Leibniz Gemeinschaft

Der Senat

31. März 2020

Stellungnahme zum
Max-Born-Institut für Nichtlineare Optik und Kurzzeitspektroskopie im Forschungsverbund Berlin e.V., Berlin (MBI)

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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.

Vor diesem Hintergrund besuchte eine Bewertungsgruppe am 16. und 17. Mai 2019 das MBI in Berlin. Ihr stand eine vom MBI erstellte Evaluierungsunterlage zur Verfügung. Die wesentlichen Aussagen dieser Unterlage sind in der Darstellung (Anlage A dieser Stellungnahme) zusammengefasst. Die Bewertungsgruppe erstellte im Anschluss an den Besuch den Bewertungsbericht (Anlage B). Das MBI nahm dazu Stellung (Anlage C). Der Senat der Leibniz-Gemeinschaft verabschiedete am 25. März 2020 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 MBI betreibt äußerst erfolgreich Grundlagenforschung auf dem Gebiet der nichtlinearen Optik und Kurzzeitdynamik bei der Wechselwirkung von Licht mit Materie. Am Institut werden teilweise einzigartige Laser und lasergesteuerte Kurzpulslichtquellen entwickelt und eingesetzt. Die damit durchgeführten Experimente auf ultrakurzen Zeit- und Längenskalen liefern Einblicke in die mikroskopischen Wechselwirkungen, die die physikalischen Eigenschaften von Atomen, Molekülen, Flüssigkeiten und Festkörpern sowie transienten elektronischen und atomaren Strukturen bestimmen. Das MBI widmet sich damit fundamentalen Fragen der Physik, Chemie und Materialwissenschaften.

Die **Forschungsleistungen** des MBI sind hervorragend. Dies zeigt sich u. a. an zahlreichen qualitativ hochwertigen Publikationen sowie der erfolgreichen Einwerbung sehr kompetitiver Fördermittel, wie u. a. drei ERC Grants. Zudem erbringt das MBI wichtige und stark nachgefragte **Infrastrukturleistungen**. So hat das MBI Lasersysteme am *European X-Ray Free-Electron Laser* (XFEL) und am *Free Electron Laser Hamburg* (FLASH) des Deutschen Elektronen-Synchrotron (DESY) mit aufgebaut. Außerdem beteiligt sich das Institut maßgeblich an der Errichtung der *Extreme Light Infrastructure* (ELI) im Rahmen

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

des *European Strategy Forum on Research Infrastructures* (ESFRI). Zudem stellt das MBI seine eigenen Labore auch für die externe Nutzung zur Verfügung.

Die Arbeiten am MBI sind in einer Matrixstruktur organisiert, in der drei experimentell ausgerichtete Bereiche und eine Theorieabteilung gemeinsam **drei Forschungsschwerpunkte und einen serviceorientierten Schwerpunkt** bearbeiten. Im Forschungsschwerpunkt 1 werden die Arbeiten auf dem Gebiet der theoretischen Grundlagenforschung als „exzellent" und die experimentellen Arbeiten als „sehr gut bis exzellent" bewertet. Die Forschungsschwerpunkte 2 und 3 werden jeweils als „exzellent" und „sehr gut bis exzellent" bewertet. Der vierte Schwerpunkt erbringt hervorragende und unverzichtbare interne Serviceleistungen. Zudem koordiniert er den Transfer von Entwicklungen an externe Partner.

Seit der letzten Evaluierung hat sich das Institut überzeugend weiterentwickelt und seine schon damals erreichte, starke internationale Position gehalten. Ruhestandsbedingt wechselte 2015 eine der drei Bereichsleitungen. Es gelang, erneut einen ausgezeichneten Wissenschaftler zu gewinnen, der den von ihm geleiteten Bereich überzeugend neu ausrichtete. Außerdem hat das MBI seine exzellenten theoretischen Arbeiten weiter ausgebaut. Die enge Verschränkung von theoretischer und experimenteller Forschung ist mittlerweile ein Alleinstellungsmerkmal des Instituts. Der Leiter der nun eigenständigen Theorie-Abteilung wird eng in Entscheidungen des Direktoriums einbezogen. Es sollte geprüft werden, ob die Institutssatzung an diese neue Situation anzupassen ist. Der Senat erwartet, dass das MBI künftig seine Mitgliedschaft in der Leibniz-Gemeinschaft in seinem Namen Ausdruck verleiht.

Die Pläne zur **weiteren Entwicklung** des Instituts sind überzeugend. Um seine internationale Spitzenposition in der Forschung mit Lasern zu materialwissenschaftlichen und auch biophysikalischen Fragestellungen halten zu können, ist das MBI auf eine entsprechende Ausstattung mit Experimentieranlagen angewiesen. Diese Anlagen müssen regelmäßig erneuert und modernisiert werden. Wie bereits vor sieben Jahren werden Planungen für die Beschaffung von Lasern vom Senat im Anschluss an die Ausführungen im Bewertungsbericht erneut nachdrücklich befürwortet. Der Bedarf ist inhaltlich und finanziell schlüssig begründet (3,1 Mio. EUR zusätzliche Mittel, 519 TEUR Eigenanteil). Der Senat hält es für erforderlich, für den nicht hinreichend bemessenen jährlichen Investitionsansatz des MBI über eine solche Einzelmaßnahme hinaus eine nachhaltige Lösung zu finden.

Das MBI wirbt erfolgreich sehr kompetitive **Drittmittel** ein, z. B. von der DFG und vom ERC. Insgesamt betrug die Drittmittelquote zwischen 2016 und 2018 jedoch lediglich ca. 17 % des Gesamtbudgets. Das MBI sollte den jüngsten positiven Trend fortsetzen und wie im Bewertungsbericht näher ausgeführt die Einnahmen durch externe Projektfinanzierungen weiter erhöhen. Möglichkeiten dazu werden insbesondere in den Förderprogrammen der EU gesehen.

Das MBI kooperiert sowohl in der Forschung als auch in der Ausbildung des wissenschaftlichen Nachwuchses eng mit den **Hochschulen der Berlin University Alliance**. Die drei Direktoren sind mit jeweils einer der Universitäten gemeinsam berufen. Das MBI plant, die 2022 anstehende ruhestandsbedingte Neubesetzung einer Direktorenstelle wieder in gemeinsamer Berufung mit der Humboldt Universität zu Berlin (HU) durchzuführen. Es

wird begrüßt, dass dazu frühzeitig Gespräche aufgenommen wurden. Durch die räumliche Nähe in Berlin-Adlershof ist die Zusammenarbeit mit der HU von besonderer Bedeutung.

Nach wie vor ist die Situation im Bereich der **Gleichstellung der Geschlechter** unbefriedigend. Seit der letzten Evaluierung ist der Anteil an Wissenschaftlerinnen von 12 % auf 11 % gefallen. Unter den 17 Personen mit Leitungsfunktion (inklusive Junior Groups) waren zum Zeitpunkt des Evaluierungsbesuchs drei Wissenschaftlerinnen. Besonders unverständlich ist jedoch, dass seit langer Zeit kaum Forscherinnen für eine Promotion am MBI gewonnen werden. Unter den 29 Promovierenden waren an dem zur Evaluierung angegebenen Stichtag 4 Doktorandinnen. Die in den nächsten Jahren anstehenden personellen Veränderungen müssen genutzt werden, um eine Verbesserung der Situation zu erreichen. Der Senat empfiehlt, sich an der *best practice* anderer Leibniz-Einrichtungen zu orientieren und bittet die Leitung des MBI, zum 31. Dezember 2023 einen Bericht zu den Maßnahmen zur Gleichstellung der Geschlechter und deren Erfolg einschließlich eines tabellarischen Überblicks über die Stellenbesetzungen in Bereich Forschung und wissenschaftliche Dienstleistungen am MBI in der Zeit vom 1. April 2020 bis 31. Dezember 2023 vorzulegen.

Das MBI ist international sichtbar und die durchgeführten Forschungsarbeiten von hervorragender Qualität und hoher Relevanz. Das MBI erfüllt damit die Anforderungen, die an eine Einrichtung von überregionaler Bedeutung und gesamtstaatlichem wissenschaftspolitischem Interesse zu stellen sind. Die für die Experimente nötige Infrastruktur kann in dieser Form nicht an einer Hochschule bereitgestellt werden. Die Eingliederung in eine Hochschule wird daher nicht empfohlen.

2. Zur Stellungnahme des MBI

Der Senat begrüßt, dass das MBI beabsichtigt, die Empfehlungen und Hinweise aus dem Bewertungsbericht in Abstimmung mit seinem Wissenschaftlichen Beirat bei seiner weiteren Arbeit zu berücksichtigen.

3. Förderempfehlung

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

17 April 2019

Annex A: Status report

Max Born Institute for Nonlinear Optics and Short Pulse Spectroscopy (MBI) in the *Forschungsverbund Berlin e. V.*

Contents

1. Structure, Tasks and Institutional Environment

Development and funding

The Max Born Institute for Nonlinear Optics and Short Pulse Spectroscopy (*Institut für Nichtlineare Optik und Kurzzeitspektroskopie*) (MBI) was founded in 1992 and is located in Berlin Adlershof. The funding of the MBI is provided to 50% each by the federal government and the states of Germany (*Länder*). The last evaluation by the Senate of the Leibniz Association took place in 2012.

Responsible department at *Länder* level: Senate Chancellery – Higher Education and Research

Responsible department at federal level: Federal Ministry of Education and Research (BMBF)

Legal form and organisation

Along with seven other scientifically and economically independent Leibniz institutes, MBI is part of the *Forschungsverbund Berlin e. V.* (FVB]. The FVB is the legal entity, organizes administrative issues and pursues common interests of the institutes. The supervisory body of the FVB is the Board of Trustees ("*Kuratorium*") consisting of one representative each of the state and federal governments, one representative appointed by the Berlin universities[1], four academic members from outside of Berlin, and three members from industry.

MBI is led by the Board of Directors, consisting of three directors who hold joint appointments with the Berlin universities. Each director oversees one of the three divisions of the MBI (Appx. 1) and for a period of three years, one of the directors serves as the MBI Managing Director. In its meetings, the board of directors is joined by the head of the MBI Theory Department. Furthermore, in administrative issues the Board of Directors is complemented by the FVB Managing Director.

On strategic issues, in particular the scientific work programme, the MBI Board of Directors is advised by a Scientific Advisory Board (SAB). The SAB evaluates the institute within the framework of an audit and advises the Board of Trustees on appointment procedures for directors and leading scientists. The SAB is composed of currently 11 scientists whose research fields are closely linked to the activity areas of MBI.

Mission and tasks

MBI conducts basic research in the field of nonlinear optics and ultrafast dynamics arising from the interaction of light with matter to address fundamental problems in physics, chemistry and material sciences. The institute develops and uses ultrafast and intense lasers and laser-driven short-pulse light sources in a broad spectral range, in combination with methods of ultrafast nonlinear spectroscopy and structure research. According to MBI, the long-term scientific goal is to utilize these tools, partially in combination with

[1] Technische Universität Berlin (TU), Humboldt-Universität zu Berlin (HU) and Freie Universität Berlin (FU).

x-ray pulses from free electron lasers and synchrotrons, in order to reveal how nature operates on ultrashort time and atomic length scales, and to understand and control the functionality of materials based on the manipulation of microscopic processes.

Organisation of Research

The organisational structure of MBI is defined by three Divisions, each one headed by one of the MBI directors. The scientific focus of the Divisions is specific for the current head of the respective division and is adapted with new appointments. The organisational structure is complemented by a Theory Department, which was established in 2016. In addition, there are technical and administrative units (see Appx. 1).

The research structure consists of four topical areas, which currently host seven research projects (in Topical Areas 1-3) and three infrastructure projects (in Topical Area 4). The annual research budget allocation is to the research projects within the topical areas. In this report, the scientific results of MBI are presented in terms of the four topical areas (see chapter 3).

