, APOGEE and Gaia. It was possible to explore the innermost regions of our Galaxy in unprecedented detail. Ages obtained from asteroseismology were used to demonstrate the effects of radial migration, thus constraining the chemical thick disc assembly timescale.
6. Separate kinematic features traced by young and intermediate-age/old stellar populations in the centre of the Small Magellanic Cloud were analysed for the first time using VISTA observations. The first proper motion measurement of the Magellanic Bridge centre was also inferred, along with a flow motion across it.
7. The MUSE Deep Fields conducted as part of the Guaranteed Time Observations constituted a breakthrough in the study of faint galaxies. Over 2200 spectroscopic redshifts were obtained in the Hubble Ultra-Deep Field alone, more than ten times the previous tally and including 400 galaxies fainter than even the HST detection limit. The same data led to the discovery of ubiquitous Lyman-alpha emission around individual galaxies, providing a new window into the study of the circumgalactic medium at high redshift.
8. Galaxy formation simulations demonstrated that cosmic rays accelerated by supernova explosions can drive powerful galactic winds, suppress star formation, and even may dominate the energy balance in the circumgalactic medium. The strength of these effects depends on the microscopic plasma physics.

9. Value-added databases complementing the Gaia DR1, DR2, and eDR3 data release provided distances, radial velocities, abundances, classifications, and orbits of millions of stars.
10. A series of publications demonstrated for the first time a high-performance miniature-format near-infrared "spectrograph-on-a-chip" covering the entire H-band with a spectral resolution of R=36,000.

Development of scientific infrastructure

AIP contributes to the establishment of infrastructure via the establishment of or participation in astronomical observatories (STELLA, GREGOR, LBT) and the development and construction of major instrumentation for large ground-based facilities (e.g., ESO) and space missions (DLR, ESA). Furthermore, AIP is involved in the activities to establish a national research data infrastructure (NFDI) in the area of astrophysics (see chapter 6).

Knowledge transfer

As an institute focusing on fundamental research and discoveries, technology transfer is not the main focus of AIP. However, technologies developed for astronomical purposes have resulted in patents that can be transferred to applications outside astronomy, such as medical imaging and cancer diagnostics. Between 2018 and 2021, a total of seven patents were filed, of which five are still being evaluated; two patents have already been awarded.

The institute's expertise in optical fibres and photonics resulted in the establishment of the BMBF-funded *innoFSPEC Centre of Excellence*, which aims at paving the way for the next generation of optical technologies. It was positively evaluated in 2015 and expanded for a second funding period (2016–2022). In this context AIP runs a joint lab together with Fraunhofer IOF. AIP also participates in regional, national and international networking activities with academic and industrial partners.

Further transfer activities include the participation in the International Virtual Observatory Alliance, which aims at the establishment of common software, data and metadata standards.

Providing advice to policy makers and funding agencies regarding major developments in the field of astronomy and astrophysics and its key major research infrastructure, AIP coordinated the decadal survey of Astronomy and Astrophysics in Germany 2017–2030 ("Denkschrift 2017"),

AIP is engaged in manifold public outreach projects. Notable AIP research publications were accompanied by press releases, news features and social media activities. From 2014–2020 a total of 145 press releases with international media impact were published and approx. 45,000 visitors were welcomed.

3. Changes and planning

Development since the previous evaluation

Changes within the three research areas

Since the last evaluation, in the research area *Cosmic Magnetic Fields* there were changes in all executive positions below the level of the research area head:

- In a joint appointment with the University of Potsdam, a new head of the section *Stellar Physics and Exoplanets* was appointed in October 2018, now also including the topic of exoplanet research. Connected with this section, a new group *Stellar Activity* was established in 2018.
- The new head of the section *Solar Physics* started in August 2019.
- A scientist of AIP has been promoted to become the new head of the section *Magnetohydrodynamics and Turbulence* in August 2021.

In the research area *Extragalactic Astrophysics*, the following changes were made:

- In a joint appointment with the University of Potsdam, a new head of the newly established section *Dwarf Galaxies and the Galactic Halo* started in October 2017. In this section, a DFG-funded Emmy-Noether Group *The Early Milky Way* was funded from 2015 to 2020. Since 2021, a research group *Satellite Galaxy Systems* was established with funding from the competitive procedure of the Leibniz Association.
- In a joint appointment with the University of Potsdam, a new head of the section *Cosmology and High-Energy Astrophysics* started in April 2017, now also including the topic of plasma-kinetical processes and cosmic rays. Connected with this section, a new group *Cosmography and Large-Scale Structure* was established in 2019.

In the research & development area *Development of Research Technology and Infrastructure* a new research group *Astrophotonics* was established in 2016.

Further changes at AIP

Thanks to the recommendation of the 2015 review board, an extraordinary item of expenditure in the amount of 2,400 k€ for the years 2018–2020 (including a co-financing of the institute of 1,093 k€) has been approved. With the programme budget 2021 the institutional funding has been increased permanently by 630 k€. This was used by AIP to increase expert staff of the Technical Section and to establish a new section Project Management, allowing the institute to keep and extend expertise in the project management of large international projects, e.g., those by the European Southern Observatory (ESO) and the European Space Agency (ESA). In 2019 a new head of the Technical Section was appointed, after the former head took up a position in academia abroad.

Financing for the construction of a new office building (including a large conference hall, storage room, and a canteen) was approved by the state of Brandenburg and the federal government and anchored in the mid-term financial plan. Construction started in 2021 with an anticipated completion in 2024.

Strategic work planning for the coming years

Changes in personnel

The following positions will become vacant due to retirement within the next few years (the first three of them jointly appointed professors at the University of Potsdam):

- The director of the research branch *Cosmic Magnetic Fields* in 2025,
- The head of the section *Galaxies and Quasars* in 2028,
- The head of the section *innoFSPEC* in 2023,
- The head of the section *Supercomputing and E-Science* in 2023,
- The head of the group *X-ray Astronomy* in 2025.

AIP plans to fill these positions based on the long-term research strategy outlined below under "Long-term strategy and planning for additional funds deriving from institutional funding".

Topical developments

More or less independent of the changes in personnel, the available facilities, instrumentation, and to some extent also the available telescope time are already set for the next period (2022–2029). Consequently, the major goals for the R&D programme and its main associated science programmes are defined:

- Complete the construction of the 4MOST facility (2023), commission it on ESO's VISTA telescope in Chile (2024) and begin the 15-year science programme (2025).
- Complete the GTO programmes for MUSE@VLT and PEPSI@LBT
- Commission the BMK10k facility in Chile (2022) and begin the three-year-long photometric survey of all stars in PLATO's deep southern field.
- Complete the preliminary (2022–23 and 2022–24) and final design (2023–25 and 2025–28) of the ELT spectrographs HIRES and MOSAIC, followed by the beginning of construction.
- Complete the construction of the second-generation instrumentation for STELLA (2023).
- Perform the phase-A studies for BlueMUSE@VLT and GAMACA@CalarAlto and the subsequent development phases, including the development of their respective science programmes.
- These R&D goals are accompanied by regular upgrades of existing facilities, e.g., PEPSI, GREGOR, and PMAS.

The scientific goals for the coming decade within the nine strategic themes build upon the existing strengths of the institute:

<u>1.1. Understanding the Dynamos in the Sun and Stars:</u> Through a combination of observations and modelling, the AIP will investigate how stellar dynamos and magnetism shape planetary habitability through observation and simulation of Sun-like stars over time.

1.2. Observing the Surfaces of the Sun and Stars: The goal is to understand how the stellar magnetic field, and with it the surface features that both mark stellar rotation and leave imprints in exoplanet atmospheric data, evolve over time and as a function of different stellar compositions. For the next decade, the involvement of the AIP in developing the high-resolution spectrograph HIRES for the ELT will ensure this leap towards stars in open clusters.

1.3. Understanding the Environments of Exoplanets, the Sun, and Stars: Over the next decade, atmospheres of Earth-like exoplanets, and crucially, exoplanets in open clusters with well-defined ages, will be explored by the AIP, for example with ELT-HIRES, with the UBV arm of the spectrograph being developed and constructed by AIP. A strong focus for the future will be eruptive events and solar/stellar winds, enabled by the contribution of the AIP to the STIX and EPD/EPT instruments in the solar case and through numerical studies of coronal mass ejections in the stellar case.

2.1. The Milky Way System as a Galaxy Prototype: Research at the AIP will exploit synchronous spectroscopic and astrometric data using modern data-mining techniques, stellar physics (modelling stellar atmospheres and high-resolution spectroscopy), chemical evolution, dynamical modelling, deep photometric large-scale observations of resolved stellar populations, deep crowded-field spectroscopy of the Galactic Bulge, and, last but not least, detailed cosmological hydrodynamical simulations. The MOSAIC and HIRES instruments at the ELT will enable a deeper view. Analyses of abundance patterns of extremely metal-poor stars and studying the structure, masses, and ages of field stars will enable a better understanding of the first stars in the Universe via Galactic archaeology.

2.2. Constituents and Habitats of Galaxies: Of particular interest are observations of spatially resolved stellar populations and 3D spectroscopy of the Magellanic Clouds and M31. Integrated-light studies of distant galaxies require advanced modelling techniques for stellar populations while improving the census of time-variable Active Galactic Nuclei enables new insights into the co-evolution of supermassive black holes and galaxies. Deep spectroscopic surveys at high redshifts are key to identifying the progenitors of present-day galaxies in the young Universe and to studying the environmental dependence of their growth. This is complemented by cosmographically constrained hydrodynamical simulations of the local universe, which also probe fundamental physics such as alternative dark matter models.

2.3. The Physics of Galaxy Formation: from Kinetic to Cosmological Scales: A comprehensive research programme ranging from small plasma kinetic to large cosmological scales will be pursued that uses observational and theoretical methods, supercomputers and information theoretical algorithms in data science, and aims at understanding the complex interplay of gravity and various baryonic physics leading to the formation of galaxies and galaxy clusters.

3.1. Spectroscopic Instrumentation for the Facilities of the 21st Century: AIP uses a two-pronged approach to astrophysical research with spectroscopy: both single-object high-resolution instruments are developed and used in AIP's research, as well as complementary multi-object and 3D spectrographs at lower resolution. For the upcoming decade, AIP is pursuing contributions to the ELT with the development and construction of the UBV arm of the HIRES high-resolution spectrograph and the development of the fibre-subsystem of the MOSAIC multi-object spectrograph.

3.2. Surveys and Monitoring: AIP will be engaged in spectroscopic surveys with SDSS-V and will pursue comprehensive joint Gaia/SDSS data releases. In the near future, researchers at AIP will deal with new, large data sets from the 4MOST spectroscopic survey and the BMK10k survey of the PLATO deep field south. AIP plans to take a leading role in organizing the participation of astronomy in the National Research Data Infrastructure (NFDI) and in the BMBF-funded data initiatives for large research infrastructure (ErUM data). Scheduling of observations at robotics facilities and automatic flagging of potentially interesting data are tasks that will require machine learning in the future and may exploit quantum computing options on longer time scales.

3.3 Technology Development and Transfer: The development of spectrographs and optical fibre systems for spectroscopy will continue to provide key technology for instrument development at AIP, thus enabling AIP researchers to scientifically harvest this investment by receiving guaranteed time observations with these instruments. The natural evolution from optical fibres to photonics solutions to the exploitation of quantum technologies in the future has fostered a new innovative research field of Astrophotonics with transformative potential for the next generation of astronomy.

Long-term strategy and planning for additional funds deriving from institutional funding

For the long-term development of AIP, a "future committee" has been established. It consists of lead scientists who are expected to spend more than the next 10 years at AIP. The report of this committee has been endorsed by the Board of Trustees and by the Science Advisory Board. The main plan is to bring *Precision Stellar Science for Exoplanets, Stellar Evolution, and Galactic Archaeology* as a major new concerted effort into AIP's topical landscape by establishing a new third research branch headed by a third director. In order to realize this vision, four *action areas* have been identified:

Action area 1 – Precision Stellar Science for exoplanets, stellar evolution, and galactic archaeology: The research field of stellar science and stellar atmospheres shall be largely expanded at AIP, in order to improve the understanding of internal stellar structure, including the identification of missing physics. Modern machine learning techniques will allow to systematically and consistently transfer the insights gained from comparably small samples observed/modelled at high precision (high-resolution spectrographs like PEPSI and HIRES, complemented by asteroseismic missions like PLATO) to understand how stellar atmospheres and spot distributions change with stellar age, and how the constituents of exoplanet atmospheres relate to the chemical abundances of their host stars. Similarly, applying these data-intensive techniques to 3D and multi-object spectrograph data (4MOST, (Blue)MUSE, MOSAIC) and deep imaging surveys in nearby stellar systems (HST, JWST, Roman Observatory) enables the probing of large galaxy populations eventually to understand galaxy assembly. To establish a new third research branch AIP sees a need for the following additional personnel: 1 W3-professorship as third director of AIP and head of the new research branch, 2 senior scientists (E14), 3 postdocs (E13) and 4 PhD-students (0.75 E13).

Action area 2 – Precision spectroscopy with the ELT: AIP has been invited to be a partner in the second-generation ELT instruments MOSAIC and HIRES. AIP's participation ensures a prominent role in these projects, including privileged access to observing time at the ELT. Guaranteed access to such a resource will also be a major asset in the upcoming searches for new directors and other leading scientists. However, a considerable contribution to the construction costs of these instruments is required. To ensure participation in the second-generation ELT spectrographs HIRES and MOSAIC AIP sees a need of a one-time investment of 2 M€.

Action area 3 – Astrophotonics for the Precision Stellar Science facilities of tomorrow: Since 2009, AIP has been operating the innoFSPEC excellence centre for optical technologies, in particular in the context of fibre-based instrumentation. innoFSPEC is funded by the BMBF (corresponding to about 1M Euro per year) and augmented by a similar sized grant portfolio from other funding agencies. innoFSPEC has been instrumental in developing technologies for the next generations of instrumentation for large optical telescopes, and some of its contributions have already been included in current instrument designs such as 4MOST and next generation ELT instrumentation. To ensure long-term operation will require core funding from the institute budget, augmented by project grants. To establish a refocused research section incorporating the innoFSPEC excellence centre AIP sees a need for the following additional personnel: 1 W2-professorship as section head, 2 scientists (E13) and 2 PhD-students (0.75 E13).

Action area 4 – Extracting knowledge from precision data with information theory and machine learning: To fully harvest the scientific content of *Precision Stellar Science* across the field from solar science to extragalactic astrophysics, AIP sees a need to pursue and incorporate the following developments and technologies within and across its research branches: (i) meet the scientific challenges associated with information-theoretical and algorithmic developments of identifying correlations in high-dimensional parameter spaces, (ii) include new advances in machine learning such as deep learning to open up new opportunities in astrophysical observations and simulations, (iii) maintain and develop the next generation of astrophysical codes to harvest the promises of exascale computing with a significantly increased GPU-based architecture, and (iv) solve the technical challenges associated with the leap in the amount and complexity of data by developing modern queries and easy-to-access databases. To establish a new permanent research group AIP sees a need for additional personnel: 1 group head (E14), 1 scientist (E13) and 2 PhD students (0.75 E13).

The measures in the four action areas are complemented by administrative and technical support positions (2 E9a, 1 E11) and investment funds for the sustained renewal of the AIP's data serving capacity, lab equipment, and participation in projects (500 k€ p.a., permanent). The total costs of the initiative is summarized in the following table:

	2025	2026	2027	2028	permanent
Personnel	1044 k€	1549 k€	1887 k€	2214 k€	2280 k€
Materials	200 k€	320 k€	380 k€	440 k€	440 k€
Invest	300 k€	300 k€	1200 k€	1200 k€	500 k€
Total	**1544 k€**	**2169 k€**	**3467 k€**	**3854 k€**	**3220 k€**

The institute commits to support the described measures by financing the 2 joint professorships (1 W3-professorship as director and 1 W2-professorship as head of the section *astrophotonics*) from the existing institute budget, as well as the already prepared activities w.r.t the ELT instrumentation HIRES and MOSAIC. Furthermore, AIP's participation in the LBT (and also in the LOFAR radio telescope) will be critically reviewed w.r.t. a possible reinvestment of these funds (currently 500 k€ per year) into the ELT initiatives and the associated science programme. According to AIP, the remaining funding cannot be realized within the existing institutional funding. Therefore AIP plans to apply for a permanent increase of its institutional funding from 2025 on („extraordinary item of expenditure"), with a co-financing of the institute well above the required 3 % of the core budget according to the following table:

„Extraordinary item of expenditure": summary of funds planning

	2025	2026	2027	2028	permanent
Total	**1544 k€**	**2169 k€**	**3467 k€**	**3854 k€**	**3220 k€**
Own contributions	445 k€	494 k€	616 k€	961 k€	1232 k€
Funding requests	1099 k€	1675 k€	2851 k€	2893 k€	1988 k€

4. Controlling and quality management

Facilities, equipment and funding

Funding (see Appendix 3)

Between 2018 and 2020, the institutional funding totalled Ø 12,680 M€ p.a.

In the same period, revenue from project grants totalled Ø 8.2 M€ p.a., corresponding to 39 % of the overall budget. Thereof, Ø 4.5 M€ p.a. were raised from Federal and *Länder* Governments, Ø 2 M€ p.a. from the EU, Ø 1.14 M€ p.a. from the DFG and Ø 407 k€ p.a. from the Leibniz Association.

Facilities and equipment

AIP administers and maintains the campus of the *Babelsberg Observatory* as a main site for its research activities. The facilities provide nominal office space for 142 employees. A need for additional space was acknowledged by the funding agencies and funding in the amount of 23 M€ is provided in the financial plans for 2019–2024 for a new building, providing office space, a large conference room, storage room, and a cafeteria. Ground was broken on the site in August 2021. AIP‘s second site at *Telegrafenberg* hosts the science-historical and outreach facilities, in particular the Great Refractor (*Großer Refraktor*) and Einstein Tower (*Einsteinturm*) buildings, although the latter is still being used for instrument verifications.

AIP’s two technology buildings in Babelsberg accommodate two precision engineering workshops and different kinds of laboratories for the realisation of instrumentation projects. In addition to several optical laboratories, there is one physics laboratory, a Faraday lab with a Faraday cage, a detector lab, a metrology laboratory with a 3D coordinate measuring machine and an electronics workshop. Furthermore, there is a clean room (ISO class 4), two cooling chambers, two large integration halls with one hall crane each, and a telescope simulator. The facilities have recently been upgraded to accommodate the integration and testing of 4MOST.

A LOFAR station is situated at Potsdam-Bornim administered by the Leibniz Institute for Agricultural Engineering and Bioeconomy (ATB). AIP’s part in GREGOR and the Vacuum Tower Telescope (VTT) is managed and represented by the Leibniz Institute for Solar Physics (KIS). The STELLA facility is a robotic observatory with two fully automated 1.2m telescopes owned by AIP and jointly run by AIP and the *Instituto de Astrofisica de Canarias*. In 2019, the *Ballistische Messkammer* with a 10k x 10k CCD (BMK10k) and a field of view of over 50 square degrees was installed in Chile at Cerro Murphy, near the construction site of the ELT.

A fixed fraction of the investment budget of the institute (in the order of 200 k€) is earmarked for renewal, upgrades, and extensions of the scientific infrastructure. These funds are supplemented by individual measures, often financed by individual grants or by infrastructure programmes, e.g., the EFRE regional development fund of the EU.

IT, data storage and library

AIP operates several IT premises including three large server rooms on its Babelsberg campus as well as the network infrastructure on all buildings on this campus, two buildings on the Telegrafenberg campus and at the LOFAR site in Potsdam-Bornim. AIP operates most of the IT services on-premise. AIP follows a strategy that provides most services in-house and uses open-source solutions whenever possible, complemented by research-tailored offers like GÉANT's Open Clouds for Research Environments (OCRE), the research data management network Globus and the various DFN services.

AIP provides HPC resources for small-to-medium simulations and in particular as a test and development environment for scientific analysis codes and in order to prepare large simulation projects on large European HPC installations. Projects creating large amounts of data are responsible for arranging long-term data storage. Storage servers of various sizes are operated by central units and some individual sections. Data on these servers are secured by means of hardware and – at least partially – mirrored over more than one premise or building. Backups of scientific data on central servers and on user workstations and laptops are performed via five tape libraries. The users are responsible for placing important data on the backup servers or directories on their workstations.

The *Scientific Library and Documentation Centre* supports AIP researchers in all their information needs, offering printed and electronic literature and collecting special literature covering the research fields of the institute. In addition, its services are also offered to external parties; in particular it provides services to students of the University of Potsdam with its comprehensive literature archive. Usage statistics and demand analyses are evaluated and offers are obtained from publishers and providers for the provision of online resources in line with demand.

Organisational and operational structure

The institute is organized in research branches with sections and groups. The Directors independently lead their research branches, including the management of the personnel and financial resources allocated to the branch.

Section heads independently lead the section in coordination with the overall strategy. Section heads are responsible for the organization, planning, coordination, and definition of milestones for the respective research programme.

Research topics that are of long-term nature in a section and that require a certain independence can be assigned to a group. Group leaders have responsibilities analogous to those of section heads.

The Internal Scientific Committee (ISC) is elected by the scientific staff. The ISC organises scientific events at the institute and is involved in key decisions affecting the working conditions of the institute (e.g., flexible working hours, travel regulations) in a way similar to the Works Council, but focussed on scientific issues.

The main decision bodies of the institute are (i) the Executive Board ("Stiftungsvorstand"), (ii) the Institute Management, and (iii) the assembly of section heads:

The Executive Board is the formal legal representation of AIP. It consists of a scientific and an administrative member, appointed by the board of trustees, typically for 5-year terms. Reappointments are possible. The scientific member chairs the executive board. The administrative member is the budget officer (*Beauftragter des Haushalts*). The Executive Board acts as the employer and deals with outside matters of the institute.

The Institute Management consists of all Executive Board members and directors of the institute. It meets at least once per month. The deputies of the directors, a representative of the central services and a representative of the section heads and group leaders are standing guests for the meetings of the Institute Management.

Once a month, typically, a meeting of all Executive Board members, directors, section heads, group leaders, representatives of the Works Council and the Internal Scientific Committee, and of the equal opportunity officer take place ("Heads meeting"), chaired by a representative of the section heads and group leaders. These meetings mainly aim at informing about developments at the institute, general developments in science and policy of wider interests, and to provide a floor to discuss issues of concern or required action.

Quality management

The members of the AIP are obliged to secure good scientific practice. All who carry out science undertake to fully document research by keeping protocols and research data securely, keep research data in an accessible location, maintain familiarity with existing research, use scientifically valid and appropriate methods, check the validity and replicability of all results, methods, design, and maintain neutrality and confidentiality when evaluating manuscripts and applications. Publications should describe scientific findings comprehensively, and published results need to be reproducible. All data relevant to a publication must be clearly documented. Results may be re-used in later publications only if essential for understanding context.

The publication strategy is to publish scientific results mainly in one of the four main international journals (*Astronomy & Astrophysics, Astronomical Journal, Astrophysical Journal, and Monthly Notices of the Royal Astronomical Society*). High impact results that are of interest for a broad interdisciplinary community are published in *Nature* or *Science*. The *Astronomische Nachrichten*, which is edited by the AIP, provides a fast-track peer-reviewed publication alternative for articles usually targeted for supplemental-like issues and for instrumentation concept descriptions. Design studies and astronomical instruments are usually published in the proceedings of the SPIE. The responsible scientific section head or director internally reviews publications before submission. Furthermore, progress is presented in (non-refereed) conference proceedings. Usually, preprints of articles and proceedings are also posted on *arXiv.org*, allowing open access.

The AIP promotes unrestricted access to scientific information free of any charge to users. It thus follows the *Berlin Declaration on Open Access to Knowledge in the Sciences and Humanities* and the Open Access policy of the Leibniz Association. The AIP library participates in funding initiatives that support free access to publications. AIP is engaged in the Leibniz Association's Open Access working group.

AIP supports open data at different stages of data processing. For the publication of data collections, the AIP developed a web framework (Daiquiri) built on modern open-source components, which also implements the main protocols and standards of the Virtual Observatory, and manages and delivers the standardised metadata sets for Digital Object Identifiers (DOI). All published data sets carry a license statement, mostly CC0 (Public Domain). Many data collections provided by AIP are of “Big Data” type.

Most research infrastructure with a direct AIP engagement is jointly operated with other partners, and the quality management is directly addressed in the respective cooperation agreement.