National and international scientific environment

At the national level, MBI considers itself one of a number of non-university institutes devoted to basic research on and with lasers. These institutes include the *Max-Planck-Institute for Quantum Optics in Garching (MPQ)*, the *Max-Planck-Institute for the Science of Light in Erlangen (MPL)*, *the Helmholtz-Institute Jena* (HI) and the *CFEL Institute in Hamburg*.

Internationally, the MBI states technological and scientific overlap with a number of research institutes, including, e.g. the *Laboratoire d'Optique Appliqué (LOA)* in Palaiseau (France), the *Saclay Laser Centre (SLIC)* in Saclay (France) and the *College of Optics and Photonics (CREOL)* in Florida (USA).

Despite a common research interest of the MBI and free electron laser or high field facilities, the MBI points out that the budget and mission differences are too large for a comparison with those facilities. Additionally, the MBI notes that individual parts of the MBI research portfolio are also covered by a large number of university groups.

National interest and justification for funding as a non-university institution

MBI states that it plays an important role in the fields of optical science on an international level. The combination of laser research and development with basic interdisciplinary research in physics and chemistry has resulted in (i) several unique experimental facilities and skills and (ii) numerous research results in atomic, molecular and condensed matter physics.

On a national level, the institute perceives itself as an active partner in a number of networks and programs with industry and academia. Internationally, MBI plays coordinating roles in several EU projects and has collaborations with partners worldwide. The institute runs the office of the LASERLAB-EUROPE network in close collaboration with the coordinating Lund Laser Center and is represented on the management board of the Laserlab. The national and international collaborations are described in Chapter 4.

According to MBI, the crucial competence fields to satisfy the long-term scientific mission are a combination of various scientific disciplines, efficient project management, specialised experimental, theoretical and technical skills and networking with external partners.

MBI develops and maintains a long-term, mission-oriented infrastructure. Besides a large number of laser laboratories, these include a customised computer infrastructure including a high-performance computing cluster and specially equipped research laboratories.

In view of MBI, to be sustainable, these activities need a longer-term funding model, as guaranteed by its role as a non-university research institute.

2. General concept and profile

Development of the institution since the last evaluation

Changes in the organisational structure

On the level of the organisational structure, since the last evaluation two groups have been closed and six new groups have been established. In the following, the current organisational structure and the changes since the last evaluation are summarized:

Division A "Attosecond Physics"

In Division A, the former department A1 was moved to the new Theory Department (see below). A new department A1 was established in 2017 as well as a new Junior Group. Division A now comprises the following units:

- New Department A1 "Strong Field Processes at Extreme Wavelengths", established 2017.
- Department A2 "Ultrafast XUV-Physics".
- Department A3 "Ultrafast Lasers and Nonlinear Optics".
- New Junior Group "Ultrashort Dynamics in Nanoplasma", established 2017 on the basis of a successful application in the Leibniz competitive procedure (SAW). The head of the group will leave MBI in September 2019 for an assistant professorship appointment at ETH Zürich.

Division B "Transient Electronic Structure and Nanoscience"

After the retirement of the former director of Division B in 2013 and the appointment of a new director in 2015, the main research focus of Division B has changed towards ultrafast electronic structure and nanoscience, with an emphasis on studies of time-resolved magnetism. To this end, the two new Departments "Electron and Spin Dynamics" and "Imaging and Coherent X-rays" have been established, while the two Departments "High Density Laser Plasma" and "Few Particle Systems in Strong Laser Fields" were closed in 2017. Division B now comprises the following units:

- New Department B1 "Electron and Spin Dynamics", established 2016.
- New Department B2 "Imaging and Coherent X-rays", established 2018.
- Department B3 "Laser Development".

Division C "Nonlinear Processes in Condensed Matter"

In Division C, no major changes occurred since the last evaluations. It still comprises the following units:

- Department C1 "Femtosecond Spectroscopy of Molecular Systems".
- Department C2 "Solid State Light Sources".
- Department C3 "Femtosecond Spectroscopy of Solids".

New Theory Department (established 2016)

The Theory department was established in 2016 out of four existing groups, one of them has been established in 2014 after the last evaluation. In 2018 a new Group joined the Department. The Theory department now comprises the following scientifically independent units:

- Group "Attosecond Theory": former Department of Division A.
- Group "Strong Field Theory": former Independent Junior Group.
- New Group "Condensed Matter Theory", established 2018.
- New Junior Group "Biomolecular Dynamics": Emmy-Noether Junior Group established in 2014, will be continued on the basis of an ERC starting grant.
- Joint MBI-HU Berlin group "Theoretical Optics": former independent group. The position of the group head is financed by HU Berlin, while MBI finances three scientists.

Changes in the research structure

On the level of the research structure there were several changes since the last evaluation. In the following, the current research structure and the changes since the last evaluation are summarized:

Topical Area 1 "Lasers and Light-Matter Interaction"

In Topical Area 1 the former Projects 1.1 "Ultrafast Nonlinear Optics" and 1.2 "Ultrafast Laser Physics" have been merged into the Project 1.2 "Ultrafast Laser Physics and Nonlinear Optics". A new project 1.1 with a focus on theoretical questions has been established. The Topical Area 1 comprises the following research projects:

- New Project 1.1 "Fundamentals of Extreme Photonics", established 2016.
- Project 1.2 "Ultrafast Laser Physics and Nonlinear Optics", merged 2016 from former Projects 1.1 and 1.2.

Topical Area 2 "Ultrafast and Nonlinear Phenomena: Atoms, Molecules, and Clusters"

In Topical Area 2 the former project 2.1 "*Laser Plasma Dynamics and Particle Acceleration*" has been discontinued, in order to make room for the research activities of the new director of Division B. The Topical Area 2 comprises the following two research projects:

- Project 2.1 "Time-resolved XUV science".
- Project 2.2 "Strong-field Few-body physics".

Topical Area 3 "Ultrafast and Nonlinear Phenomena: Condensed Phase"

In Topical Area 3, the new activities in magnetism and imaging were integrated in the research structure, still comprising three projects:

- Project 3.1 "Dynamics of Condensed Phase Molecular Systems".
- Project 3.2 "Solids and Nanostructures: Electrons, Spins, and Phonons", since 2016. Formerly "Solids and Nanostructures".
- Project 3.3 "Transient Structures and Imaging with X-rays".

Topical Area 4 "Infrastructure and Application"

In Topical Area 4 a new Project 4.3 was added. The Topical Area 4 comprises the following three infrastructure projects:

- Project 4.1 "Implementation of Lasers and Measuring Techniques.
- Project 4.2 "Application Laboratories and Technology Transfer".
- New Project 4.3 "Nanoscale Samples and Optics", established 2016.

Results

Research

Between 2016 and 2018 scientists from MBI published 597 publications of which 507 were articles in peer-reviewed journals (see appendix 2). This includes 178 articles in journals with an impact factor between 3 and 7 and 73 papers in journals with an impact factor larger than 7. The scientific results of the four Topical Areas are described in chapter 3 below. The institute names the following eight overarching research highlights of the last years:

- Generation and characterisation of elliptically polarised attosecond pulses (published in inter alia *Nature Communications* and *Physical Review Letters*).
- Optical Parametric Chirped Pulse Amplification (OPCPA) (published in *Optical Letters* and *Optics Express*).
- Ultrafast atomic excitation in strong fields (published in inter alia *Nature Physics* and *Physical Review Letters*).
- Transient absorption spectroscopy at short wavelength (published in inter alia *Physical Review Letters, Journal of Physical Chemistry Letters,* and *Physical Review B*).
- Non-covalent interactions of hydrated ions and biomolecules (published in inter alia *Science* and *Angewandte Chemie*).
- Phonon driven charge relocations in polar crystals and ferroelectrics (published in inter alia *Physical Review Letters* and *Structural Dynamics*).

- Chiral spin textures in thin magnetic films (published in *Nature Nanotechnology*).
- Clusters in intense XUV laser fields (published in inter alia *Nature* and *Nature Communications*).

Scientific services and infrastructure tasks

MBI offers services and facilities to the regional, national and international scientific community. One example, which grew out the European Union's "Transnational Access" programme, is the LASERLAB-EUROPE project which is administered by MBI. Access projects under this programme are largely performed as collaborations, rather than pure services. Within the LASERLAB-EUROPE project, the institute provided 102 days of access to international scientific users over the last three years.

Scientific Consulting

According to the institute, MBI scientists engage in consultation activities in science policy, steering committees and selection panels for federal funding programmes, or foreign funding agencies. They also serve in numerous scientific advisory or supervisory boards of scientific institutions both nationally and internationally. Furthermore, MBI states to regularly consult for industry within project collaborations or contracts, and is a partner within the regional network OpTecBB. [2]

Knowledge and Technology Transfer

As of Dec. 31, 2018, MBI holds 25 patents of which two were granted between 2016 and 2018 (see Appx. 2). Additionally, MBI developed prototype solutions in collaboration with industry (Greateyes GmbH) and for research facilities like Deutsches Elektronen-Synchrotron DESY or the European X-Ray Free-Electron Laser (XFEL). MBI currently supports the development of the Extreme Light Infrastructure (ELI), in particular the part of the facility located in Szeged, Hungary.

Since 2011, MBI and the TU Berlin run BLiX, the *Berlin Laboratory for innovative X-ray Technologies*, as a joint application laboratory. BLiX serves as an interface between research and industry. Additionally, within the EU-funded project Nanomovie, MBI is developing the technology and setting up the infrastructure to operate an application laboratory providing ultrashort XUV and soft X-ray pulses to external users.

Academic events and public relations

Between 2016 and 2018, 325 invited talks were given by MBI scientists at major international conferences and about 140 in seminars and colloquia. The MBI laboratories are made accessible for the public on the annual "Night of Science"(*Lange Nacht der Wissenschaften*) and the "Research Days".

[2] OpTecBB is a joint initiative of around 100 members from industry and academia focusing on optical technologies in the Berlin-Brandenburg region.

Strategic work planning for the next few years

The term of the appointment of the director of Division C will end in September 2022 in accord with current retirement regulations. The process towards the appointment of a new director will be started about two years prior to this date.

MBI pursues the long-term scientific goal to utilize laser-based tools in order to reveal most directly how nature operates on ultrashort time and atomic length scales, and to understand and control the functionality of materials by manipulating microscopic processes. This results in three strategic directions for the next few years:

i) MBI plans to address the microscopic nature of field-driven quantum processes on ultra-short time scales by a combination of novel experimental tools and in-depth theory. The goal is to get insight into the role of quantum coherences and correlations, decoherence mechanisms, and the role of electric and magnetic fields in ultrafast processes.

ii) MBI further plans to investigate the fundamental spatio-temporal dynamics that determine the function of materials, via a combination of spectroscopic and structural probes. This research direction aims at linking material properties and emerging functionality to fundamental processes in matter.

iii) MBI wants to maintain a leading role of the laboratory in terms of combining laser systems and secondary sources with unique performance parameters enabling research targeting fundamental scientific problems.

MBI states that to remain scientifically competitive the renewal of three laser systems is mandatory. To finance this demand, MBI wants to apply for temporary additional funding in the form of an Extraordinary Item of Expenditure (*Temporärer Sondertatbestand*) in the 2022 budget. MBI will contribute 3% of its core budget towards this renewal. With the funding MBI aims to acquire three commercially available laser systems of which two would update existing OPCPA systems. In detail these systems are:

1. TRUMPF Scientific Lasers DIRA: 500 mJ @1 kHz. This laser would replace a laser developed in house as the driver in an existing OPCPA chain to generate high harmonics for attosecond pump-probe and diffractive imaging experiments. It would be predominately used in research area 2 for the study of atoms, molecules and clusters. Cost estimate: 1.4 M€.
2. TRUMPF SDL H2-400: 4mJ @ 100 kHz. This laser would upgrade a laser in an OPCPA system currently operated with InnoSlab technology used for the generation of high harmonics for transient absorption and velocity map imaging experiments. It would be used in research area 2 for the study of atoms and molecules and in research area 3 for the study of condensed matter. Cost estimate: 0.9 M€.
3. KMLabs RedDragon: 30mJ @ 1 kHz. This system would drive high-field and high average power THz generation for experiments on (bio)molecules, magnetic and correlated materials using OPA for frequency conversion to optimally fit to different THz generation schemes. It would be predominately used in research area 3 for the study of condensed matter. Cost estimate: 1.3 M€.