The institute has established several structures for a performance-based allocation of resources. Probably the most valuable resource the institute has to offer is access to the LBT. An internal time allocation committee (TAC) distributes telescope time based on a competitive proposal review. Solar telescope time (GREGOR and VTT) is allocated through a national TAC. STELLA AIP-time is distributed internally by the operator group. STELLA, GREGOR and VTT CCI time is distributed by a TAC that consists of the operators of telescopes in the Canary Islands.

Furthermore, the institute resources, such as travel funds and the guest programme, scale with the size of each group, i.e., groups that raise more grants receive a larger share of the institute's funds for travel and the guest programme. In addition, section and group heads can make proposals on measures (typically additional travel, extension & bridge funding for researchers, conference support, guests) financed by the management reserve (2–3% of the total institute budget in order to be prepared for unexpected events). As an incentive, requests are served approximately in proportion to the third-party funding raised by the respective section or research group.

The base of the annual budget negotiation with the funding institutions is the programme budget. It constitutes an agreement of objectives between the funding institution and the institute and is used for internal control by the management and the Board of Trustees, providing the Science Advisory Board (see below) with information for its monitoring activities.

Quality management by advisory board and supervisory board

According to the AIP statutes, the Science Advisory Board (SAB) advises the Board of Trustees (BoT, see below) and the Executive Board on all scientific and interdisciplinary issues. It consists of 8 members, each of them an expert in a field relevant to the research portfolio of the AIP. New members are usually identified in consultation between the Directors and the existing SAB, and a corresponding proposal is made to the BoT. The BoT elects and appoints the members of the SAB. Appointments are usually for four years and can be renewed once. The SAB meets once per year and discusses the programme budget, as well as new project ideas, significant long-term commitments and intended senior hires. Four years after an evaluation the SAB performs an audit that closely follows the external evaluation procedures used by the Leibniz Association.

The Board of Trustees consists of four members, one appointed by the *Land Brandenburg*, one by the federal government, the chair of the SAB and the President of the University of Potsdam. The BoT is convened once each half calendar year. It decides on the general research objectives and on important research policy issues and financial matters of the foundation. The BoT shall monitor the legality, purposefulness, and efficiency of the Executive Board's management. The BoT examines the financial statements and the annual reports presented by the Executive Board. It decides on new hires, reappointments, and dismissal of the Executive Board's members and on joint professorships with universities.

5. Human Resources

As of 31 December 2020, the AIP employed 191 people. 117 of the employees were occupied in research and scientific services, 51 in science-supporting service positions, and 23 in science-supporting administrative positions (see Appendix 4).

Leading scientific and administrative positions

AIP Directors are usually jointly appointed professors at the University of Potsdam (UP). These appointments are made following the regulations for appointing professors at the

UP. A joint search committee with equal representation of AIP and the UP identifies candidates. The Board of Trustees appoints the members of the Executive Board. The Administrative Member of the Executive Board is hired on a dedicated work contract in this function.

For section heads and group leaders, the regulations for tenure-track personnel (see below) or for joint professorships are applied. As a matter of policy, lead personnel at AIP are appointed for five-year terms; reappointments are possible.

Junior research groups are usually initiated by postdocs primarily via the programmes of DFG (Emmy Noether), Leibniz (Leibniz junior research groups), and ERC (Starting Grants). Junior research groups are associated with a section for organisational purposes but enjoy scientific independence. The main purpose of a junior research group is to give the group leader the opportunity for qualification for the academic job market. This also includes the option to be engaged in the course programme at the UP. Tenure-track as default is not foreseen. Junior research group leaders are, however, encouraged to apply when tenure-track positions are advertised.

Staff with a doctoral degree

The majority of postdocs and non-tenured staff are hired via research grants and the length of their employment corresponds to the length of the funding period in agreement with the legal boundary conditions. Postdocs on institute funds are usually hired on a 2+1 year (junior) or a 3+2 year (senior) contract with the extension given based on performance. Regular status talks (at least once per year) ensure that expectations are known and met for all involved parties. AIP provides access to the coaching programmes of the Potsdam Graduate School (PoGS), that offer a wide range of seminars and workshops for professional and soft skills development for postdoctoral researchers.

In order to promote the training of young scientists, the AIP has established the *Karl Schwarzschild Postdoc Programme*. The fellowship is offered on an alternating basis between the research areas and is aimed at candidates in the first 5 years after their doctorate. The appointment is for 3 years with a possibility of extension for 2 years based on an interim evaluation. So far, 7 Schwarzschild Fellows have been hired.

AIP has introduced a formal tenure-track procedure. Tenure-track positions are filled based on external job advertisements in a competitive process. The decision for tenure is based on a tenure review, which is based on a predetermined, internationally comparable and homogeneous catalogue of criteria at the AIP as well as the target agreement to be concluded at the start.

Since the last evaluation, seven AIP staff have successfully applied for leading scientific positions at other institutions. Furthermore, four staff members were promoted to leadership positions at AIP (the heads of the sections *Magnetohydrodynamik and Turbulence*, *Project Management*, *Solar Physics* and the head of the *Technical Section*). Four staff members were promoted to heads of a research group in their respective section. Five further AIP scientists have successfully transferred to tenure-track and permanent positions at AIP and 13 at other institutions. The AIP aims at organizing a meeting for alumni and other former members of the institute about every five years.

Doctoral Candidates

As of 31 December 2020, 29 doctoral students were employed at AIP. Between 2018 and 2020 a total of 19 doctoral degrees was completed at the institute. The median length of a doctorate amounts to 4 years and 1 month. AIP staff members who are also faculty members at a university (jointly appointed professors, adjunct professors, and lecturers) supervise the doctoral candidates.

While the scientific supervision of the dissertation is formally the responsibility of the primary supervisor, the *Structured Doctoral Training* implemented at the University of Potsdam provides mentoring, supervision by thesis committees, an independent second supervisor, a mandatory supervision agreement, and regular progress meetings. At the beginning of the dissertation, the supervisory committee meets and agrees with the doctoral student on the topic and work programme of the dissertation. At least once a year the doctoral candidate documents the progress of the dissertation project to the committee. The student writes an annual project report in which the achieved goals are recorded and the work programme for the following year is defined.

During their work at the AIP, the doctoral students have equal rights and duties as all other institute members. In the context of the elections to the Internal Scientific Committee (ISC), doctoral students send at least one representative to the ISC.

Science supporting staff

The institute offers a total of four different vocational training apprenticeships, the duration of which is usually three to three and a half years; the Technical Section offers apprenticeships for two vocational qualifications: precision mechanics and electronics technician for devices and systems. The IT service trains IT specialists in system integration and offers practical training in the two-year course of study at the specialized secondary school for the acquisition of the entrance qualification for a university of applied sciences. The administration offers apprenticeship as specialist for office management. Between 2018 and 2020, a total of 3 apprentices successfully completed their vocational training.

Vocational training continues under a human resources development plan to increase the individual, professional, and social skills of AIP staff, and is adapted to their individual tasks as well as individual work and personal circumstances. Dedicated budgets for the financial support of vocational training are assigned to every individual administrative section, to Central Scientific Services, to the Equal Opportunities Officers and to the Works Council. In general, AIP calls on external training services for professional and methodical programmes.

Equal opportunities and work-life balance

As of 31 December 2020, out of the 117 employees in research and scientific services 33 were female (28 %). Among the two directors there were no women. Out of 12 section heads, two were female (17 %). Out of four group leaders none was female. Out of 70 scientists in non-executive positions, 16 were female (23 %). Out of 29 doctoral candidates

15 were female (52 %). Of the recent three hires of professors two were female. Of the other five recent permanent hires, two are female.

The AIP established equal opportunity standards in 2005 and has adopted the DFG's *research-oriented equal opportunity standards*. The planning for the period 2021–25 follows the guidelines of the Leibniz Association for the cascade model: first, the fraction of positions that become vacant is determined for every salary class and leadership level. Then these vacant positions are filled by a proportion according to the gender distribution at the next lower level.

In 2017, AIP successfully applied for the TOTAL E-QUALITY designation for a family-aware work environment. In 2021 the certification was renewed based on a proposal drafted by a TEQ working group consisting of the institute's management, equal opportunity officers, public outreach, works council, employees from science and administration as well as student representatives and doctoral students. Measures already implemented include flexible working hours, mobile working regulations, Institute guidelines to avoid meetings before 10 a.m. and after 4 p.m., sports and stress management measures, management training for senior staff, mobile office for parents with children, emergency childcare and childcare for conferences.

On 3 May 2019, a Code of Conduct, a guideline for protection against discrimination, harassment, and violence, was adopted at the AIP. It contains principles of conduct for institute employees and regulates how to deal with discrimination, bullying, harassment, and violence, specifying the designation of contact or complaint points and giving a description of the complaint procedure. The Code of Conduct is accompanied by regular workshop for members of the institute.

6. Cooperation and environment

Collaboration with universities

A close relationship exists with the University of Potsdam (UP), where both AIP directors have been full professors since 2000 and 2002. In the past ten years, UP and AIP have established five new joint professorships (W2) at AIP, a joint structured PhD programme, the Leibniz Graduate School for Quantitative Spectroscopy (2013–2018), and the joint innoFSPEC Centre of Excellence for fibre optics. Furthermore, one adjunct professorship and one lectureship (Privatdozentur) currently exists between AIP and UP. Since 2016, UP has offered an international master's programme “Astrophysics”, jointly organised by UP, AIP, DESY Zeuthen and the Max Planck Institute for Gravitational Physics, with an increasing number of applicants (2016: 28, 2021: >350). This group of institutions has also established the “Astrophysics Network Potsdam”, which offers a joint portal to research opportunities for students and young researchers.

AIP scientists usually teach the introductory astronomy course for physics students at Humboldt-Universität Berlin (HU Berlin). In order to strengthen the ties between AIP, UP, HU Berlin and Technical University Berlin (TU Berlin), the joint “Berlin-Potsdam-Kolloquium” has now run for 9 years. AIP expects the ties between these partners to increase further with the now established chair for Astro-Particle Physics and Cosmology at HU Berlin (joint appointment with DESY), the appointment of the head of the section *Cosmology and High-Energy Astrophysics* at AIP and UP, and the upcoming Cherenkov Telescope Array (CTA) data centre hosted by DESY Zeuthen.

Key partners in Germany and abroad

Considering the instrumentation programme, AIP's major partner is the European Southern Observatory (ESO) via several instrumentation projects, which are usually done in collaboration with a number of institutions in Germany:

- AIP coordinates 4MOST, the 4-m Spectroscopic Survey Telescope. 4MOST is an instrumentation consortium with partners in Australia, France, Germany, the Netherlands, Sweden, and the UK.
- AIP is a partner in the ESO next generation VLT instrumentation project BlueMUSE, a blue-sensitive 3D spectrograph.
- AIP is a partner in two design studies for the ELT, HIRES and MOSAIC, which are in the preliminary design phase.

The AIP is a member of the Large Binocular Telescope Cooperation (Partners: LBTB Germany, INAF Italy, University of Arizona, Ohio State University) via the LBT holding company (with MPIA, MPE, MPIfR, AIP, and Heidelberg University), which runs the largest optical telescope in the world. The AIP has guaranteed access to 3.35% of the scheduled nights per year (approximately 10 nights) as a result. AIP provided LBT's high-resolution spectrograph and polarimeter PEPSI.

The AIP is involved with hardware and software contributions in the European Space Agency (ESA) missions Gaia, XMM-Newton, Solar Orbiter, and in the German-Russian X-Ray satellite Spektrum-Roentgen-Gamma with the German eROSITA telescope. These cooperations are coordinated and financed by the German Aerospace Agency (DLR).

The AIP is a partner in the International LOFAR Telescope (ILT) with participation of scientists from the Netherlands, France, Germany, Ireland, Poland, and Sweden. The establishment of an ERIC is underway. AIP operates one of the remote stations at Potsdam-Bornim.

AIP's STELLA observatory is operated and maintained jointly with IAC on Tenerife through a Level-III contract with the IAC. AIP executes all observations and hosts the central data archive in Potsdam, and also provides technical input to the Spanish and the CCI time-allocation committees.

A new robotics facility (BMK10k) is currently being commissioned in Chile for support of ESA's PLATO mission. It is located near ESO's Cerro Armazones site for the ELT and its aim is to identify false positives for PLATO's input catalogue.

AIP has initiated and coordinated the international RAVE survey, a spectroscopic survey of the Milky Way that has amassed 570,000 spectra for stars in the Milky Way between 2003 and 2013. The final data release was published in summer 2020. RAVE can be seen as a prototype for ongoing major spectroscopic endeavours like 4MOST and SDSS-V. It involved scientists from Australia, France, Germany, Italy, the Netherlands, Slovenia, the UK, and the USA.

Due to its significant in-kind contributions (75 Integral-Field-Units for the VIRUS instrument), AIP is a full partner in the Hobby-Eberly-Telescope Dark Energy Experiment (HETDEX) with full access to all HETDEX survey and parallel science data. In addition, AIP has access to observing time with VIRUS-P at the McDonald Observatory.

Based on an agreement with the Centro Astronomical Hispano-Aleman (CAHA), the AIP-built PMAS instrument is available to the German, Spanish, and OPTICON communities at Calar Alto for an exchange of 10 GTO nights for AIP researchers, often used for MSc and PhD theses work.

AIP has initiated a feasibility study to build a new integral field spectrograph for the 3.5m telescope of the Centro Astronomical Hispano-Aleman (CAHA). The *Instituto de Astrofisica de Andalucia* (IAA) is an equal co-lead in this project. The Galaxy Mapper Instrument at Calar Alto (GAMAICA) will have a combination of spatial resolution and number of resolution elements for the northern sky. The GTO time will be used to conduct surveys of the Andromeda galaxy and the Virgo cluster (Galaxy Mapping at Calar Alto, GAMACA).

AIP was a founding member of the Virtual Observatory initiative GAVO, and coordinates the astrophysics activities in the national research data initiative (NFDI) of particle, astro, astroparticle, and nuclear physics PUNCH4NFDI.

Collaboration with Leibniz Institutes

Together with the Leibniz Institute for Solar Physics (KIS) and the Max Planck Institute for Solar System Research (MPS), the AIP is a partner in the 1.5-m solar telescope GREGOR on Tenerife operated by the *Instituto de Astrofísica de Canarias* (IAC).

The AIP participates in activities of the Leibniz network on Mathematical Modelling and Simulation (MMS), and is engaged in organizing interdisciplinary meetings and training schools for facilitating knowledge exchange, primarily in fluid modelling.

AIP is an associate member of the Leibniz Research Alliance “Health technologies”. It mainly contributes with the application of integral field techniques from astronomy to problems in medical imaging, in particular in the context of cancer diagnostics.

AIP is an active participant in the Research Data Work Group of the Leibniz Association, with an AIP staff member as the elected spokesperson. He also represented the Leibniz Association within the Science Europe Working Group on Research Data for two years (2016–2018), and contributed to drawing the guidelines of the Leibniz Association w.r.t research data management, which was adopted by Leibniz General Assembly in 2018. AIP implemented the Research Data Management Organiser (RDMO), which is used by several Leibniz Institutes.

7. Subdivisions of AIP

Research area *Cosmic Magnetic Fields*

[35.1 FTE, thereof 24.3 FTE Research and scientific services, 7.6 FTE Doctoral candidates, and 3.2 FTE Service staff]

The focus of the research area lies on the exploration of solar and stellar magnetic fields, along with the magneto-hydrodynamic (MHD) mechanisms that generate them. It comprises the following three sections:

- Magnetohydrodynamics and Turbulence (since 2021)
- Solar Physics (since 2019)
- Stellar Physics and Exoplanets (since 2018) including the group Stellar Activity (since 2018)

The goal is to understand the complex relationship between the structure of matter and the geometry and strength of magnetic fields and their recoupling with the surrounding astrophysical plasma, including the effects on habitability of exoplanets. It links the Sun and its heliosphere, seen in great detail, to that of other stars. The underlying processes of convection and rotation, turbulence, magnetic field generation and amplification, and particle acceleration are the key physics drivers. Supercomputers are used for MHD simulations, and large telescopes such as the LBT, VLT, and in the future ELT are employed, along with smaller and robotic telescopes (e.g., GREGOR and STELLA) for high-resolution spectroscopy and spectropolarimetry. Efforts are mainly focused on three subtopics, each bridging all three science sections, constituting the “magnetic solar-stellar connection”:

1. Understanding the dynamos in the Sun and Stars
2. Observing the Surfaces of the Sun and Stars
3. Understanding the Environments of Exoplanets, the Sun and Stars

While the “magnetic solar-stellar connection” has been and continues to be the prominent landmark of the research area, shifts in the research orientation were implemented by new lead personnel, in sync with the life cycle of major instrumentation projects. Understanding dynamos in the Sun, in stars, in circumstellar discs, and on galactic scales provides the essential theoretical link across the above research topics. Related to the origin and key properties of the underlying turbulence, an associated task is the discovery and exploration of magneto-/hydrodynamic instabilities, as well as the assessment of their effect on the host environment (e.g., by means of transporting angular momentum, heat or chemical trace species). Adapting to the ever-increasing census of magnetically active stars in relation to stellar surface rotation, the focus recently shifted from more fundamental to more applied questions in dynamo theory. These questions are ultimately aimed at building a theoretically founded understanding of entire ensembles of stars and will inform the interpretation of future missions, like PLATO, which are expected to produce a wealth of high-quality data. The current head of the section “Magnetohydrodynamics and Turbulence” was awarded an ERC Starting Grant in 2014.

Solar activity is traced from the Sun's surface through its atmosphere to its impact on the inner heliosphere by developing and operating own instruments for high-resolution solar observations (e.g., with GREGOR) and by engaging in space missions for in-situ measurements of the solar wind and remote sensing of the X-ray Sun (e.g., with Solar Orbiter/STIX/EPD). The physics of solar eruptive events addresses electron acceleration, energy partition, coronal shock waves, and electron propagation through the corona and heliosphere (e.g., with LOFAR). Thereby, the general scientific topic remained the fundamental process of the interaction between plasma motions and magnetic fields. Taking the next step towards resolving stellar surfaces, Zeeman-Doppler Imaging (ZDI) provides the ultimate tool for revealing the underlying magnetic field structure of the star. However, validating this technique on solar data remains a formidable task to be addressed with PEPSI/SDI-POL.

The evolution of stars and exoplanets is studied using photometric, spectroscopic, and polarimetric observations in different wavelength regimes to collectively understand stellar and planetary atmospheres. The existence of stellar and planetary magnetic fields is a decisive factor for the formation and evolution of life on planets, as magnetic fields shield the planetary atmosphere against stellar high-energy phenomena. Star-planet relations and the study of exoplanet atmospheres and habitability have increasingly moved into the science focus, where they are being explored using ground-based and space-based observations. Stellar activity research now focuses on rotation and activity in low mass stars and expands prior rotation and activity work on individual field stars into the regime of open clusters. Thus, precisely dated cluster stars facilitate the construction of chronologies and the development of methods to derive astronomical ages from rotation and activity measurements.

Between 2018 and 2020, the research area published ∅ 80 articles p.a. in peer-reviewed journals. In the same period, the revenue from project grants was ∅ 977 k€ p.a., with ∅ 360 k€ p.a. spent from federal and *Länder* governments, ∅ 243 k€ p.a. from the DFG, ∅ 244 k€ from the EU and ∅ 118 k€ p.a. from the Leibniz Association. Furthermore, in the same period, 6 doctoral degrees were completed.

Research area *Extragalactic Astrophysics*

[47.1 FTE, thereof 37 FTE Research and scientific services, 7.7 FTE Doctoral candidates, and 2.4 FTE Service staff]

The mission of the research area is understanding the structure, formation, and evolution of galaxies as the fundamental cosmic building blocks. It comprises the following four sections:

- Milky Way and the Local Volume
- Dwarf Galaxies and the Galactic Halo (since 2017)
- Galaxies and Quasars including the group X-ray Astronomy
- Section Cosmology and High-Energy Astrophysics (since 2017 including the group Cosmography and Large-Scale Structure)

The research area investigates physical processes on vastly different scales, acting on complex systems of billions of constituent entities. Observations span a wide range of techniques in a succession of increasing distance and decreasing level of accessible detail, from the spectroscopy of individual stars in the Milky Way via integrated-light studies up to the domain where galaxies appear only as a single point. Numerical simulations combine the effects of gravity acting on large scales with the gas dynamical and electromagnetic interactions in astrophysical plasmas. A strong focus has been set on highly multiplexed spectroscopy, taking advantage of instruments developed in-house. The engagement in large surveys and giga-scale numerical simulations is accompanied by the deployment of innovative methods in data science. The diversity of approaches can be grouped into three main research themes, each of which reaches across the individual science sections:

1. The Milky Way as a Galaxy Prototype
2. Constituents and Habitats of Galaxies
3. The Physics of Galaxy Formation: from Kinetic to Cosmological Scales

The exploration of the inner structure of the Milky Way, the dynamical interplay of its components, and the reconstruction of its formation history drive the AIP's engagement in several major projects. Foremost is the AIP lead of the 4-metre Multi-Object Spectroscopic Telescope (4MOST) development and construction, currently planned to go on-sky in 2025. As part of these activities, several dedicated large surveys are being prepared to cover the halo, discs, and inner regions of the Galaxy. The 4MOST goals are closely linked to the astrometric and photometric catalogues produced by the Gaia satellite, for which the AIP provided software, co-hosted the data releases, and derived improved distances, extinction values, and stellar properties through the combination with asteroseismological and other spectroscopic data. These augmented catalogues have yielded several new insights into the Galactic Bulge and Bar as well as substructures of the Galactic disc. The Pristine survey focused on a search for extremely low metallicity stars in the Galactic halo, with puzzling results that challenge current models of Milky Way-like galaxies.

The structure, composition, and dynamics of the Magellanic Clouds, and their interaction with each other as well as with the Milky Way, are the topic of the VMC survey. These studies were furthermore supported by an ERC Consolidator Grant awarded to the head of the section "Dwarf Galaxies and the Galactic Halo" in 2015. In the same section, between 2015 and 2020 an Emmy Noether research group was funded by the DFG and in 2021, the Leibniz junior research group "Satellite Galaxy Systems" was established to perform a census of orbital plane alignments in the Local Group and beyond, and use this to test standard cosmological models.

More generally probing the cosmic environment of the Milky Way is the goal of the CosmicFlows project: to reconstruct the underlying matter distribution and compare it with cosmological simulations constrained to the properties of the Local Group. Several observational projects with AIP (co-)leadership are dedicated to dissecting and modelling the stellar and gaseous ingredients of galaxies over a wide range of distances, such as: the GHOSTS imaging survey of the haloes of nearby Milky Way-sized galaxies; CALIFA, the first large IFU survey of galaxies across the Hubble diagram; and MUSE guaranteed time observations of galaxies, in particular the outstandingly successful MUSE Deep Fields. Another milestone was the launch of the eROSITA X-ray satellite observatory in 2019 and the beginning of its multi-epoch all-sky survey, used by AIP scientists for a multitude of research goals.

Capturing the complex physical processes of galaxy formation and evolution in numerical simulations is one of the biggest challenges in astrophysics since many years. Several new ideas and approaches on this theme were established at AIP following the appointment of the new head of the section “Cosmology and High-Energy Astrophysics” in 2016. The section head is professor of “Computational Cosmology” at the University of Potsdam, supported by an ERC Consolidator Grant and, since 2021 an ERC Advanced Grant. This involved the development of a strong focus on plasma astrophysics, in particular on acceleration mechanisms of cosmic rays and the formation and propagation of instabilities, but also the investigation of the impact of these effects on galaxy-wide phenomena such as the still enigmatic problems of “feedback” and the formation of galaxy clusters. Another topic within this theme has been the exploration of the circumgalactic and intergalactic medium at high redshifts, in particular through the detailed analysis of extended emission line envelopes around galaxies discovered with the MUSE instrument. This new research topic was also honoured in 2021 with the award of an ERC Advanced Grant to the head of the “Galaxies and Quasars” section.

Between 2018 and 2020, the research area published ∅ 166 articles p.a. in peer-reviewed journals. In the same period, the revenue from project grants was ∅ 3.12 M€ p.a., with ∅ 1.18 M€ p.a. spent from the EU, ∅ 951 k€ p.a. from federal and *Länder* governments, ∅ 725 k€ p.a. from the DFG, and ∅ 207 k€ p.a. from the Leibniz Association. Furthermore, in the same period, 10 doctoral degrees were completed.