The financial planning is summarized in the table below.

	2022
MBI share + additional funds = Exceptional Item of Expenditure	3.600 K€
MBI share from its existing core budget (prediction)	519 K€
Additional institutional funding	3.081 K€

Appropriateness of facilities, equipment and staffing

Funding

In 2018, MBI's institutional funding was approx. 17.6 M€ (see appendix 3).

Additionally, 3.8 M€ were spent from revenues from project grants (corresponding to 17.6 % of the overall budget). The revenues split into 1.2 M€ from the German Science Foundation (DFG), 1.1 M€ from Federal or *Länder* governments, 744 K€ from the competitive procedure of the Leibniz Association and 480 K€ from EU grants. Moreover, revenue from industrial project grants, foundations and other sponsors (310 K€) was acquired.

Between 2016 and 2018, MBI also acquired 779 K€ from miscellaneous services and sales.

Buildings and laboratories

MBI's facilities were completely rebuilt between 1995 and 1998 and offer an amount of space that the institute regards as satisfactory. However, the institute points out that the quality of the buildings and technical infrastructure is below the current international standard for scientific institutes and that the rapid aging of the buildings and technical infrastructure represents a major and increasing challenge.

The research infrastructure of MBI focuses on amplified femtosecond laser and OPCPA systems in combination with setups for nonlinear frequency conversion, attosecond pulse generation, XUV and hard X-ray generation. Laboratories dedicated to particular classes of experiments based on the primary and secondary sources are equipped with custom setups for, e.g., nonlinear spectroscopy, femtosecond X-ray diffraction or charged particle momentum imaging. A second group of laboratories serves for the development of OPCPA technologies and of special laser systems to be operated in conjunction with accelerator-based light sources such as DESY and other user facilities. The infrastructure is complemented by standard equipment for optical and spectroscopic measurements, facilities for the preparation, structuring, and characterisation of thin-film samples and chemical laboratories for sample preparation.

Experiments and simulations acquire large scale numerical data which are required to be processed and transferred within the institute's network. MBI thus runs a full data centre and communication infrastructure as well as a mid-size computing cluster. External IT services (DFN/Internet, SAP, Eduroam, central Backup, certificates) are provided through the Forschungsverbund Berlin e.V. External commercial IT services, e.g., cloud based services, are not in use.

For personnel see chapter 4.

3. Topical Areas of MBI

Topical Area 1: Lasers and light-matter-interaction

[29.73 FTE, thereof 16.89 FTE Researchers, 6.62 FTE PhD Students, 6.22 FTE Engineers/Technicians]

Research within Topical Area 1 focuses on the theoretical understanding, control and exploitation of nonlinear light-matter interaction at the fundamental level as well as fundamental experimental research in nonlinear optics and the generation of ultrashort and/or ultra-intense light pulses across a wide frequency range. Topical Area 1 currently consists of two research projects:

- Project 1.1 "*Extreme Photonics*" focusing mainly on the development of theoretical concepts and tools required for research across the institute and the exploration of novel ideas. [13.02 FTE, thereof 8.40 FTE Researchers, 3.62 FTE PhD Students, 1.00 FTE Engineers/Technicians]
- Project 1.2 "*Ultrafast Laser Physics and Nonlinear Optics*" with a dominantly experimental scope focusing on research in nonlinear optics and the development of novel lasers and experimental techniques. [16.71 FTE, thereof 8.49 FTE Researchers, 3.00 FTE PhD Students, 5.22 FTE Engineers/Technicians]

Between 2016 and 2018 Topical Area 1 published 271 articles in peer-reviewed journals and 27 articles in other journals, as well as 5 individual contributions to edited volumes. Two patents were granted. In the same time period the revenue from project grants totalled 2.4 M€ with 40% (966 K€) spent from the German Science Foundation (DFG), 21% (507 K€) from the competitive procedure of the Leibniz Association, 10% (247 K€) from Federal or Länder governments and 21% (511 K€) from EU grants. Moreover, revenue from industrial project grants, foundations and other sponsors was acquired. 9 doctoral degrees and 1 habilitation were completed between 2016 and 2018 in Topical Area 1.

The research highlights between 2016 and 2018 include:

- The prediction (published in *New Journal of Physics* and *Nature Photonics*) and demonstration (published in *Nature Physics*) of attosecond bunches of up to 100% spin-polarized electrons from optical tunnelling.
- Investigation of the physics behind chiral-sensitive signals in high harmonic generation, with application of high harmonic spectroscopy for imaging electron dynamics in chiral molecules on the attosecond time scale (published in *Nature Physics*).
- Orders of magnitude enhancement in the enantio-sensitive optical response of neutral chiral molecules due to coherent excitation of vibronic motion (published in *Nature Physics*).
- Analysis of the application of high harmonic spectroscopy for time-resolving phase transitions between a Mott-insulating dielectric and a metallic state (published in *Nature Photonics*).
- Demonstration that free electrons oscillating in the laser field and yet still loosely bound to the core in rare gases, at and above atmospheric pressure, can act as a gain medium (published in *Nature Physics* and *Physical Review Letters*).

- Development and demonstration of algorithms for strongly coupled electronic and nuclear motions (published in inter alia *Chemical Reviews* and *Journal of Chemical Theory and Computation*).
- The development and the commissioning of several OPCPA systems (published in *Optics Letters and Optics Express*).
- Analysis and control of formation and behaviour of rogue waves (published in *Scientific Reports* and *Journal of Optics*).
- Demonstration and explanation of correlations between amplitude and frequency fluctuations at low Fourier frequencies (published in *Optics Letters*) used for CEP stabilization.
- Generation and characterization of pulses with properties tailored on a sub-cycle scale (published in *Optics Letters* and *Optics Express*).

The future plans include on the theory side a focus on nonlinear optical spectroscopies of charge, spin, and energy flow on attosecond to femtosecond time scale. Current work is being extended from simple gas phase molecules to biologically relevant molecules in gas and liquid phase, including chiral systems, and to condensed matter systems. The future experimental activities encompass research on both "primary" and "secondary" laser sources.

Topical Area 2: Ultrafast and nonlinear phenomena: atoms, molecules and plasma

[28.12 FTE, thereof 16.65 FTE Researchers, 5.82 FTE PhD Students, 5.65 FTE Engineers/Technicians]

The focus of Topical Area 2 is on the attosecond science program which was initiated in 2010, aiming at a basic understanding of electronic/nuclear dynamics on attosecond to femtosecond time scales, the development of novel spectroscopic probes of time-resolved molecular dynamics, and the investigation of strong field ionisation and dissociation. Topical Area 2 currently hosts two research projects:

- Project 2.1 "*Time-resolved XUV Science*" focusing on research of the dynamics of photophysical and photochemical processes with ultrashort laser pulses in the XUV and X-ray domain. [15.50 FTE, thereof 7.75 FTE Researchers, 3.89 FTE PhD Students, 3.86 FTE Engineers/Technicians]
- Project 2.2 "*Strong field few body physics*" where strong laser field-induced dynamics are studied on ultra-short time and temporal length scales. [12.62 FTE, thereof 8.90 FTE Researchers, 1.93 FTE PhD Students, 1.79 FTE Engineers/Technicians]

Between 2016 and 2018 Topical Area 2 published 120 articles in peer-reviewed journals and 11 articles in other journals, as well as 9 individual contributions to edited volumes and one editorship of an edited volume. In the same time period the revenue from project grants totalled 1.9 M€ with 45% (875 K€) spent from the German Science Foundation (DFG), 27% (521 K€) from the competitive procedure of the Leibniz Association and 21%

(401 K€) from EU grants. Moreover, revenue from foundations and other sponsors was acquired. 11 doctoral degrees were completed between 2016 and 2018 in Topical Area 2.

The research highlights between 2016 and 2018 include:

- A study of ionization channel-dependent electron-ion re-scattering (published in *Science Advances*).
- The development of a unified view for the interaction of matter with intense laser radiation including the seemingly opposite wave and particle pictures, on the basis of combined experimental and theoretical work (published in *Physical Review Letters*).
- Investigations of the ionization of dynamics of clusters illustrating the complementarity of HHG sources to free electron lasers, and including investigations of the concept of ignition (published in *Physical Review Letters*).
- A determination of the amplitudes and phases characterizing an outgoing continuum photoelectron wave packet by photoionization of neon by a train of attosecond pulses in the presence of a co-propagating infrared laser field (published in *Science*).
- The demonstration of single-shot imaging of isolated Helium nanodroplets (published in *Nature Communications*).
- A theoretical and experimental study of ultrafast nonadiabatic vibronic processes (published in *Nature Communications*).
- The generation and characterization of chiral attosecond pulses (published in inter alia in *Nature Communications* and *Physical Review Letters*).
- The development of a refractive lens for XUV radiation based on the use of a gas jet (published in *Nature*).

The future plans include the elucidation of time-resolved electron dynamics and coupled electron-nuclear dynamics, in particular using novel tools resulting from the OPCPA development.

Topical Area 3: Ultrafast and nonlinear phenomena: condensed phase

[38.19 FTE, thereof 20.35 FTE Researchers, 10.90 FTE PhD Students, 6.94 FTE Engineers/Technicians]

The research in Topical Area 3 addresses basic interactions and non-equilibrium dynamics in condensed-phase molecular systems, semiconductors and dielectrics, magnetic and correlated materials, dynamics of the electronic, spin and crystalline structure of solids, field-driven processes including charge transport, and light-matter interaction in optoelectronics and materials processing. Currently Topical Area 3 consists of 3 research projects:

- Project 3.1 "*Dynamics of Condensed Phase Molecular Systems*" addressing ultrafast molecular dynamics and chemical processes in liquids by a combination of ultrafast time-resolved experiments and theory. [13.08 FTE, thereof 6.73 FTE Researchers, 3.5 FTE PhD Students, 2.85 FTE Engineers/Technicians]
- Project 3.2 "*Solids and nanostructures: Electrons, Spins and Phonons*" combining basic research on nonlinear and ultrafast phenomena in solids and nanostructures with applications of ultrashort pulses in materials processing and research on optoelectronic

devices and structures, in particular semiconductor lasers. The joint HU-MBI group on Theoretical optics contributes to this project. [16.58 FTE, thereof 8.35 FTE Researchers, 5.25 FTE PhD Students, 2.98 FTE Engineers/Technicians]

- Project 3.3 "*Transient Structures and Imaging with X-rays*" where transient structures in solids occurring after optical excitation are studied on atomic and mesoscopic length scales. [8.53 FTE, thereof 5.27 FTE Researchers, 2.15 FTE PhD Students, 1.11 FTE Engineers/Technicians]

Between 2016 and 2018 Topical Area 3 published 116 articles in peer-reviewed journals and 22 articles in other journals, as well as two monographies, 12 individual contributions to edited volumes and one editorship of an edited volume. One license was granted. In the same time period the revenue from project grants totalled 3 M€ with 60% (1.82 M€) spent from the German Science Foundation (*DFG*), 18% (551 K€) from the competitive procedure of the Leibniz Association and 14% (435 K€) from Federal or *Länder* governments. Moreover, revenue from industrial project grants, foundations, EU grants and other sponsors was acquired. 9 doctoral degrees were completed between 2016 and 2018 in Topical Area 3.

The research highlights between 2016 and 2018 include:

- A study of hydration dynamics via backbone vibrations of DNA and RNA (published in *Journal of Physical Chemistry Letters, The Journal of Physical Chemistry*, and *Structural Dynamics*).
- The investigation of proton solvation in polar solvents and water (published in *Angewandte Chemie* and *Science*).
- X-ray spectroscopy of solutes via a liquid flatjet in the water window and beyond (published in *Structural Dynamics* and *Journal of Physical Chemistry Letters*) and experiments on condensed phase molecular systems (published in *Journal of the American Chemical Society*).
- A study of the interplay of lattice excitations and charge dynamics on atomic length and time scales (published in *Structural Dynamics*), including theoretical work (published in *Physical Review)*.
- The extension of two-dimensional THz spectroscopy to a full 3-pulse scheme (published in *The Journal of Physical Chemistry*) and study of two-phonon quantum coherences (published in *Physical Review Letters*). Amplification of coherent acoustic phonons by intraminiband currents in a semiconductor superlattice (published in *Physical Review Letters,* editor's suggestion, featured in *Physics*).
- Measurements of ultrafast demagnetization via lab-based x-ray magnetic circular dichroism (published in *Physical Review B*) with additional theory work allowing for an *ab-initio* understanding of the dichroic index of refraction.
- The realization of deterministic nucleation of magnetic skyrmions in a device-compatible structure (published in *Nature Nanotechnology*) and the demonstration that antiferrimagnetic materials can support extremely small and efficiently moveable skyrmions (published in *Nature Nanotechnology*).

- Insight into the role of local strain in a metal-insulator phase transition (published in *Nano Letters*) and demonstration of a novel approach to image the spatial fluence distribution in single free electron x-ray laser pulses (published in *Nature Communications*).

The future plans include the study of fundamental interactions and ultrafast nonequilibrium and structural dynamics in prototype systems on the one hand and moving to more complex materials on the other hand by exploiting multi-method investigations. Biomolecular systems and solids with correlated charges and spins, electron transfer systems, extended spin textures as well as materials where local excitations, phase transitions and mesoscale order determine functionality are addressed.

Topical Area 4: Laser infrastructure and knowledge transfer

[16.35 FTE, thereof 9.26 FTE Researchers, 7.09 FTE Engineers/Technicians]
Topical Area 4 has no independent research strategy. Its role within the MBI is to implement the lasers and measuring techniques, operate the dedicated application laboratories and manufacture specific sample systems and tailored optics for use in other projects. The work in Topical Area 4 is divided in 3 infrastructure projects:

- Project 4.1 "*Implementation of laser systems*". Within Project 4.1 highly specialized laser systems and measurement facilities are developed for research at the MBI in the Topical Areas 2 and 3. Furthermore, lasers for routine use in accelerator-based large scale facilities are developed. These developments are strongly oriented towards the establishment of systems with high stability and reliability. [5.99 FTE, thereof 4.3 FTE Researchers, 1.69 FTE Engineers/Technicians]
- Project 4.2 "*Development and operation of dedicated application laboratories*". The application laboratories offer access to research developments from the MBI to external users. Currently one dedicated application laboratory is run jointly with TU Berlin and another is being set up. Further MBI laboratories are offered to external users on demand. [8.93 FTE, thereof 4.16 FTE Researchers, 4.77 FTE Engineers/Technicians]
- Project 4.3 "*Nanoscaled samples and optics*". In this project, thin-film samples, near field and diffractive optics are produced for use within other MBI projects. [1.43 FTE, thereof 0.8 FTE Researchers, 0.63 FTE Engineers/Technicians]

Between 2016 and 2018 in the Topical Area 4 the revenue from project grants totalled 3.35 M€ with 54% (1.8 M€) spent from Federal or *Länder* governments, 23% (781 K€) from EU grants and 135 K€ from the German Science Foundation (*DFG*). Moreover, revenue from industrial project grants and other sponsors (605 K€) was acquired.

As Topical Area 4 has no independent research strategy the future plans for this topical area depend on the demands in the other projects within the institute. Currently, these include the further development and engineering of OPCPA systems, the further implementation of hollow core fiber (HCF) pulse compression technology, in order to improve the efficiency of water window HHG, as well as the implementations of various pulse characterisation techniques. The collaborations with large scale facilities as well as the support of application laboratories is an ongoing focus of Topical Area 4.

4. Collaboration and networking

Collaboration with universities

MBI collaborates with universities in Berlin (FU, HU and TU) where the three directors and three other leading scientists hold faculty appointments in the S-W3 category. Three of these appointments took place since the last evaluation in 2012. The joint appointments are summarized in the table below.

Position at MBI	University	Year of appointment
Director (Head of Division A)	FU Berlin	2010
Director (Head of Division B)	TU Berlin	2015
Director (Head of Division C)	HU Berlin	1994
Head of Theory Department	HU Berlin	2012
Group Leader (Theory)	TU Berlin	2016
Department Head (Dept. C2)	HU Berlin	2017

Furthermore, the joint MBI-HU Berlin research group (integrated in the Theory Department) is headed by a professor of HU Berlin and supported by three positions for postdoctoral fellows and an annual budget from MBI's institutional funding.

In the last years MBI was engaged with universities in four Collaborative Research Centres founded by the DFG of which one is ongoing. Furthermore, MBI was involved in subprojects of three Priority Programs financed by the DFG. MBI cooperates with numerous individual university groups in Germany and world- wide. According to the institute, the cooperation with the TU is further tightened by the joint operation of the application laboratory BLiX (see chapter 2) and jointly used designated equipment in the Central Facility for Electron Microscopy (ZELMI).

Collaboration with other domestic and international institutions

MBI coordinates and participates in national and international projects and networks together with other research institutions and industry funded by the BMBF and by the EU. Furthermore, a large number of international research cooperations is maintained. Since the last evaluation the MBI served as a coordinator to the following projects:

- LASERLAB-EUROPE - European Integrated Activity of Laser Infrastructures (EU Framework Programme 7).
- ELI - European ESFRI Roadmap project "Extreme Light Infrastructure" (coordinator of one of the Work Packages during the preparatory phase).
- ATTOFEL - Ultrafast Dynamics Using Attosecond and XUV Free Electron Laser Pulses (EU Initial Training Network).
- CORINF - Correlated Multielectron Dynamics in Intense Laser Fields (EU Initial Training Network).
- JMAP - Joint Max Born Institute - Amplitude PhD Programme (EU Initial Training Network).

The MBI participates in the following BMBF and EU projects:

- ASPIRE- Angular Studies of Photoelectron in Innovative Research Environments (EU Initial Training Network).

- ATLANTIC - Advanced theoretical network for modelling light-matter Interaction, MSCA-RISE-2018, Research and Innovation Staff Exchange (RISE).
- MEDEA - Molecular Electron Dynamics Investigated by Intense Fields and Attosecond Pulses (EU Initial Training Network).
- MIDAS - Partner ERC Starting Grant: Multidimensional Spectroscopy at the Attosecond frontier, Coordinator: Weizmann Institute of Science, Israel.
- INPHAS - Fluctuation-Induced Interactions at the Interface between Photons, Atoms and Solids (EU Career Integration Grants).
- IMOTHEB Project with OSRAM Opto Semiconductors, Regensburg, DILAS GmbH, Mainz and FhG-IOF, Jena.
- BLAULAS, Project with OSRAM Opto Semiconductors, Regensburg, DILAS GmbH, Mainz und FhG-IOF, Jena: Development of a direct blue kW diode laser.
- DYNAMAX - Development of improved experimental infrastructure for femtosecond-slicing experiments at BESSY II.
- SPLIT-X-MID - Development of a split-and-delay X-ray optics to be operated at the Materials Imaging and Dynamics Instrument at the European XFEL.
- FEMTO-THz-X - Development of THz-pump X-ray-probe capabilities at the MAX IV FemtoMax beamline.

The institute has cooperation contracts for the development and improvement of lasers for electron accelerators with three institutes of the Helmholtz-Association (DESY, HZB and HZDR), and for the development of an end station at the Extreme Light Infrastructure in Hungary. In addition, MBI states to run a large number of individual projects funded through agencies like the ERC, DFG, the BMBF, the EU, the state of Berlin, the DAAD and the Alexander von Humboldt Foundation.

Other collaborations and networks

The collaboration with industry is on a bilateral basis and through participation in larger research networks as the institute states. Accordingly, the MBI has several cooperation agreements with small and medium-size companies in the Berlin-Brandenburg area and beyond, e.g. with BESTEC GmbH, Berlin for the development of laser-based XUV and EUV sources or the strain analysis in laser structures with Trumpf Photonics, Inc., Cranbury USA.

MBI is running a guest program where researchers are invited to initiate new projects and/or join ongoing activities. Within 2016 and 2018, a total of 98 visiting scientists reportedly worked at MBI for a period of at least one month.

5. Staff development and promotion of junior researchers

Staff development and personnel structure

On 31 December 2018, MBI employed 172 persons (without student assistants, trainees and scholarship recipients, see Appx. 4). 100 persons worked in research and scientific

services (including 29 doctoral candidates), 61 persons had service positions and 11 persons had administrative tasks. In total 37 % of the people employed in research and scientific services were on temporary contracts.

The MBI reports that in the period from 2016 to 2018, a total of 108 employees (28 scientists, 33 graduate students, 15 technicians, 32 others) left MBI and a total of 112 employees (39 scientists, 30 graduate students, 13 technicians, 30 others) were newly hired. These numbers do not include guest scientists and undergraduate students. MBI researchers received six calls to a professor position between 2016 and 2018.

On the postdoctoral level, MBI offers contracts with a first period limited to 2 or 3 years. On the PhD student level, MBI makes contracts for three years, with the possibility to be extended by up to one year. Following the MBI statutes, department heads are hired following similar rules as for appointments at German universities. Beyond the divisional structure of MBI, several independent groups led by young scientists have been established over the years. According to MBI, the fraction of non-German scientists in the total scientific staff amounts to 39%.

Promotion of gender equality

As of 31 December 2018, 11 out of 100 people employed in research and scientific services were female. Among the three directors there is no woman. Out of the nine department heads and three group leaders two were female (the head of the joint MBI/HU group is financed by HU Berlin). One out of two junior groups is headed by a female scientist. Of the 29 doctoral candidates four were female.

MBI states to aim at increasing the share of female scientists in research and technical activities at the institute to 20% in the near future. In outreach activities, the institute tries to raise interest in natural sciences in general and physics in particular. The MBI has adopted the DFG cascade model.

For MBI members, measures promoting family friendliness are pursued and the generation of role models supported. The family-friendly working environment at the MBI was confirmed by the certificate “berufundfamilie” which the institute was awarded in 2015 and again in 2018.

Promotion of junior researchers

As of 31 December 2018, 29 (22 FTE) doctoral candidates are employed at the MBI. Between 2016 and 2018, 27 doctoral degrees were completed of which five were awarded dissertation prizes. According to the MBI the institute integrates young scientists into its research teams and enables them to contribute to the respective project. Undergraduate and graduate students are provided with basic laboratory training and each graduate student is given opportunity to present the research results at an international scientific conference. MBI organizes language training in English and German on different levels, and other courses to improve “soft” skills of young scientists. MBI provides “seed money” exclusively for PhD students and junior postdocs when they make a pitch for a new promising project. Between 2016 and 2018, the average time needed to complete a thesis was 4.25 years.

Postdoctoral researchers can run their own research projects, typically combining the support by MBI with their own third party funding. Scientists who are new in leading their own group or a department can participate in the "leadership training programme" of the Forschungsverbund Berlin, which combines information, soft skill training and individual coaching geared towards leadership within an institute of the FVB.

Vocational training for non-academic staff

The MBI provides training for the non-academic staff specific for the job requirements of the respective group, e.g. AutoCAD seminars for members of the machine shop. Annually the MBI scientists give talks about the ongoing research and new developments for the non-academic staff. MBI supports initiatives from employees for further vocational training opportunities. It offers training positions for the professions of physics laboratory assistant, precision mechanic, and clerk (together with the administration of the Forschungsverbund Berlin). Between 2016 and 2018, 2 trainees completed their vocational training.