Research and Development area *Development of Research Infrastructure and Technology*

[36.9 FTE, thereof 25.6 FTE Research and scientific services, 2.6 FTE Doctoral candidates, and 8.7 FTE Service staff]

The research area is dedicated to the development and operation of advanced instrumentation at powerful telescopes in the best locations on Earth or in space, and to enabling flexible and intelligent data handling and data mining of archival observations and high-level data products as well as for the output of numerical simulations with large supercomputers. It comprises the following five sections:

- Telescope Control and Robotics
- High-resolution Spectroscopy and Polarimetry
- 3D and Multi Object Spectroscopy
- Supercomputing and E-Science
- innoFSPEC including the group Astrophotonics

The addressed topics can be broadly aligned along the following three strategic themes

1. Spectroscopic Instrumentation for the Facilities of the 21st Century
2. Surveys and Monitoring

3. Technology Development and Transfer

AIP has a strong track record in spectroscopy, from designing and assembling spectroscopic instruments to the development of innovative methods for spectral analysis. The institute operates the high-resolution spectrographic facilities STELLA-SES and LBT-PEPSI, and implemented a generic data reduction system with applications for these and other instruments. Building on the success of PMAS at Calar Alto, 3D (or integral field) spectroscopy has become a signature competence of AIP, leading to strong involvement in the panoramic VLT-MUSE and HETDEX-VIRUS instruments, with contributions to both hard- and software. A culmination of these efforts has been reached with the PI-ship of the 4MOST multi-object spectrograph for the ESO-VISTA telescope. Design studies for the ELT second generation instruments HIRES und MOSAIC already imply significant future engagements in this field.

Major efforts have been taken at AIP to invest in the development and application of information technologies (again both hard- and software) to address several challenges in observational and theoretical astrophysics. Innovative processes to enable autonomous observing have been implemented – with the "robotic" STELLA observatory as showcase – that permit uniquely flexible time-domain astronomical observations. Another challenge is the data flow from large surveys, which needs to be curated and rendered into a user-digestible form, including the dissemination through public data releases. Related in many aspects has been the handling and release of large numerical simulation suites, as well as providing collaborative software environments used during the actual design and execution of such simulations. Important contributions were also made to a number of space-based facilities.

The core goal of the innoFSPEC competence centre and its research groups Multi-Channel Spectroscopy (2009–2014) and Astrophotonics (2015–2022) is the exploration of new approaches in fibre-coupled spectroscopy and sensing; these activities have meanwhile broadened substantially towards the investigation of a wide variety of possible photonics solutions for astronomical instrumentation. This involves developing prototypes for possible future innovative instruments, but also – if the opportunity arises – transferring technologies and methods to industry or other sectors of research; an outstanding example is the successful transfer of the integral field spectroscopy concept from astronomy to medical imaging. innoFSPEC has been awarded substantial BMBF and DFG funding to establish a lab infrastructure with equipment for photonic research that is unique in Germany.

Between 2018 and 2020, the research area published ∅ 43 articles p.a. in peer-reviewed journals. In the same period, the revenue from project grants was ∅ 4.1 M€ p.a., with ∅ 3.2 M€ p.a. spent from federal and *Länder* governments, ∅ 650 k€ p.a. from the EU, ∅ 170 k€ p.a. from the DFG, and ∅ 80 k€ p.a. from the Leibniz Association. Furthermore, in the same period, 3 doctoral degrees were completed.

8. Handling of recommendations from the previous evaluation

AIP responded as follows to the six recommendations of the last external evaluation (highlighted in italics, see also statement of the Senate of the Leibniz Association issued on 26 November 2015, pages B-2/B-3):

1) In terms of its expertise in astrophysics, AIP is firmly and broadly based. This is one of its great strengths that enables it to implement a comprehensive, cross-disciplinary research strategy. At the same time, AIP has defined appropriate ***cross-cutting themes*** *which allow it to set priorities. The institute is encouraged to continue along this path in order to maintain and further develop its standing as an internationally competitive research institution.*

According to AIP, many of the seeds of 2015 have now come to fruition: the GTO programme of the MUSE instrument on ESO'S VLT is in full swing with a substantial number of high-impact publications already out. The GREGOR solar telescope has published a first series of science papers based on commissioning data and is now in science operation. The high-resolution spectrograph PEPSI has been commissioned and the first publications demonstrate the immense potential of this instrument. The polarimeters were installed in 2017/18, and science commissioning is ongoing.

2) Due to the development of the institute's technology and infrastructure sector in the last few years, the potential for ***knowledge and technology transfer (KTT)*** *outcomes has grown but is not yet being fully exploited. The Review Board assumes that further interesting transfers will be forthcoming in the future.*

AIP shares the view that there is further potential in the area of KTT, and it is devoted to exploiting this potential predominantly in the context of the innoFSPEC Centre of Excellence. A prime example is the collaboration with the Charité Berlin to study the application of fibre-based 3D spectroscopy for medical applications in cancer research. Seven patents have been filed in the area of optical and photonic technologies – some by AIP alone, some in collaboration with partners. Two patents have already been awarded and five are under various stages of examination.

3) Due to the central importance of the Technical Section for AIP's strategic development and competitiveness, the plans to strengthen it and to ensure permanent employment for the highly-qualified personnel are logical. AIP has developed a coherent mid-term development plan for the ***enlargement of the Technical Section****. From 2017, for implementation it envisages additional funding of up to approximately 950 k€ per year, staggered over a three- to four-year period. This is well justified. The implementation of these plans is explicitly supported.*

Thanks to the recommendation of the 2015 review board, an extraordinary item of expenditure in the amount of 2,400 k€ for the years 2018–2020 (including a co-financing of the institute of 1,093 k€) has been approved. With the programme budget 2021 the institutional funding has been increased permanently by 630 k€ . This measure, for example, enabled the institute to establish a section devoted to the management of large ground- and space-based projects starting with 2018, as recommended by the Science Advisory Board.

4) AIP is encouraged to continue ***focusing on projects that reflect the institute's particular strengths*** *and promote its scientific work. By boosting the Technical Section, the best possible preconditions for this mission will be created.*

As already reported under recommendation 1, the institute is continuing its strategy of recent years with a clear focus on its particular strengths, i.e., joint strengths between the science and the technical programmes. State-of-the-art instruments like MUSE and PEPSI are expected to deliver excellent data for many years to come and thus will continue to be cornerstones of the science programme of AIP. The 4MOST multi-object spectroscopic facility is now in its assembly and testing phase with an anticipated beginning of the up-to-15-year-long science exploitation in 2025. The institute has already set the path for the next generations of instruments like the blue-sensitive MUSE clone BlueMUSE for the VLT and the ELT instruments HIRES and MOSAIC. This long-term science strategy will also be the cornerstone for the hiring of lead personnel, particularly with regard to the upcoming generation change.

5) AIP's office capacity, however, has long lagged behind actual needs. Moreover, thanks to the institute's success in acquiring third-party funding, the workforce has grown significantly since the last evaluation; additional office space is urgently required. Consequently, the ongoing plans to construct a ***new, bilaterally-financed building*** *are strongly supported.*

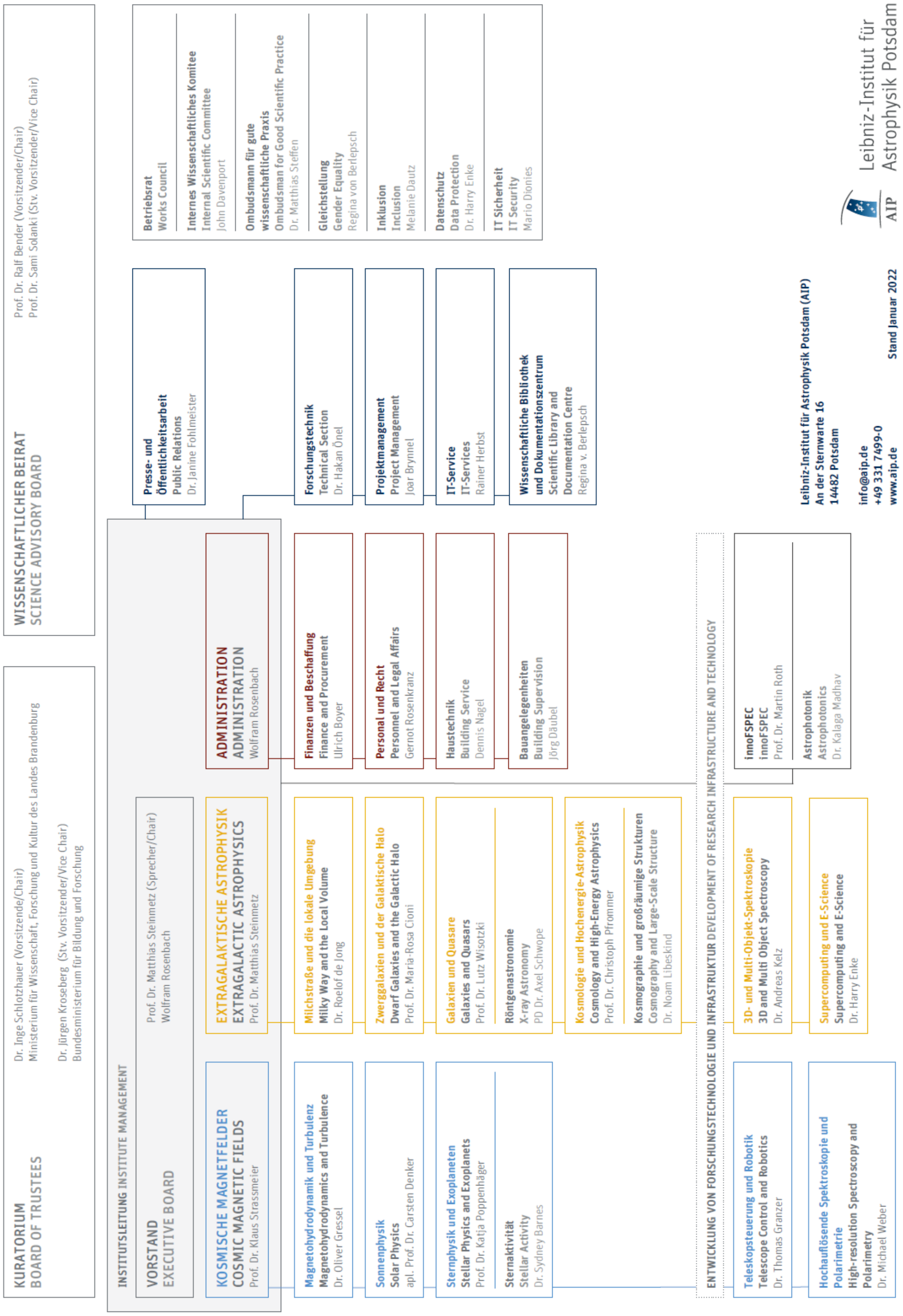
The state of Brandenburg and the federal government have agreed to construct a new building on the Babelsberg campus starting in 2019 (total budget 2019–2024: 23 M€). Such a construction project is particularly challenging as the site of the AIP campus is part of the UNESCO world heritage site "Prussian Palaces and Gardens". Despite these challenges, a building permit could be secured and ground-breaking took place in August 2021 with an anticipated end of construction in 2024.

6) ***Women*** *are clearly underrepresented in AIP's scientific sector, particularly in leadership positions. AIP is called upon to achieve the binding quotas determined for this institute in the cascade model.*

The institute is strongly committed to increasing the number of female scientists at all levels and has set itself ambitious benchmarks for 2017, 2020, and 2025 via the cascading model. Indeed, the institute surpassed the 2017 and 2020 benchmarks. Highlights of these efforts were the establishment of 3 new professorships in the past 5 years; for two of them internationally recognized female scientists could be recruited. Other highlights include a female apprentice in the mechanical workshop and a female group leader for optical design. Institute regulations that have been implemented since the last evaluation such as flexible work hours and home office opportunities further help in providing a proper work-life balance. The institute's view on equal opportunities, however, is not limited to the underrepresentation of women but extends to the question of diversity and inclusion in general. A progressive code-of-conduct was implemented to enable a healthy work environment, senior staff are encouraged to participate in relevant workshops and issues are continuously addressed at a monthly "Equity and Inclusion" lunch.

Appendix 1

Organisational Chart



Appendix 2

Publications and patents

Type of publication	2018	2019	2020
Monographs	1	1	1
Individual contributions to edited volumes	1	1	3
Articles in peer-reviewed journals	284	244	279
Articles in other journals	122	102	119
thereof proceedings	91	51	68
thereof public journals	14	27	18
Working and discussion papers	1	3	1
Software and Data Releases	10	7	10
Editorship of edited volumes	10	10	11

Patents	2018	2019	2020
Applications giving rise to a right of priority (in the calendar year)	2	2	2
Patents (number held as of 31.12. of the year)	0	1	1
Patent families (number held as of 31.12. of the year)	0	1	1

Other industrial property rights	2018	2019	2020
Applications giving rise to a right of priority (in the calendar year)	0	0	0
Property rights (number held as of 31.12. of the year)	3	3	3
Property rights families (number held as of 31.12. of the year)	3	3	3

Appendix 3 Revenue and Expenditure

	Revenue	2018 k€	2018 % 2)	2018 % 3)	2019 k€	2019 % 2)	2019 % 3)	2020 1) k€	2020 % 2)	2020 % 3)
Total revenue (sum of I., II. and III.; excluding DFG fees)		**22,607.8**			**24,454.8**			**27,818.1**		
I.	**Revenue (sum of I.1.; I.2., and I.3.)**	**19,785.5**	**100 %**		**20,715.4**	**100 %**		**22,080.8**	**100 %**	
1.	Institutional Funding (excluding construction projects and acquisition of property)	12,355.5	62 %		12,626.6	61 %		13,055.3	59 %	
1.1	Institutional funding (excluding construction projects and acquisition of property) by Federal and *Länder* governments according to AV-WGL	12,355.5			12,626.6			13,055.3		
1.2	Institutional funding (excluding construction projects and acquisition of property) not received in accordance with AV-WGL	0.0			0.0			0.0		
2.	Revenue from project grants	7,430.0	38 %	100 %	8,088.8	39 %	100 %	9,025.5	41 %	100 %
2.1	DFG	1,147.0		15 %	1,195.2		15 %	1,074.7		12 %
2.2	Leibniz Association (competitive procedure)	427.2		6 %	466.8		6 %	327.0		4 %
2.3	Federal, *Länder* governments	3,460.4		47 %	4,279.4		53 %	5,830.4		65 %
2.4	EU	2,359.4		32 %	1,989.3		25 %	1,628.6		18 %
2.5	Industry	0.0		0 %	0.0		0 %	0.0		0 %
2.6	Foundations	7.2		0 %	8.1		0 %	10.8		0 %
2.7	other sponsors like IAU Symposium, CERN*, GSO**	28.8		0 %	150.0		2 %	154.0		2 %
3.	Revenue from services	0.0	0 %		0.0	0 %		0.0	0 %	
3.1	Revenue from commissioned work	0.0			0.0			0.0		
3.2	Revenue from publications	0.0			0.0			0.0		
3.3	Revenue from exploitation of intellectual property for which the institution holds industrial property rights (patents, utility models, etc.)	0.0			0.0			0.0		
3.4	Revenue from exploitation of intellectual property without industrial property rights	0.0			0.0			0.0		
II.	**Miscellaneous revenue** (e. g. membership fees, donations, rental income, funds drawn from reserves)	2,822.3			2,739.4			2,737.3		
III.	**Revenue for construction projects** (institutional funding by Federal and *Länder* governments, EU structural funds, etc.)	0.0			1,000.0			3,000.0		

	Expenditures	2018 k€	2019 k€	2020 k€
Expenditures (excluding DFG fees)		**22,607.8**	**24,454.8**	**27,818.1**
1.	Personnel	11,553.4	12,491.7	13,093.4
2.	Material expenses	5,248.9	4,921.7	4,587.9
2.1	*Proportion of these expenditures used for registering industrial property rights (patents, utility models, etc.)*	*2.5*	*14.1*	*12.8*
3.	Equipment investments	5,805.5	6,434.7	9,423.6
4.	Construction projects, acquisition of property	0.0	606.7	713.2
5.	Other operating expenses (if applicable, please be specific)	0.0	0.0	0.0

	2018	2019	2020
DFG fees (if paid for the institution - 2.5 % of revenue from institutional funding)	307.5	314.4	325.7

* European Organization for Nuclear Research, ** German Scholar Organization

[1] Preliminary data: no

[2] Figures I.1., I.2. und I.3. add up to 100 %. The information requested here is thus the percentage of "Institutional funding (excluding construction projects and acquisition of property)" in relation to "Revenue from project grants" and "Revenue from services".

[3] Figures I.2.1 bis I.2.7 add up to 100 %. The information requested here is thus the percentage of the various sources of "Revenue from project grants".

Appendix 4

Staff

(Basic financing and third-party funding / proportion of women (as of: 31 December 2020)

	Full-time equivalents		Employees		Female employees		Foreigners
	Total	on third-party funding	Total	on temporary contracts	Total	on temporary contracts	Total
	Number	Percent	Number	Percent	Number	Percent	Number
Research and scientific services	**104.8**	**47.4**	**117**	**70.0**	**33**	**90.9**	**60**
1st level (scientific directors)	2.0	0.0	2	0.0	0	0.0	1
2nd level (section heads)	12.0	6.8	12	0.0	2	0.0	4
3rd level (group leaders)	4.0	25.0	4	25.0	0	0.0	3
Scientists in non-executive positions (E13, E14 or equiv.)	68.8	54.0	70	74.3	16	93.8	40
Doctoral candidates (E13, E13/2 or equiv.)	18.0	59.8	29	100.0	15	100.0	12
Science supporting staff (laboratories, technical support etc.)	**48.7**	**19.7**	**51**				
Laboratory/ Construction / Workshop (E13, senior-level service)	4.9	24.5	5				
Laboratory/ Construction / Workshop (E9 to E12, upper-mid-level service)	15.5	28.0	16				
Laboratory/ Construction / Workshop (E5 to E8, mid-level service)	5.0	8.0	5				
Library (E9 to E12, senior service)	2.0	10.0	2				
Information technology - IT (E13, senior-level service)	2.5	0.0	3				
Information technology - IT (E9 to E12, upper-mid-level service)	3.8	0.0	4				
Information technology - IT (E5 to E8, mid-level service)	2.0	0.0	2				
Project management/ Support (E13 to E15, senior-level service)	4.7	49.3	5				
Project management/ Support (E9 to E12, upper-mid-level service)	2.0	32.5	2				
Project management/ Support (E5 to E8, mid-level service)	6.3	8.6	7				
Science supporting staff (administration)	**22.3**	**3.8**	**23**				
Head of administration	1.0	0.0	1				
Staff positions (from E13, senior-level service)	2.0	2.5	2				
Internal administration (financial administration, personnel, etc.) (from E13, senior-level service)	3.0	3.3	3				
Internal administration (financial administration, personnel, etc.) (E9 to E12, upper-mid-level service)	1.9	2.3	2				
Internal administration (financial administration, personnel, etc.) (E5 to E8, mid-level service)	8.4	7.6	9				
Building service (E5 to E13)	3.0	0.0	3				
House service (E5 to E8, mid-level service)	3.0	0.0	3				
Student assistants	**11.0**	**69.3**	**25**				
Trainees	**3.0**	**6.7**	**3**				
Scholarship recipients at the institution	**0.7**	**100.0**	**1**		**1**		**1**
Doctoral candidates	0.7	100.0	1		1		1
Post-doctoral researchers	0.0	0.0	0		0		0

21 June 2022

Annex B: Evaluation Report

Leibniz Institute for Astrophysics Potsdam (AIP)

Contents

1. Summary and main recommendations

The AIP conducts basic research in astrophysics with great success and develops cutting-edge astrophysical instruments. The institute's work covers the whole spectrum of modern astronomy, from solar physics to high-redshift galaxies. The AIP is organised in three areas with a total of 12 sections. The two research areas *Cosmic Magnetic Fields* and *Extragalactic Astrophysics* are each headed by a director. They are complemented by the third area, *Development of Research Technology and Infrastructure*, which is supervised by both directors. All three areas produce outstanding achievements.

The AIP's research results are excellent and visible internationally. They are regularly published in high-ranking journals. The publication output, which was already impressive at the time of the last evaluation, has increased again. One of the AIP's greatest strengths is in designing, building and maintaining astrophysical instrumentation. The institute is involved in international networks that operate world-leading telescopes and satellite missions. Together with partners, it develops highly complex instruments for these and often plays a leading role in such projects. For instance, the AIP is currently heavily involved in developing two important instruments (ANDES[1] and MOSAIC) for the *Extremely Large Telescope* (ELT). It also successfully carries out knowledge and technology transfer: it holds several patents, and instruments developed at the AIP are also used in applications outside the field of astrophysics, e.g. in medical technology. To promote transfer, the AIP and the University of Potsdam run a joint venture called innoFSPEC, which is being funded by the German Federal Ministry of Education and Research (BMBF) from 2009 to 2022.

The institute has developed in a convincing manner since the last evaluation. Among other things, new section heads were appointed for five of the twelve sections that exist today. In the course of these very well-organised personnel changes, the AIP has made sensible adaptations to its research profile. Third-party funding accounts for a remarkably high share of the institute's budget (around 40%), and the AIP has now become extremely successful at applying for European funding, as recommended seven years ago. Notably, AIP scientists have managed to secure six ERC grants since then. It is very good to see that the construction of a new building is underway, with completion foreseen for 2024.

Important changes at leadership level are expected again in the next few years. In particular, one of the two scientific directors will retire in 2025. In addition, four other senior scientists will retire by 2028. Against this background, the AIP and its committees have developed a convincing future strategy. The aim is to establish Precision Stellar Science as a new, extremely promising research topic at the AIP.

Special consideration should be given to the following main recommendations in the evaluation report (highlighted in **bold face** in the text):

<u>Changes and planning</u> (chapter 3)

1. For its development in the period 2022–2029, the institute envisages establishing **Precision Stellar Science for Exoplanets, Stellar Evolution, and Galactic Archaeology** at the AIP. Among other things, this will involve creating a new research

[1] ANDES was previously known as HIRES (see status report).

area, to be led by a third director. The AIP intends to finance these planned measures to a great extent from its own funds (approx. €1.2m p.a.). In addition, the institute sees a need for permanent additional funding of €2.0m p.a. for ongoing activities and €2.0m for a one-off investment in its stake in ANDES and MOSAIC. The review board is very supportive of these plans, and the proposed application for additional institutional funding (extraordinary item of expenditure) is expressly endorsed.

2. Participation in the ELT instruments ANDES and MOSAIC, which are very important for the scientific community, is of great strategic significance for the AIP. These major projects require a considerable investment of resources. So it is essential that the AIP reviews its involvement in the **development and operation of other research instruments**, as planned. Decisions about redeploying the AIP's own resources should be guided by their medium- to long-term relevance for the AIP. In particular, securing access to the *European Solar Telescope* (EST) and ensuring continued access to the *Large Binocular Telescope* (LBT) and satellite-based telescopes may be expedient. With this in mind, the AIP now needs to make strategic decisions about how its resources should be allocated in the future.

Controlling and quality management (chapter 4)

3. The Chair of the **Scientific Advisory Board** is a voting member of the Board of Trustees. In order to make a clear distinction between the functions of supervision and scientific advice, this should be changed. The Chair of the Scientific Advisory Board should be a non-voting member of the Supervisory Board, as is usually the case at Leibniz institutions.

Human resources (chapter 5)

4. In addition to the resources on offer from the University of Potsdam, the AIP should expand its own support for **career paths** inside and outside academia. For example, an in-house mentoring program could make sense.

5. The share of women among the scientific and scientific services staff stands at 28% (33 out of 117 employees). Among the lead scientists (2 directors, 12 section heads, 4 group heads), only two section heads are female. In non-executive positions, there are only 16 women out of 70 scientists (23%). It is pleasing to see that there is a gender balance among the doctoral researchers. Although the AIP has made progress in promoting **gender equality**, women are not yet adequately represented above doctoral level. The AIP must intensify its efforts, also by fostering a culture that places a high value on work-life balance and individual support at all career levels. It must take advantage of the upcoming appointments to make significant improvements, especially in executive positions.

2. Overall concept, activities and results

Overall concept

The AIP conducts basic research in astrophysics with great success. It also develops innovative technologies and measurement instruments to pursue its scientific questions.

These are used in major telescopes around the world and also in satellite missions. The institute's work covers the whole spectrum of modern astronomy, from solar physics to high-redshift galaxies.

The AIP carries out its work in three areas. The two research areas Cosmic Magnetic Fields and Extragalactic Astrophysics are each headed by a director. They are complemented by the third area, Development of Research Technology and Infrastructure, which is supervised by both directors. The research areas are subdivided into a total of 12 sections. In four of the sections there also is a research group.