6. Quality assurance

Internal quality management

The MBI states to oblige all of its members to act according to the guidelines for good scientific practice, following the recommendations of the German Science Foundation for Safeguarding Good Scientific Practice. Both MBI and the Forschungsverbund Berlin (FVB) have an Ombudsperson who can be addressed by any staff member and deal with (potential) scientific misconduct. Publications by MBI staff are prepared following the guidelines and are checked for plagiarism via the *iThenticate* software prior to submission.

MBI considers an open scientific exchange and intense discussions within the institute key prerequisites for high-quality research. The discussion of new results both from the institute's own work and from the literature is typically assured during several seminars per week held at the MBI. Researchers within a project as well as the project coordinators together with the directorate meet on a regular basis. Annually, MBI has an internal workshop for all scientists at which the results and future planning of each project is presented and a budget request made. MBI has a full-cost accounting system which contains scientific output parameters (e.g., number of publications, external funds) for each project, accessible within the MBI intranet on a daily updated data basis.

The MBI stresses that the development and/or renewal of equipment is an important aspect of quality management. The investment budget of the institute complemented by third party funding is mainly used to keep the scientific infrastructure competitive and to acquire equipment for new research directions.

Quality management by the Scientific Advisory Board and Supervisory Board

The MBI's Scientific Advisory Board (SAB) holds one meeting per year at the institute during which the latest research results of all research projects are presented. Strategic issues are discussed with the MBI directors joined by the leading scientists if appropriate. The

SAB provides a written report assessing the research strategy and performance which includes recommendations on scientifically and organisational aspects. The SAB also performs the regular audit required by the Leibniz Association in the period in-between two evaluations. The last audit took place in 2016.

Implementation of recommendations from the last external evaluation

1. *MBI's continued development will strongly depend on the successor to the leadership position of Division B (Light-Matter-Interaction in Intense Laser Fields). In order to recruit a globally renowned, successful research personality, commensurate with MBI's scientific status, enormous efforts will be required. It should be noted that the charm of the position rests to no small extent on the provision of experimental facilities.*

In November 2015, the new director accepted the position of the director of division B. He has changed the structure and focus of Division B, and has integrated research on transient electronic and spin structure of solids and nanostructures into a revised research structure of MBI.

2. *The significant upgrading of theoretical physics at MBI has generated important strategies and definitive further developments in the general concept. It strengthens and individuates the institute as a whole. Hence the review board recommends the institute to examine whether, and possibly how, theoretical physics could also be regularly and systematically represented at MBI's leadership level.*

In spring 2016, MBI has introduced a new theory department. The head of the theory department participates in the meetings of the Board of Directors and accordingly is involved in all strategic and budget decisions.

3. *In order to guarantee the institute's full competitiveness in the long term the review board supports MBI's convincing plans to use additional funding over and above the annual five-percent increase in the core budget to acquire or extend the following experimental facilities by one-off investments:*

a. 2 Joule, 100 Hz thin disk driver for OPCPA for attosecond science and high field experiments,

b. upgrade of the 400 kHz OPCPA system after which the system could reach output energy levels of about 40-50 micro-Joule,

c. 1 kHz 5 μm OPCPA laser system as an X-ray plasma driver to further strengthen the position of MBI as a world leader in the ultrafast structural dynamics field.

Based on this recommendation and in view of the fact that 600 k€ had meanwhile been acquired for the development of a 5 μm OPCPA system within the Leibniz competitive procedure, additional 1.4 M€ were approved and spent in the years 2016 (768 k€) and 2017 (632 k€).

4. *To enhance the visibility of expert scientists below the leadership level, the review board recommends the institute to design its website so that their profiles and research focus areas can be assigned and showcased more effectively.*

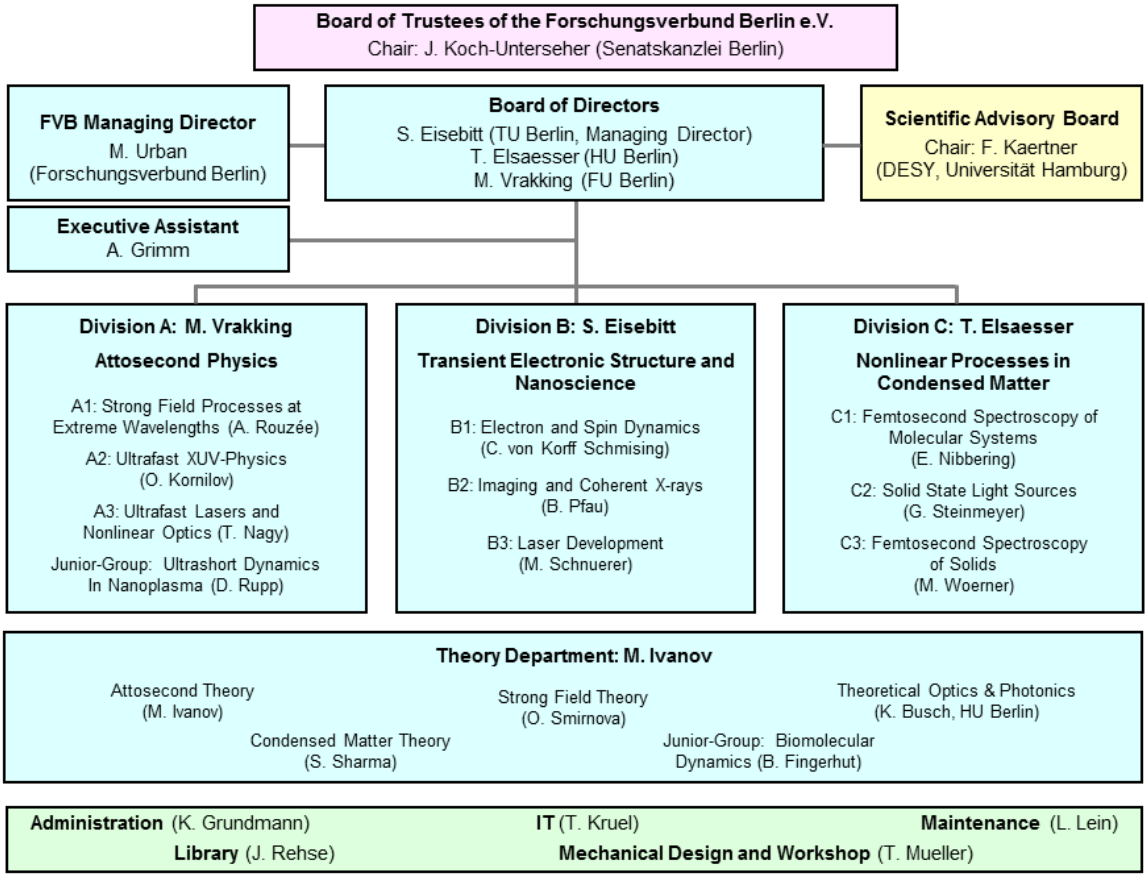
A new MBI website has been designed in close interaction with the project coordinators and group leaders. In particular, the website allows to obtain professional information about individual scientists. This is achieved via pages featuring individual MBI scientists and their scientific CVs and providing links from research project pages as well as from publication list to the individual researchers. The new MBI web-design is device-responsive to enable access via smartphones and tablets as well.

5. *MBI is pursuing a number of meaningful measures to increase the percentage of women, particularly amongst the scientific staff. The review board recommends the institute to drive efforts to increase the percentage of women in scientific positions, particularly at leadership level, and to gear these efforts to the decision of the Joint Science requiring the Leibniz-Association to adopt and implement flexible targets according to the DFG's cascade model. The supervisory board has the task of monitoring the implementation of these efforts to promote equal opportunities. The institute has already gained an excellent role model in the leader of the junior theory group, in which 40 percent of the researchers are female.*

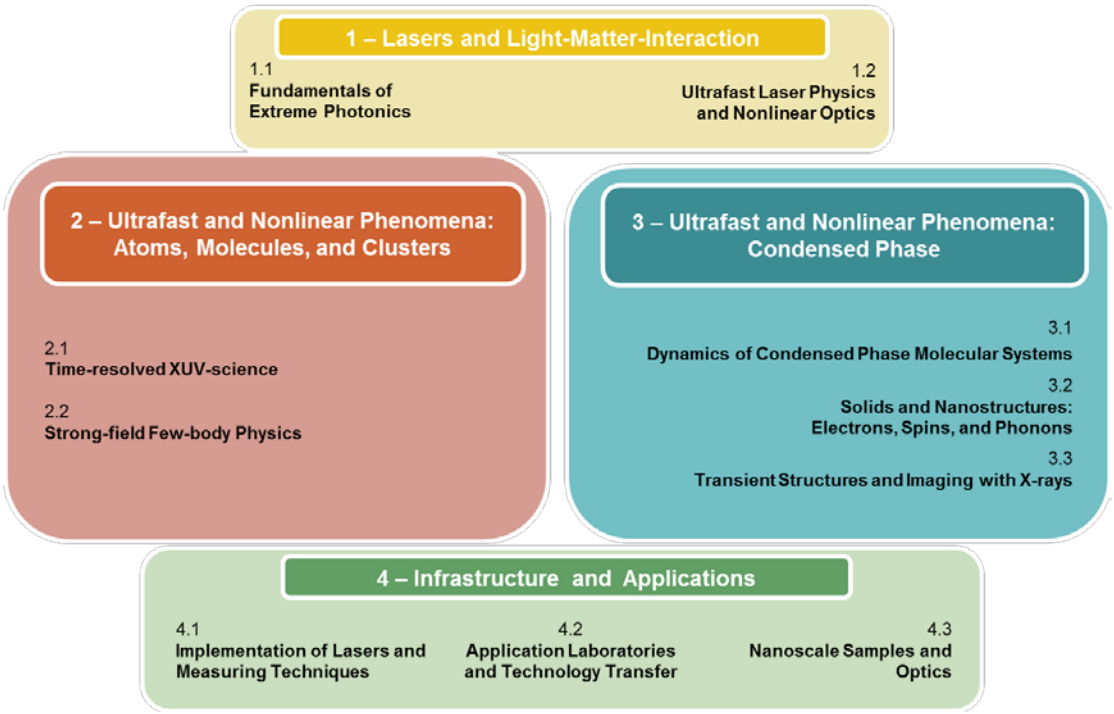
MBI has further increased its efforts to increase the percentage of women in scientific positions. As a result, MBI has in the last few years successfully managed to increase the number of women within the institute who either have found a permanent position within the academic system or are seeking to do so. The DFG cascade model has been adapted and is part of the annual program budget.

Appendix 1

MBI Organisation Structure



MBI Topical Areas and Projects



Appendix 2

Publications and patents

	Period		
	2016	**2017**	**2018**
Total number of publications	197	210	190
Monographs	1	-	1
Individual contributions to edited volumes	11	10	5
Articles in peer-reviewed journals	168	175	164
Articles in other journals	17	24	19
Working and discussion papers	-	-	-
Editorship of edited volumes	-	1	1

Industrial property rights (2016-2018)	Granted	Registered
Patents	2	25
Other industrial property rights		
Exploitation rights / licences (number)	1	

Appendix 3 Revenue and Expenditure

Revenue		2016			2017			2018 [1]		
		K€	%	%	K€	%	%	K€	%	%
Total revenue (sum of I., II. and III.; excluding DFG fees)		25.677,2			23.149,5			22.782,7		
I.	**Revenue (sum of I.1., I.2. and I.3)**	21.356,0	100 %		20.171,3	100 %		21.388,7	100 %	
1.	INSTITUTIONAL FUNDING (EXCLUDING CONSTRUCTION PROJECTS AND ACQUISITION OF PROPERTY)	17.849,6	83.6		16.760,3	83.1		17.628,4	82.4	
1.1	Institutional funding (excluding construction projects and acquisition of property) by Federal and *Länder* governments according to AV-WGL	17.323,7			16.234,4			17.102,5		
1.2	Institutional funding (excluding construction projects and acquisition of property) not received in accordance with AV-WGL[2]	525,9			525,9			529,9		
2.	REVENUE FROM PROJECT GRANTS [3]	3.506,4	16.4	100 %	3.411,0	16.9	100 %	3.762,8	17.6	100 %
2.1	DFG	1.515,0		43.2	1.122,8		32.9	1.156,3		30.7
2.2	Leibniz Association (competitive procedure)	466,6		13.3	368,6		10.8	743,8		19.8
2.3	Federal, *Länder* governments	504,7		14.4	904,8		26.5	1.074,3		28.6
2.4	EU	648,8		18.5	611,0		17.9	480,7		12.8
2.5	Industry	16,9		0.5	24,0		0.7	28,5		0.8
2.6	Foundations	17,0		0.5	4,4		0.1	20,1		0.5
2.7	*Other sponsors*	337,4		9.6	375,4		11.0	259,2		6.9
3.	REVENUE FROM SERVICES									
3.1	Revenue from commissioned work									
3.2	Revenue from publications									
3.3	Revenue from exploitation of intellectual property for which the institution holds industrial property rights (patents, utility models etc.)									
3.4	Revenue from exploitation of intellectual property without industrial property rights									
3.5	*Revenue from other services, if applicable; please specify*									
II.	**Miscellaneous revenue** (e.g. membership fees, donations, rental income, funds drawn from reserves)[3]	4.321,2			2.978,1			1.396,0		
III.	**Revenue for construction projects** (institutional funding by Federal and *Länder* governments, EU structural funds, etc.)									