Results

Research

The AIP achieves first-class, internationally visible research results that are regularly published in high-ranking journals. Highlights include, for example, the detection of potassium in the atmosphere of a hot Jupiter exoplanet and the discovery that high-redshift galaxies are surrounded by extended Lyman-alpha-emitting envelopes. The publication output, which was already impressive at the time of the last evaluation, has improved even further. It is outstanding, both in terms of numbers and quality.

Development of scientific infrastructure

One of the AIP's greatest strengths is in designing, building and maintaining cutting-edge astrophysical instrumentation. The institute is involved in international networks that operate world-leading telescopes and satellite missions. Together with partners, it develops highly complex instruments for these and often plays a leading role in such projects. Examples include coordinating the development of the 4MOST multi-object spectrograph for the VISTA telescope of the European South Observatory (ESO) in Chile, and PEPSI, a spectrograph and polarimeter used in the *Large Binocular Telescope*. The AIP also provides instruments for space missions (e.g. Gaia, Solar Orbiter and PLATO). Currently, the AIP is heavily involved in developing two important instruments for the *Extremely Large Telescope* (ELT): the ANDES high-resolution instrument and the MOSAIC multi-object spectrograph (see chapter 3). These intensive activities in instrument development also give the AIP regular access to the telescopes in the form of Guaranteed Time Observations (GTO).

Commendably, the AIP is heavily engaged in e-Science and research data management. A highlight in this field is its leading role in PUNCH4NFDI, a consortium of the German National Research Data Infrastructure (NFDI). The AIP is encouraged to continue along this path.

Knowledge and technology transfer

The AIP has intensified its efforts in the area of technology transfer in recent years, as recommended during the last evaluation. This is due in large part to the successes of the BMBF-funded innoFSPEC innovation centre (2nd funding period 2015–2022), which is run jointly by the AIP and the University of Potsdam. Here, technologies – primarily from the fields of spectrography and photonics – are developed for use in next-generation astrophysical instruments. These technologies are also sometimes successfully used in other areas besides astronomy, for instance in medical technology. Between 2018 and 2021, a total of seven applications for patents were filed, and the institute currently holds two patents. The AIP should continue along this path and pursue its plans to strengthen technology transfer further.

The AIP was heavily involved in compiling the "Denkschrift 2017"[2], a compendium aimed at scientific organisations, but also political authorities at federal government and *Länder* level. It presents the status and development prospects of astrophysics in Germany for the period 2017–2030.

3. Changes and planning

Development since the previous evaluation

The institute has developed in a convincing manner since the last evaluation. Among other things, new section heads were appointed for five of the twelve sections that exist today. In four cases, the previous occupant retired, and in the other, a new section was established following the award of an ERC *Consolidator Grant*. Outstanding scientists have been recruited for all five posts: three transferred to the AIP from outside, and two positions were filled with applicants from within the institute who demonstrated an excellent track record.

The personnel changes were accompanied by sensible enhancements to the scope of the sections, in line with the AIP's research strategy. For example, the "Stellar Physics" section now also conducts research on exoplanets, and the "Cosmology and High-Energy Astrophysics" section has developed a focus on high-energy astrophysics.

Strategic work planning for the coming years and planning for additional institutional funding

Important changes at leadership level are expected again in the next few years. In particular, the director of the Cosmic Magnetic Fields research area will retire in 2025. The AIP's committees must set in motion the recruitment process for his replacement in good time. They should ensure that the appointee is able to continue seamlessly with ELT-ANDES, a key differentiator project pursued with great commitment by the current director. In addition, three section heads and one group head will retire by 2028. Against this background, the AIP and its committees have developed a convincing future strategy.

For its development in the period 2022–2029, the institute envisages establishing Precision Stellar Science for Exoplanets, Stellar Evolution, and Galactic Archaeology at the AIP. Among other things, this will involve creating a new research area, to be led by a third director. A total of four individual measures are planned:

- Another research area is to be set up, which will be led by a third scientific director (1 W3 professor, 2 senior scientists (E14), 3 postdocs (E13), 4 PhD students (0.75 E13)).
- The institute's participation in the two ELT projects, ANDES and MOSAIC, is to be continued and intensified (one-off investment of €2.0m).

[2] https://denkschrift2017.de/.

- The astrophotonic expertise developed in the BMBF-funded innoFSPEC centre is to be retained at the institute long-term (1 W2 professor, 2 scientists (E13), 2 PhD students (0.75 E13)).
- The AIP plans to develop a machine learning research group so as to optimise its ability to analyse the expected large data volumes (1 group head (E14), 1 scientist (E13), 2 PhD students (0.75 E13)).

The measures are to be supported by administrative and technical support positions (1 E11, 2 E9a) and financial investments (€0.5m p.a.). **The AIP intends to finance these planned measures to a great extent from its own funds (approx. €1.2m p.a.). In addition, the institute sees a need for permanent additional funding of €2.0m p.a. for ongoing activities and €2.0m for a one-off investment in a stake in ANDES and MOSAIC. The review board is very supportive of these plans, and the proposed application for additional institutional funding (extraordinary item of expenditure) is expressly endorsed.**

Participation in the ELT instruments ANDES and MOSAIC, which are very important for the scientific community, is of great strategic significance for the AIP. These major projects require a considerable investment of resources. So it is essential that the AIP reviews its involvement in the development and operation of other research instruments, as planned. Decisions about redeploying the AIP's own resources should be guided by the medium- to long-term relevance for the AIP. In particular, securing access to the *European Solar Telescope* (EST) and ensuring continued access to the *Large Binocular Telescope* (LBT) and satellite-based telescopes may be expedient. With this in mind, the AIP now needs to make strategic decisions about how its resources should be allocated in the future.

4. Controlling and quality management

Facilities, equipment and funding

Funding

The institutional funding of the AIP is deemed sufficient for its current activities. As of 2020, it stands at €13.1m p.a. (up from €10.8m in 2013).

The high level of third-party funding is pleasing and amounts to around 40% of the total budget (€8.2m p.a. on average, 2018–2020). It comes from the federal government and the Länder (€4.5m), the EU (€2.0m), the DFG (€1.2m) and the Leibniz Association (€0.4m). As recommended, funds secured from the EU have increased sharply, thanks in part to the six ERC grants awarded to AIP scientists. The innoFSPEC innovation centre is also funded by the federal government (around €0.75m p.a. from the BMBF in 2009–2022).

While the institute's extraordinary successes in acquiring third-party funding are testament to its exceptional capabilities, the AIP should not specifically aim to further increase its third-party quota. This was also recommended by its Scientific Advisory Board.

Facilities and equipment

The AIP administers and maintains the campus of the Babelsberg Observatory as a main site for its research activities. As the AIP has continuously increased in size in the last 20 years, office facilities have lagged behind actual needs. It is therefore very good to see that the construction of a new building is underway, with completion foreseen for 2024. The federal government and host Land have provided €23.0m for this purpose.

As a part of its own facilities, the AIP runs a station of the LOFAR radio inferometer at Potsdam-Bornim. It also has its own research telescopes on Tenerife (STELLA, GREGOR, VTT) which it maintains, in some cases with partners such as the Instituto de Astrofísica de Canarias and KIS. Besides these, it participates in state-of-the-art observational facilities all over the world, both directly and via national consortia.

Organisational and operational structure

The organisational and operational structures are appropriate and effective. The AIP has a clear structure with an Executive Board, consisting of one of the scientific directors as a scientific member, and an administrative member. Decision-making is suitably informed by the Institute Management (scientific directors and head of administration) and complemented by regular "Heads meetings", i.e. meetings of all directors, section and group heads, and representatives of the Works Council and scientific staff.

Quality management

The quality management measures in place are appropriate. All scientists are introduced to good scientific practice as handled at the institute. There are contact persons appointed for doctoral students, postdocs and international scientists, who are, among other things, dedicated to issues of good scientific practice.

Access to the AIP's primary research resources, i.e. Guaranteed Time Observations at leading telescopes, is administered via dedicated competitive processes (some of them in-house, some of them, e.g. for MUSE, coordinated via a consortium). It is good to see that these procedures are transparent and open to all researchers, including those at doctoral level.

The AIP actively follows an open science programme, with publications regularly made freely available on the NASA Astrophysics Data System. It should continue on this path, and its efforts to make more and more of its codes freely accessible are welcomed. The AIP is committed to further developing research data management (see chapter 2).

Quality management by advisory board and supervisory board

The Board of Trustees and the Scientific Advisory Board each fulfil their roles in an appropriate manner. The Scientific Advisory Board meets once a year and conducts an audit between external evaluations.

The Chair of the Scientific Advisory Board is a voting member of the Board of Trustees. In order to make a clear distinction between the functions of supervision and scientific advice, this should be changed. The Chair of the Scientific Advisory Board

should be a non-voting member of the Supervisory Board, as is usually the case at Leibniz institutions.

5. Human resources

Leading scientific and administrative positions

The AIP, as a rule, fills leading scientific positions through joint appointments with the University of Potsdam. Seven individuals are currently jointly appointed: the two directors (W3) and five of the twelve section heads (W2). A further joint appointment to a W3 professorship will be added in future for the planned third director position (see chapter 3). As a result of upcoming retirements at senior level, joint appointments will also be needed for one W3 professor (director) and two W2 professors (section heads).

After the position of the administrative member of the Executive Board fell vacant, it was filled again in 3/2021.

Junior researchers

The AIP offers very good working conditions for doctoral researchers and postdocs. From 2018 to 2020, a total of 19 doctorates were awarded, and at 31 December 2020, 29 doctoral candidates were pursuing their research at the AIP, of whom more than 40% were from abroad. The average length of a doctorate is just over four years and the supervision regulations in place are adequate.

The fact that 20 junior scientists have been appointed to permanent or tenure track positions at foreign institutions since the last evaluation is testament to the high quality of the support given to early-career scientists at the AIP. In addition, a total of 13 successful scientists were given long-term contracts at the AIP – eight of them as section or group heads, and the other five in tenure-track or permanent positions.

Regular discussions are held with doctoral researchers and postdocs about their scientific progress. They have access to the workshops and seminars of the Potsdam Graduate School. **In addition to the resources on offer from the University of Potsdam, the AIP should expand its own support for career paths inside and outside academia. For example, an in-house mentoring program could make sense.** As a way of offering outstanding young scientists additional development prospects, the AIP could also give excellent early-career scientists opportunities to act as PIs in international instrumentation projects even earlier in their careers.

The Karl Schwarzschild fellowship, which the AIP set up a few years ago, is a very successful instrument for attracting promising early-career scientists to the institute. It is awarded each year to one excellent postdoc researcher for up to five years and is highly regarded; Schwarzschild fellows have repeatedly secured external funding to establish their own research groups.

Scientific support staff

The AIP's commitment to vocational training is laudable. It offers apprenticeships in four different fields, ranging from IT systems integration to precision mechanics. In 2020, three apprentices were employed, and between 2018 and 2020, three apprentices completed their training.

Backed by the 2015 evaluation, the AIP was granted extended institutional funding to boost its technical section and employ adequate numbers of experts.

Equal opportunities and work-life balance

The measures to promote equal opportunities recommended by the Leibniz standards, including the cascade model, are in place. As of 2020, **the share of women among the scientific and scientific services staff stands at 28% (33 out of 117 employees). Among the lead scientists (2 directors, 12 section heads, 4 group heads), only two section heads are female. In non-executive positions, there are only 16 women out of 70 scientists (23%). It is pleasing to see that there is a gender balance among the doctoral researchers. Although the AIP has made progress in promoting gender equality, women are not yet adequately represented above doctoral level. The AIP must intensify its efforts, also by fostering a culture that places a high value on work-life balance and individual support at all career levels. It must take advantage of the upcoming appointments to make significant improvements, especially in executive positions.**

6. Cooperation and environment

Collaboration with universities

The AIP maintains close ties with the University of Potsdam (UP). Collaboration with UP extends from joint appointments of professors (see chapter 5) to a successful joint international Master's degree programme in astrophysics. The programme was established after the last evaluation and has proved to be very attractive: in 2020, there were 300 applicants for 60 places. Many of the doctoral researchers at the AIP who graduated in Germany completed the Master's programme. Further fruitful collaboration between the AIP and UP exists, e.g. in the innoFSPEC joint venture. AIP scientists are also regularly involved in teaching at UP and at the Berlin universities.

Key partners in Germany and abroad

The AIP plays a highly visible role in Germany's astrophysical landscape and also has outstanding international connections. Together with the Max Planck Society and the Landessternwarte Heidelberg-Königstuhl observatory, it holds a 25% stake in the *Large Binocular Telescope* (LBT). Here, and in other infrastructure projects, including ESO telescopes (especially ELT) and ESA satellites (e.g. Gaia, Solar Orbiter and PLATO), the AIP collaborates with many partners in the development of scientific infrastructure, often taking on a coordinating role.

Besides its involvement in these multinational networks, the AIP also works closely with Spanish partners to operate research facilities such as the STELLA robotic observatory and the GAMAICA integral field spectrograph.

Collaboration with Leibniz Institutes

The AIP collaborates closely with the Leibniz Institute for Solar Physics (KIS). Together with local and German partners, they jointly operate the GREGOR and VTT telescopes on Tenerife. The AIP also participates in the Leibniz Research Network "Mathematical Modelling and Simulation". It is an associate member of the Leibniz Research Alliance "Health Technologies", to which it contributes integral field spectroscopy techniques. It is also very active in the Leibniz Association's Research Data Working Group, with the head of the e-Science section elected as a deputy spokesperson.

7. Subdivisions of AIP

Research area: *Cosmic Magnetic Fields*

[35.1 FTE, of whom 24.3 FTE research and scientific services staff, 7.6 FTE doctoral candidates, and 3.2 FTE service staff]

The research in this area very successfully explores solar, stellar, and galactic magnetic fields, along with the underlying magnetohydrodynamic mechanisms that generate them. Its work is conducted in the three sections "Magnetohydrodynamics and Turbulence", "Solar Physics", and "Stellar Physics and Exoplanets". The research aims to understand the complex interplay between the structure of matter, the geometry and strength of magnetic fields, and their feedback. The research area is exceptional in the international context of the study of cosmic magnetic fields, as it successfully combines in single unit observations, data analysis, and supercomputing simulations.

The research area has delivered outstanding results. Highlights include the application of gyrochronology to stars of a similar age to the Sun, and the detection of potassium in the atmosphere of a hot Jupiter exoplanet, using PEPSI, an instrument designed by the AIP. The research area's publication output is even more laudable than it was seven years ago, in terms of both quantity and quality. The degree of involvement in ground-based instrumentation (e.g. ELT-ANDES, GREGOR, LOFAR) and space missions (e.g. Solar Orbiter, PLATO) is very impressive and well-balanced. The level of third-party funding is very good and has risen in recent years.

Since the last evaluation, the research area has undergone a substantial generational change, with new heads appointed in all three sections, among them a recipient of an ERC *Starting Grant*. Since the evaluation meeting, he has been awarded an ERC *Consolidator Grant*. It is welcomed that the research focus has shifted slightly and now also includes exoplanets, star-planet interaction, and planet habitability. The incumbent director is due to retire in 2025 (see chapter 3).

Research area: *Extragalactic Astrophysics*

[47.1 FTE, of whom 37 FTE research and scientific services staff, 7.7 FTE doctoral candidates, and 2.4 FTE service staff]

This research area devotes itself very successfully to understanding the structure, formation, and evolution of galaxies as the fundamental cosmic building blocks. It covers a very large and impressive range of cutting-edge topics in its four research sections: "Milky Way and the Local Volume", "Dwarf Galaxies and the Galactic Halo", "Galaxies and Quasars", and "Cosmology and High-Energy Astrophysics". It combines observations, instrument development, surveys, simulations, and data science in an ideal manner, and the different methods complement one another fruitfully.

The research outputs are outstanding and regularly lead to publications in high-ranking journals. In the last few years, the research area has gained excellent new insights into topics such as the structure and star formation history of the Magellanic Clouds (obtained via the Vista survey) and, through the MUSE Deep Fields analysis, the discovery that high-redshift galaxies are surrounded by extended Lyman-alpha-emitting envelopes. It is extremely successful when it comes to devising instrumentation and large-scale surveys for its research. The research area is in charge of the AIP's participation in MUSE, 4MOST, eROSITA, and ELT-MOSAIC, and it led RAVE, a very successful Milky Way sky survey, which was completed in 2021. It enjoys outstanding success in acquiring third-party funding.

A major, and very welcome, new addition to the area's portfolio was the introduction of a "Dwarf Galaxies" section. New section heads were appointed for this section and the "Cosmology and High-Energy Astrophysics" section. It is testament to the research area's excellent reputation that in both cases it managed to appoint recent ERC *Consolidator Grant* awardees. In addition, two of its senior scientists were awarded ERC *Advanced Grants* in 2021. With only one section head due to retire in the next couple of years, and the high-scale instruments available and Guaranteed Time Observations (GTO) allotted to the AIP, this research area is ideally positioned to continue on its successful path in the years to come.

Research and Development area: *Development of Research Infrastructure and Technology*

[36.9 FTE, of whom 25.6 FTE research and scientific services staff, 2.6 FTE doctoral candidates, and 8.7 FTE service staff]

This research and development area is jointly headed by the two scientific directors. It comprises five sections, which successfully develop the technological and instrumental foundations on which the observations and research carried out in the research areas are based. The instrumentation and technology work closely follows the scientific objectives. The area concentrates on both hardware and software, and it develops instruments for use both in space and on the ground. It has also developed a focus on the transfer of technological research, primarily within the BMBF-funded innoFSPEC centre (2009–2022).

The area has demonstrated a world-class capability to design, build, and operate high-quality spectroscopic instrumentation. In recent years, high-level instruments such as PEPSI, a spectrograph and polarimeter used in the *Large Binocular Telescope* (LBT), have been implemented successfully. They were only just taking shape seven years ago and are now key to the AIP's observational successes. Furthermore, the AIP is a leading partner in building 4MOST, a multi-object spectrograph for the VISTA telescope of the European South Observatory (ESO) which is scheduled to go into operation in 2024. The research and development area is renowned for its numerical simulations and for the very sought-after data reduction software packages it has developed; among other things, the AIP is a Gaia partner data centre, delivering modules for data reduction pipelines. In addition to its instrumentation efforts, the area is also involved in a large number of high-quality publications and generates a very high level of third-party revenue. It has also generated a number of works protected by intellectual property rights.

The AIP has committed itself to designing and building two high-profile, next-generation instruments for ESO's ELT: ANDES, a near-infrared spectrograph, and MOSAIC, a multi-object spectrograph. Their development will shape the institute's work over the coming years, particularly in this research and development area, and the recent achievements in instrumentation mean that great successes can be expected here too. In 2022 and 2023, the heads of the "Supercomputing and E-Science" and "innoFSPEC" sections will retire. It is highly important for new section heads to be appointed in good time for both sections.

8. Handling of recommendations of the last external evaluation

The AIP has successfully addressed most of the recommendations made by the Leibniz Association Senate in 2015 (see status report, A-26f). It still needs to increase the proportion of women (no. 6).

Appendix

1. Review Board

Chair (Member of the Leibniz Senate Evaluation Committee)

Roland **Sauerbrey**	Helmholtz-Zentrum Dresden-Rossendorf, Germany

Deputy Chair (Member of the Leibniz Senate Evaluation Committee)

Konrad **Fiedler**	Department of Botany and Biodiversity Research, Division of Tropical Ecology and Animal Biodiversity, University of Vienna, Austria

Reviewers

Bernhard R. **Brandl**	Leiden University, Leiden Observatory, The Netherlands
Brice-Olivier **Demory**	Center for Space and Habitability, University of Bern, Switzerland
Yvonne **Elsworth**	School of Physics and Astronomy, University of Birmingham, UK
Andrea **Ferrara**	Scuola Normale Superiore, Pisa, Italy
Anna **Frebel**	MIT Kavli Institute for Astrophysics and Space Research, Massachusetts Institute of Technology, USA
Artie **Hatzes**	Karl Schwarzschild Observatory (Thuringian State Observatory), Tautenburg, Germany
Johan H. **Knapen**	Instituto de Astrofísica de Canarias, Spain
Sabine **Schindler**	Department of Atmospheric and Cryospheric Sciences (ACINN), University of Innsbruck, Austria
Eline **Tolstoy**	Kapteyn Astronomical Institute, University of Groningen, The Netherlands
Stefanie **Walch-Gassner**	Department of Physics, University of Cologne, Germany
Joachim **Wambsganß**	Astronomical Calculation Institute, Center for Astronomy of Heidelberg University, Germany

Representative of the federal government

Frank **Wolf**	Federal Ministry of Education and Research, Bonn, Germany

Representative of the Länder *governments (member of the Leibniz Senate Evaluation Committee)*

Babett **Gläser**	Saxon State Ministry for Science, Culture and Tourism, Germany

8 July 2022

Annex C: Statement of the Institution on the Evaluation Report

Leibniz Institute for Astrophysics Potsdam (AIP)

The Leibniz Institute for Astrophysics Potsdam (AIP) would like to thank the evaluation committee for its very thorough and fair report and for the very helpful recommendations. The institute is pleased to see the excellent marks it received for its past and current research programme as well as for its international standing. The institute is excited to learn about the extremely strong support the review panel gives to its strategic plan for the coming decade, especially the endorsement for our planned Sondertatbestand, which is a significant step in advancing our strategy. The institute is very thankful to its Science Advisory Board and its Board of Trustees for the excellent advice given over the past seven years and to the state and federal funding agencies for their continued strong support of the AIP. Together we will implement the recommendations of the review board in the coming years and looking forward to further AIP's role as a prime place for astrophysical research in the international research landscape.

Many aspects of the recommendations are already part of the institute's future plannings and strategy. We thus take the opportunity to add some additional information and recent developments, in particular as, owing to the reduced format caused by the pandemic situation, some aspects may not have been communicated and discussed as thoroughly as this would have been the case in a regular evaluation visit.

1) The AIP welcomes the strong endorsement of the institute's **strategic plan** including the request for **additional institutional funding.** The establishment of a new research area headed by a third director in the context of strengthening the emerging field of **Precision Stellar Science for Exoplanets, Stellar Evolution and Galactic Archeology** will be *the* major strategic initiative of the institute for the coming years.
2) While on the short and midterm **key projects** like PEPSI@LBT and 4MOST@VISTA will be the backbone of AIP's **research programme,** a critical resource on the longer term will be the 39m European Large Telescope (ELT) with its spectroscopic instruments ANDES and MOSAIC, both with significant AIP participation. First light is foreseen in the earlier 2030s. As the review panel emphasizes, implementation will require *substantial* investments of resources. The level of engagement in MOSAIC and ANDES will thus require a critical review of AIP's involvement in the LBT (in strong coordination with a similar review undertaken by our German partners in the MPG and at the University of Heidelberg) as well as in other projects. Such an assessment is foreseen to be performed in the context of upcoming director appointments and will not be independent on our success in securing the requested additional institutional funding. The Science Advisory Board will support the institute in this critical endeavor. Regarding the European Solar Telescope (EST): Funding of the EST as an ESFRI measure will primarily depend on the joint funding decision by European funding agencies. Should this observatory go forward, it will be an important resource for AIP's research programme and a significant participation in the development of state-of-the-art instrumentation and the subsequent science exploitation appears natural.

3) The Executive Board and the Board of Trustees is in contact with the respective bodies on how to implement the recommendation with regards to the **Chair of the Scientific Advisory Board as non-voting member in the Board or Trustees.**

4) We agree with the recommendation of the review committee with regards to **career path counseling.** AIP is already offering a number of such measures including mandatory annual status talks, training sessions also with focus on career models outside of academia, language courses, sufficient funds for travel to conferences and summer schools, and more informal activities such as the monthly "Equity and inclusion lunch". The structured PhD programme at Potsdam University was to a significant amount designed by members of AIP and has meanwhile been implemented into the PhD programme for natural science and mathematics at UP. Further measures are already in planning.

5) We agree with the recommendation of the review panel on **gender equality.** While the AIP has made considerable progress in the past decade, we are not at the end (nor near the end) of what needs to be achieved, and upcoming hires at the leadership level provide a unique opportunity for further progress.

   According to the German Physical Society, 20% of the graduating students in physics are female, a number basically unchanged throughout the past decade. AIP has engaged in considerably more ambitious plans and meanwhile achieved a fraction of 50% female scientist among the PhD students. Furthermore, the institute has set itself very ambitious quotas in the cascading model and has mostly exceeded its goals. Considerable effort has been taken, including head hunting (two out of the last three W2 professorial appointments since the last evaluation were female), emergency day care, family-friendly committee and event plannings, or flexible work hours. While the institute sees these as noteworthy achievements, they can only be seen as a first milestone towards the goal of further advances in equity and inclusion.