Expenditures		T€	T€	T€
Expenditures (excluding DFG fees)		25677,2	23149,5	22784,7
1.	Personnel	11513,7	12140,5	12524,9
2.	Material expenses	5235,3	5242,0	4707,5
2.1	*Proportion of these expenditures used for registering industrial property rights (patents, utility models etc.)*	12,6	9,2	15,0
3.	Equipment investments	5765,6	3886,2	3214,5
4.	Construction projects, acquisition of property	3,1	0	637,3
5.	Other operating expenses (if applicable, please be specific)	646,7	640,5	664,6
6.	Miscellaneous items	2512,8	1240,3	1035,9
DFG fees (if paid for the institution – 2.5% of revenue from institutional funding)		431,3	401,6	409,5

[1] Preliminary data: yes
[2] Special provision by the *Land* Berlin to cover the rent for the buildings.
[3] The numbers listed in "Revenue from project grants" correspond to expenditures during the corresponding year.
[3] Note that "Misc. Revenue" includes the institute's own resources "Selbstbewirtschaftungsmittel" (budget transfer to the following year) and "Kassenreste" (cash remainders).

Appendix 4

Staff

(As of: 31.12.2018)[1]

	Full time equivalents		Employees		Female employees	
	Total	on third-party funding	Total	on temporary contracts	Total	on temporary contracts
	Number	Percent	Number	Percent	Number	Percent
Research and scientific services	**91,9**	**32,4**	**100**	**37,0**	**11**	**81,8**
Professors / Direct. (C4, W3 or equivalent)	6	0	6	0	1	0
Professors / Direct. (C3, W2, A16 or equi.)	-	-	-	-	-	-
Academic staff in executive positions [2](A15, A16, E15 or equivalent)	8	0	8	0	0	0
Junior research group leaders / junior professors/ post-doctoral fellows (C1, W1, A14, E14 or equivalent)	2	100	2	100	1	100
Scientists in non-executive positions (A13, A14, E13, E14 or equivalent)	53,9	23,6	55	67,3	5	80,0
Doctoral candidates (A13, E13, E13/2 or equi.)	22	69,0	29	100	4	100
Service positions	**59,6**		**61**			
Laboratory (E9 to E13,upper-mid-level service)	24,6	8,1	26			
Laboratory (E5 to E8, mid-level service)	3,9	0	4			
Workshops (E5 to E11, mid-level service)	5,5	0	6			
Secretary (E5 to E9, mid-level service)	6,65	0	7			
Library (E5 to E9, mid-level service)	1	0	1			
Head of Information technology – IT	1		1			
Information technology - IT (E5 to E12, mid-level & upper mid-level service)	7,9	0	8			
Technical (large equipment, service) (E5 to E12, mid-level & upper mid-level service)	8	0	8			
Administration	**9,45**		**11**			
Head of the administration	1	0	1			
Staff positions (from E13, senior service)	1,95	50,0	2			
Internal administration (financial administration, personell etc.) (E9 to E12, upper-mid-level service)	6,5	0	8			
Student assistants	**3,55**	**0**	**11**			
Trainees	**4**	**0**	**4**			
Scholarship recipients at the institution	**2**		**2**		**0**	
Doctoral candidates	-	-	-		0	
Post-doctoral researchers	2	100	2		0	

[1] In addition to the positions listed here, MBI provides the salary for 7 people in the central administration of the Forschungsverbund Berlin e.V.

[2] = Department heads

23 October 2019

Annex B: Evaluation Report

Max Born Institute for Nonlinear Optics and Short Pulse Spectroscopy (MBI) in the *Forschungsverbund Berlin e. V.*

Contents

1. Summary and main recommendations

MBI conducts very successful basic research in the field of non-linear optics and ultrafast dynamics arising from the interaction of matter with light. For this purpose, it develops and employs ultrashort and ultra-intense lasers and laser-driven short-pulse light sources in a broad spectral range in combination with ultrafast nonlinear spectroscopy methods and time-resolved structural studies. The investigations made possible by these techniques deliver insights into the microscopic interactions that determine the physical properties of atoms, molecules, fluids and solids as well as transient electronic and atomic structures. MBI's research addresses fundamental questions in physics, chemistry and materials science.

Already following the last two evaluations in 2006 and 2012, the Leibniz Association Senate was very positive in its assessment of MBI's scientific work. Since then, the institute has continued to develop convincingly and has reinforced its role as one of the world's leading institutes in its field. MBI is managed by three directors who each head one of the institute's three Divisions. An important change since the last evaluation was the retirement of one of the three directors in 2013. During the 20 years that he worked at the institute he had decisively helped shape it and made a major contribution to the institute's positive development. His position was successfully refilled in 2015 and the Division headed by the new director was convincingly redesigned. While this has been taking place, MBI has continued to expand its highly successful theoretical activities. To do so, existing expertise at MBI has been pooled in an independent Theory Department and provided with additional human resources. The dovetailing of theoretical and experimental research is now a unique feature of MBI.

MBI's research is organised according to a matrix structure in which the three Divisions and the Theory Department jointly address four Topical Areas. The activities in Topical Area 1 are rated as "excellent" (theoretical basic research) and "very good to excellent" (experimental work). In Topical Areas 2 and 3, theoretical and experimental activities are inextricably linked, whereby experimental questions generate theoretical activities. These Topical Areas are rated as "excellent" and "very good to excellent" respectively. Topical Area 4 provides excellent and indispensable services for the other three Topical Areas as well as for external partners; it does not have a research agenda of its own.

The institute's outstanding research outcomes are reflected in numerous, high-quality publications and the successful acquisition of very competitive third-party funding, such as three ERC Grants. Moreover, MBI provides important services in the field of scientific services and technology transfer that are in great demand worldwide. The institute was involved, for example, in building the laser systems for the European X-Ray Free-Electron Laser (XFEL) and the Free Electron Laser Hamburg (FLASH) at the Deutsches Elektronen-Synchrotron (DESY). MBI is also a major contributor to developing the Extreme Light Infrastructure ELI, an international research infrastructure which is being built by three countries under the ESFRI Roadmap (European Strategy Forum on Research Infrastructures). In the framework of the EU project Laserlab Europe, MBI, together with 22 other facilities at European laser research institutes, opens its laboratories to external users.

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

General concept and profile (Chapter 2)

1. MBI's outstanding, highly competitive infrastructure forms the indispensable basis for its excellent scientific work. Only if these facilities are constantly developed and updated MBI will be able to maintain its world-leading position in the long term. At present, however, the institute's investment budget is too tightly calculated, as already pointed out at the last evaluation. In recent years, MBI has been able to compensate for this with fixed-term third-party income or one-time grants from the Federal and State Governments *(Länder)*. MBI must, however, agree with its funding bodies on a sustainable solution for this deficit so as not to endanger its international competitiveness in the long term.
2. MBI plans to acquire three new lasers. Two of them are destined to replace lasers in the OPCPA (optical parametric chirped-pulse amplification) systems, developed by MBI, which will open up extremely promising new research opportunities for the institute in the study of atoms, molecules and clusters in Topical Area 2 as well as of condensed matter in Topical Area 3. The third laser is destined to be used in Topical Area 3 to continue and extend the particularly successful research in the THz range. The institute envisages financing these acquisitions with additional funding from the Federal and State Governments (temporary extraordinary item of expenditure). The one-time investment required totals €3,081 m (plus 3 percent MBI share) in 2022. The plans are coherent and are explicitly endorsed. Their implementation will allow MBI to remain internationally competitive in the medium term.
3. MBI is very successful in its efforts to raise third-party funding for research proposals. It is thus involved in various collaborative projects funded by the DFG (German Research Foundation). Furthermore, it has recently acquired two Advanced Grants from the ERC together with one Starting Grant. Between 2016 and 2018, however, total third-party funding only accounted for approx. 17 percent of the overall budget. MBI should continue the recent positive trend and increase third-party income. The EU's funding programmes, in particular, would offer the relevant potential. Overall, MBI should achieve a third-party funding share of approx. 25 percent.

Staff development and promotion of junior researchers (Chapter 5)

4. MBI is well managed by the three directors. It is welcomed that, in line with recommendations, the head of the Theory Department is included in all directorial decisions and thus effectively holds the position of a fourth director. Given the enormous importance of theoretical work for MBI as a whole, it should be considered to formally designate the position of head of theory as a directorship.
5. With regard to gender equality the situation at MBI is still unsatisfactory. By the end of 2018, the overall figure for female scientists employed at MBI was 11 percent, the target quotas determined by MBI in the programme budget according to the DFG's cascade model have not been reached. The personnel changes that will be taking place

in the coming years, partly as a result of the retirement of another of the directors, must be used to improve this situation. During the site visit it appeared that, below top leadership level, there is a wealth of creative ideas for relevant measures, and it is recommended that the institute pursues an open conversation on this subject.

2. General concept and profile

Development of the institution since the last evaluation and strategic work planning for the coming years

MBI conducts very successful basic research in the field of non-linear optics and ultrafast dynamics arising from the interaction of matter with light. For this purpose, it develops and employs ultrashort and ultra-intense lasers and laser-driven short-pulse light sources in a broad spectral range in combination with ultrafast nonlinear spectroscopy methods and time-resolved structural studies. The investigations made possible by these techniques deliver insights into the microscopic interactions that determine the physical properties of atoms, molecules, fluids and solids as well as transient electronic and atomic structures. MBI's research addresses fundamental questions in physics, chemistry and materials science.

Since the last evaluation, the institute has reinforced its role as one of the world's leading institutes in its field and continued to convincingly develop its research strategy. Given that high-quality lasers are now increasingly available commercially, it is becoming less important for MBI to develop its own lasers. In view of the above, MBI is correctly intensifying its focus on optimising and developing existing lasers, for instance by optical parametric chirped-pulse amplification (OPCPA) and its applications in innovative experiments for investigating the interaction of matter and light. The institute is managing this transition extremely convincingly, not least by appointing the new director and head of Division B (see below). While this has been taking place, MBI has continued to expand its highly successful theoretical activities.

Organisational structure

Organisationally, MBI is divided into three Divisions that are each headed by a director. Each Division comprises three Departments. In addition, MBI has pooled the theoretical activities conducted at the institute and, in 2016, formed an independent Theory Department.

The leadership position in Division A was refilled shortly before the last evaluation in 2012 due to retirement. At the time, the resulting new work in the field of attosecond phenomena was rated as very promising, and the high expectations have been fulfilled. Since the last evaluation, a new Department has been established as well as a Junior Research Group acquired under the Leibniz Competition. A former Division A Department is now located in the newly-established Theory Department.

Following the retirement of the long-serving, extremely successful head of Division B in 2013, MBI refilled this position very effectively at the end of 2015. Under the new leadership the focus has been redirected to ultrafast electronic structures and

nanoscience with an emphasis on studies of time-resolved magnetism. In this process, two Departments were phased out and two were newly established. This convincingly implemented the refocussing resulting from the change in leadership.

In Division C, research in femtosecond spectroscopy and structural studies has continued to be conducted extremely successfully without any organisational changes. The head of Division C will retire in 2022. It will be important to find an excellent successor and it is welcomed that MBI has already initiated negotiations to once again fill the position as a joint appointment with Humboldt-Universität zu Berlin.

MBI has continued to reinforce theory at the institute and enhanced its visibility in line with recommendations. In particular, it has amalgamated the four groups that existed in 2016 (one Department in Division A and three independent groups) into an independent Theory Department and since then augmented it by an additional group. The dovetailing of theoretical and experimental research has now become a unique feature of MBI. The institute is encouraged to pursue its plans to strengthen the international networking of its own outstanding theoretical expertise yet further. As outlined by MBI during the evaluation visit, for example, a platform for informally sharing ideas and concepts *(Virtual Theory Centre)* could be established, which could enhance the visibility of theory at MBI yet further.

Research structure

Overall, research at MBI is organised according to a matrix structure in which the three Divisions and the Theory Department jointly address four Topical Areas. Thanks to this matrix structure, internal networking is excellent. It promotes close and extremely successful cooperation between MBI's various theoretical and experimental competencies (see Chapter 3 for the evaluation of the four Topical Areas).

Results

Research

MBI's outstanding research outcomes are reflected in numerous, high-quality publications in the leading international journals. In comparison with the last evaluation in 2012, its publication performance has been enhanced yet further both in terms of quantity and quality.

Scientific services, knowledge and technology transfer

In recent years, MBI has been very successful in developing laser systems for experiments with free electron lasers and synchrotron radiation sources at large-scale research facilities. It was, for example, centrally involved in developing the European X-Ray Free-Electron Laser (XFEL) and the Free Electron Laser Hamburg (FLASH) at the Deutsches Elektronen-Synchrotron (DESY). An ongoing project deals with the optimisation of a laser for use by the Max Planck Institute for Intelligent Systems at Helmholtz-Zentrum Berlin's (HZB) storage ring BESSY II. It is welcomed that MBI is contributing to the planning of BESSY III. In the future, developing laser systems for external partners, but also for use at MBI, will become less important because the relevant developments are increasingly

available commercially. In its overall strategy, MBI is taking appropriate account of this situation (see comments above).

MBI pursues important activities for partners in industry and research, such as characterising and developing optical components. It also opens its unique laboratories to external users, such as the BLiX laboratory (Berlin Laboratory for innovative X-ray Technologies) and the NanoMovie laboratory (see Chapter 3, Topical Area 4). Special mention should be made of MBI's major involvement in the EU project Laserlab Europe: together with 22 other facilities at European laser research institutes, MBI opens its infrastructure to external users. The institute is also a major contributor to developing the Extreme Light Infrastructure (ELI), an international research infrastructure which is being built by three countries under the ESFRI Roadmap (European Strategy Forum on Research Infrastructures).

MBI also promotes the industrial exploitation of its results. On the reporting date, 31 December 2018, MBI held more than 25 patents. Overall, the institute pursues a meaningful patents strategy, additionally aided in its implementation by the joint administration of the Forschungsverbund Berlin. It is logical to continue holding promising patents for a certain amount of time, even though these did not actually generate any revenue between 2016 and 2018. Moreover, MBI also successfully acquires collaborative projects together with small and medium-sized enterprises. In order to drive knowledge transfer between science and industry MBI participates in the Photonics Cluster of the Joint Strategy for Innovation pursued by the State Governments (*Länder*) Berlin and Brandenburg (innoBB) as well as the Competence Network for Optical Technologies (OpTecBB). The institute should examine whether its various activities can be bundled to an even greater extent in order to further optimise the exploitation of results.

Public relations

It is welcomed that MBI has redesigned its website, as recommended at the last evaluation. It now provides a good overview of the institute's activities.

Appropriateness of facilities, equipment and staffing

Institutional funding and equipment

In 2018, MBI's institutional funding was approx. €17.6 m.

MBI's outstanding, highly competitive infrastructure forms the indispensable basis for its excellent scientific work. Only if these facilities are constantly developed and updated MBI will be able to maintain its world-leading position in the long term. At present, however, the institute's investment budget is too tightly calculated, as already pointed out at the last evaluation. In recent years, MBI has been able to compensate for this with fixed-term third-party income or one-time grants from the Federal and State Governments *(Länder)*. MBI must, however, agree with its funding bodies on a sustainable solution for this deficit so as not to endanger its international competitiveness in the long term.

MBI plans to acquire three new lasers. Two of them are destined to replace lasers in the OPCPA (optical parametric chirped-pulse amplification) systems, developed by MBI, which will open up extremely promising new research opportunities for the institute in the study of atoms, molecules and clusters in Topical Area 2 as well as of condensed matter in Topical Area 3. The third laser is destined to be used in Topical Area 3 to continue and extend the particularly successful research in the THz range. The institute envisages financing these acquisitions with additional funding from the Federal and State Governments (temporary extraordinary item of expenditure). The one-time investment required totals €3,081 m (plus 3 percent MBI share) in 2022. The plans are coherent and are explicitly endorsed. Their implementation will allow MBI to remain internationally competitive in the medium term.

Revenue from project funding grants

MBI is very successful in its efforts to raise third-party funding for research proposals. It is thus involved in various collaborative projects funded by the DFG (German Research Foundation). Furthermore, it has recently acquired two Advanced Grants from the ERC together with one Starting Grant. Between 2016 and 2018, however, total third-party funding only accounted for approx. 17 percent of the overall budget. MBI should continue the recent positive trend and increase third-party income. The EU's funding programmes, in particular, would offer the relevant potential. Overall, MBI should achieve a third-party funding share of approx. 25 percent.

Revenue from services

MBI's services are provided in the framework of third-party funded collaborative projects. Consequently, no revenue is generated by services (see Status Report, Appendix 3, line 3).

Buildings

It is very pleasing that a number of measures have been undertaken in recent years to modernise MBI's buildings. This means that building requirements for the coming years have been placed on a firm footing. However, to what extent in the long term the buildings will still meet the future standards required for MBI's special infrastructure MBI should discuss with its committees and start planning at an early stage for any construction work deemed necessary.

3. Subdivisions of MBI

Topical Area 1: Lasers and light-matter interaction

[29.73 FTE, thereof 16.89 FTE researchers, 6.62 FTE PhD students, 6.22 FTE engineers/technicians]

Topical Area 1 is composed of two thematically different projects. Project 1.1 conducts basic theoretical research in the field of non-linear interaction between light and matter.

Since the last evaluation, this project has been newly established and it is essentially driven by the groups in the new Theory Department. Project 1.2 conducts research on the experimental principles of non-linear optics and the generation of ultra-short and/or ultra-intensive lights pulses with, in some cases, unique laboratory sources.

Project 1.1 "Extreme Photonics"

MBI's theoretical basic research in the field of non-linear light-matter interaction is outstanding in every respect. The results achieved in describing chiral measurements with and without magnetic interactions as well as the characterisation of chiral attosecond pulses are impressive. It is welcomed that MBI also very successfully addresses theory in relation to quantum photonics. Its work on biomolecular dynamics is also highly successful. In the context of expanding its theoretical work, it is welcomed that the institute has introduced new topics such as its successful research on magnetic excitations.

The activities in Project 1.1 are of the highest quality and achieve major international visibility. The theories it develops are innovative and its research outcomes are published remarkably often in high-ranking journals. Moreover, it also successfully acquires third-party funding under highly competitive procedures. Its activities are financed, amongst others, by an ERC Starting Grant, a DFG-funded Emmy-Noether Junior Research Group and two DFG Priority Programmes.

Project 1.1 is rated as "excellent".

Project 1.2 "Ultrafast Laser Physics and Nonlinear Optics"

Project 1.2 conducts very successful experimental research on the basis of which innovative and, in some cases, unique light sources are developed. The project cooperates closely with Topical Area 4 which provides the relevant knowledge transfer and technology transfer for internal and external users.

In the field of developing new light sources, impressive results have been achieved since the last evaluation. Several unique OPCPA systems have been constructed which are used both within the institute and by external partners. The 5 µm source for hard X-rays for research in Topical Area 3, in particular, which has achieved a very high photon flux, is a remarkable development that facilitates complementary activities to large-scale research facilities. Excellent results have also been achieved in expanding the parameter range of light sources (pulse energy, pulse duration, stability, repetition rate etc.). Outcomes worthy of special mention include those in the field of carrier-envelope phase stabilisation.

The activities undertaken in Project 1.2 display great potential for scientific innovation and the results are published in high-ranking peer-reviewed journals. The project has also been very successful in raising third-party funding, including in the Leibniz Competition. Together with Topical Area 4, Project 1.2 creates the indispensable experimental foundations for MBI's activities.

Project 1.2 is rated as "very good to excellent".

Topical Area 2: Ultrafast and nonlinear phenomena: atoms, molecules and plasma

[28.12 FTE, thereof 16.65 FTE researchers, 5.82 FTE PhD students, 5.65 FTE engineers/technicians]

Since the last evaluation, research in the attosecond field in Topical Area 2 has been extremely successfully expanded. In this context, the previous Project 2.1. "Laser Plasma Dynamics and Particle Acceleration" was wound up and activities in the two continuing projects addressing time-resolved XUV-science and strong-field few-body physics were developed further. Topical Area 2 can thus boast a very convincing profile. Research outcomes are excellent and reach an international audience. Cooperation between theory and experimentation is especially close and productive in this Topical Area.

Particularly noteworthy results have been achieved in the field of fundamental processes in strong fields. The work on strong field excitations and high harmonic generation in tailored fields is exemplary. The research on ultrafast electronic relaxation and fragmentation dynamics at XUV/X-ray wavelengths has also produced excellent results. In an innovative experiment, a gas jet was used for the controlled refraction of XUV light. This work has the potential to generate further extremely interesting developments in XUV science. Outstanding results have also been achieved in the area of collective and correlated dynamics at the nanoscale. It is welcomed that various activities in Topical Area 2 combine experiments with the unique OPCPAs, which were developed at the institute, with MBI's measurements on FELs (free electron lasers) at large-scale research facilities.

The outstanding research outcomes are reflected in many publications in high-ranking journals. Furthermore, competitive third-party funding is regularly raised. For example there is intense involvement in a DFG Priority Programme (six part-projects).

Topical Area 2 is rated as "excellent".

Topical Area 3: Ultrafast and nonlinear phenomena: condensed phase

[38.19 FTE, thereof 20.35 FTE researchers, 10.90 FTE PhD students, 6.94 FTE engineers/technicians]

In Topical Area 3 very successful research is conducted on the basic interactions and non-equilibrium dynamics in (bio-)molecules in the fluid phase, solids and nanostructures. The Topical Area's three projects have convincingly developed since the last evaluation. The extremely successful, long-established research on the basic interactions at molecular and atomic level has been continued whilst new and promising work on magnetism and imaging has been introduced.

One highlight are the measurements using the femtosecond X-ray diffraction method, which are employed to study ultrafast electronic charge redistribution. Developments in the field of two-dimensional nonlinear terahertz and mid-infrared spectroscopy have been successfully used to investigate electrical fields on the DNA surface. They hold the potential, which MBI should exploit to greater effect, to generate further innovative, experimental work. More recent and very promising work is being done on investigating magnetism and transient electronic structures as well as nanoscale imaging and

spectroscopy with soft X-rays. The measurements using high harmonic generation sources at MBI are combined very effectively with measurements at large-scale research facilities.

The Topical Area's research results are regularly published in high-ranking journals. Moreover, very competitive third-party funding has been obtained. Especially impressive are two ERC Advanced Grants and the participation with two part-projects in a DFG Collaborative Research Center/Transregio.

Topical Area 3 is rated as "very good to excellent".

Topical Area 4: Laser infrastructure and knowledge transfer

[16.35 FTE, thereof 9.26 FTE researchers, 7.09 FTE engineers/technicians]

Topical Area 4 does not pursue a research agenda of its own but provides essential inhouse services for MBI's own research as well as for external partners in the context of three projects. Its role within MBI is to implement lasers and measuring techniques, operate the dedicated application laboratories and manufacture specific sample systems and tailored optics for use in other projects. Topical Area 4 cooperates closely with Project 1.2 in Topical Area 1 and is also responsible for MBI's technology transfer.

Since the last evaluation, OPCPA engineering has continued to be developed successfully, creating the foundations for the impressive scientific results in Topical Areas 2 and 3. MBI is an international leader in the field of implementing and optimising OPCPAs. Moreover, Topical Area 4 coordinates the development of laser systems in large-scale research facilities (see Chapter 2). MBI's two application laboratories are also operated by Topical Area 4. At the Berlin Laboratory for innovative X-ray Technologies (BLiX), which was established jointly with TU Berlin in 2011, laser-based plasma sources are provided for external users, for example for biomedical examinations at Charité Berlin. In the NanoMovie Laboratory, which is currently being established with funding from the European Regional Development Fund, OPCPAs for ultra-short soft X-ray pulses will be made available. Moreover, a promising new topic has been incorporated whereby magnetic layer systems for applications at the institute are produced and characterized. All of MBI's Topical Areas will benefit from these activities.

The expertise delivered in this Topical Area is of the highest quality and indispensable for the outstanding research work conducted in the other Topical Areas.

4. Collaboration and networking

Institutional collaborations with universities

Cooperation with the Berlin universities

MBI cooperates closely with the three Berlin universities – Technische Universität Berlin (TU), Humboldt-Universität zu Berlin (HU) and Freie Universität Berlin (FU). Each of the three directors holds a joint professorship (W3) at one of these universities. In addition, there are two joint appointments at HU and one at TU (also W3). Two of these appointments have been made since the last evaluation. A joint theory group also exists with HU, headed by an HU professor and co-financed by MBI. Furthermore, the application

laboratory BLiX is jointly operated with TU (see Chapter 3). MBI makes an appropriate contribution to university teaching.

When one of the directors retires in a few years' time, MBI plans to refill the position as a joint appointment with HU once again. It is welcomed that the institute has already initiated negotiations at this early stage. Due to the close proximity to HU's Department of Physics in Adlershof, cooperation is especially close and of particular importance.

Institutional cooperation with other institutions at home and abroad

MBI is very well connected both nationally and internationally. At national level, especially the cooperation with large-scale research facilities that provide free electron lasers and synchrotron radiation sources, such as DESY in Hamburg (see Chapter 2) is intense. Within the Leibniz Association, connections at project level exist to institutes belonging to the Forschungsverbund Berlin (FVB), for example the Paul-Drude-Institut für Festkörperelektronik (PDI), the Weierstrass Institute for Applied Analysis und Stochastics (WIAS) and the Ferdinand-Braun-Institut – Leibniz-Institut für Höchstfrequenztechnik (FBH).

At international level, MBI is intensively involved in the EU project Laserlab Europe together with 22 other facilities at European laser research institutes. MBI is also a major contributor to developing the Extreme Light Infrastructure at three European locations (see Chapter 2).

5. Staff development and promotion of junior researchers

Staff development and personnel structure

The personnel structure is appropriate for the institute's mission. As of 31 December 2018, MBI employed 172 individuals (excluding student assistants, trainees and scholarship recipients). One hundred of them worked in research and scientific services (including 29 doctoral candidates).

MBI is well managed by the three directors. It is welcomed that, in line with recommendations, the head of the Theory Department is included in all directorial decisions and thus effectively holds the position of a fourth director. Given the enormous importance of theoretical work for MBI as a whole, it should be considered to formally designate the position of head of theory as a directorship.

Since the last evaluation, the number of executive scientists has risen from 13 to 18. MBI managed to recruit highly respected researchers for these positions. It is welcomed that in this context, two new junior groups have been established, one under the DFG's Emmy Noether Programme, the other under the Leibniz Competition.

Promotion of gender equality and compatibility of work and family life

As of 31 December 2018, 11 out of 100 people employed in research and scientific services were female (11 %). None of the three directors nor the head of the Theory Department is a woman. Out of the 15 executive scientists at 2nd level (9 department heads, 3 group leaders, 2 junior groups and one joint group with HU Berlin) three were female (20 %).

Out of the 29 doctoral candidates four were female (14 %). The ten projects in the four Topical Areas are coordinated by 22 individuals in total, of whom two are women (10 %).

With regard to gender equality the situation at MBI is still unsatisfactory. By the end of 2018, the overall figure for female scientists employed at MBI was 11 percent, the target quotas determined by MBI in the programme budget according to the DFG's cascade model have not been reached. The personnel changes that will be taking place in the coming years, partly as a result of the retirement of another of the directors, must be used to improve this situation. During the site visit it appeared that, below top leadership level, there is a wealth of creative ideas for relevant measures, and it is recommended that the institute pursues an open conversation on this subject.

It is welcomed that MBI has already twice been awarded the "berufundfamilie" certificate. The institute should ensure that the various measures available to improve the compatibility of work and family life are communicated to all members of staff and are open for everyone to use equally.

Promotion of junior researchers

The number of doctoral candidates and completed dissertations is appropriate. As of 31 December 2018, 29 doctoral candidates were employed at MBI; between 2016 and 2018, 27 doctoral degrees were completed at the institute. At 4.2 years, the average length of doctoral studies is appropriate.

Junior researchers are very well supervised at MBI. They are given basic laboratory training as well as additional language and soft skill courses. All doctoral candidates may, furthermore, take part in the training programmes at the institute's partner universities. It is welcomed that, one year after embarking on the doctoral phase, every candidate prepares a paper summarising their results which is then presented to their colleagues. It is also welcomed that, since 2019, MBI has started awarding seed money for promising research projects to doctoral candidates and postdocs in order to drive creative ideas.

Overall, career prospects for junior researchers who have spent time at MBI are excellent. It is very pleasing that, since the last evaluation, two MBI employees have completed their habilitations and four individuals have been appointed to professorships. Thanks to the institute's many collaborations and the outstanding reputation of MBI's training, many MBI researchers also transfer to industry. In order to continue promoting its excellent, existing networking, the institute should consider introducing an alumni programme.

Promotion of non-scientific staff

MBI has appropriate tools for enhancing the qualifications of its non-scientific staff. It offers training positions for physics laboratory assistants, precision mechanics, and clerks (in collaboration with the administration of the Forschungsverbund Berlin). By the reporting date of 31 December 2018, four individuals were being trained at MBI; between 2016 and 2018 two traineeships were successfully completed.

6. Quality assurance

Internal quality management

MBI employs effective internal scientific quality assurance. Both MBI and the Forschungsverbund Berlin (FVB) have an ombudsperson. Every year, MBI organises an internal workshop at which the results and future planning of each research project are presented, and a budget request made. MBI has a full-cost accounting system which contains scientific output parameters (e.g., number of publications, external funds) for each project, accessible on the MBI intranet and updated daily. Communication amongst all MBI staff on various formats is intensive.

Quality management by the Scientific Advisory Board

MBI's Scientific Advisory Board fulfils its mission conscientiously and fairly. In 2016, it conducted the audit that Leibniz institutions are expected to hold between two evaluations. As intended, the Board's written audit addressed both the institute as a whole and the individual Topical Areas. The share of women on the Board should be increased. Of the 11 members serving on 31 December 2018, only one was female.

Implementation of recommendations from the last external evaluation

MBI has implemented most of the recommendations issued at the last evaluation. Merely the recommendation to increase the percentage of women researchers is still valid (see Chapter 5). Furthermore, the problem of the too tightly calculated investment budget (see chapter 2) has also been addressed already at the last evaluation.

Appendix

1. Review Board

Chair (Member of the Leibniz Senate Evaluation Committee)

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

Deputy Chair (Member of the Leibniz Senate Evaluation Committee)

Susanne **Renner**	Systematic Botany and Mycology, Ludwig-Maximilians-Universität München

Reviewers

Martin **Aeschlimann**	Department of Physics, Technische Universität Kaiserslautern
Thomas **Baumert**	Institute for Physics, Kassel University
Joachim **Burgdörfer**	Institute of Theoretical Physics, Vienna University of Technology (Austria)
Steven **Cundiff**	Professor of Physics, University of Michigan (USA)
Louis **DiMauro**	Professor of Physics, The Ohio State University (USA)
Sandro **de Silvestri**	Centre for Ultrafast Science and Biomedical Optics, Politecnico di Milano (Italy)
Robert **Schoenlein**	PULSE Institute, Stanford University (USA)
Jonathan **Tennyson**	Department of Physics and Astronomy, University College London (UK)

Representative of the Federal Government

absent with apologies	Federal Ministry of Education and Research, Bonn

Representative of the State Governments (Länder) *(Member of the Leibniz Senate Evaluation Committee)*

Bernd **Ebersold**	Thuringian Ministry of Economy, Science and the Digital Society, Erfurt

6 November 2019

Annex C: Statement of the Institution on the Evaluation Report

Max Born Institute for Nonlinear Optics and Short Pulse Spectroscopy (MBI) in the *Forschungsverbund Berlin e. V.*

MBI has gratefully taken note of the Evaluation Report and appreciates the picture that emerges regarding MBI´s scientific performance and its position in the national and international scientific community.

MBI finds the recommendations made by the Review Board for the future development of the institute very helpful. The institute will consider their implementation in each case together with the Scientific Advisory Board. MBI gratefully acknowledges that the recommendations are intended to further strengthen the institute's position within the global competition.

With respect to the specific recommendations of the Review Board on page B-3 of the Evaluation Report MBI likes to make the following comments.

Recommendation 1

MBI strongly agrees with the recommendation of the Review Board that

“At present, however, the institute’s investment budget is too tightly calculated, as already pointed out at the last evaluation. In recent years, MBI has been able to compensate for this with fixed-term third-party income or one-time grants from the Federal and State Governments (Länder). MBI must, however, agree with its funding bodies on a sustainable solution for this deficit so as not to endanger its international competitiveness in the long term.”

Recommendation 2

MBI agrees with and thanks the Review Board for its explicit endorsement of MBI´s plans for use of additional investment funding in 2022 to guarantee the institute´s medium term competitiveness.

Recommendation 3

MBI acknowledges that its third-party funding ratio should be increased over the ratio achieved in the reporting period 2016-2018 and is thankful that the review board acknowledged that this process is well underway - e.g. with two new ERC Advanced Grants and one new ERC Starting Grant of MBI scientists active since 2018/2019 in addition to many other third party funded projects. MBI would like to point out, however, that the orientation of the institute´s mission towards fundamental research makes increasing the third-party funding ratio by a factor of about 1.5 a formidable challenge, in view of the fact that many funding opportunities require significant co-funding and resources from the institute.

Recommendation 4

MBI is pleased that its strategy to strengthen theory at MBI via an independent theory department has been received very positively and that MBI’s theory activities and in particular the ability to combine experiment and theory within MBI is perceived as an important asset. MBI would like to point out that to “formally designate the position of head of theory as a directorship” implies that a theory director, like the existing directors, has to act as the managing director in a rotating fashion and assume personal legal responsibility for jointly leading the institute. Furthermore, the formal designation of a theory director requires

consent with the funding bodies to install and fund such a position on top of the existing three director positions. Given the size of MBI and the leadership structure of the other member institutes of the Forschungsverbund Berlin, we consider reaching such a consent difficult. In any case, in line with governance at MBI and the Forschungsverbund Berlin, such a director appointment would require a competitive search procedure beyond a simple formal designation.

Recommendation 5

MBI will continue its efforts to increase the ratio of female scientists according to the DFG cascade model and will of course make use of the opportunities connected in particular with the retirement of permanent staff.