Leibniz-Gemeinschaft

Der Senat

21. März 2013

Stellungnahme zum

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

Inhaltsverzeichnis

Anlage A: Darstellung

Anlage B: Bewertungsbericht

Anlage C: Stellungnahme der Einrichtung zum Bewertungsbericht

Vorbemerkung

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

Die wesentliche Grundlage für die Überprüfung in der Gemeinsamen Wissenschaftskonferenz ist regelmäßig eine unabhängige Evaluierung durch den Senat der Leibniz-Gemeinschaft. Die Stellungnahmen des Senats bereitet der Senatsausschuss Evaluierung vor. Für die Bewertung einer Einrichtung setzt der Ausschuss Bewertungsgruppen mit unabhängigen, fachlich einschlägigen Sachverständigen ein.

Vor diesem Hintergrund besuchte eine Bewertungsgruppe am 4. und 5. September 2012 das Max-Born-Institut für Nichtlineare Optik und Kurzzeitspektroskopie in Berlin. Ihr stand eine vom Institut 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 21. März 2013 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.

Im weltweiten Vergleich zählt das Max-Born-Institut für Nichtlineare Optik und Kurzzeitspektroskopie (MBI) zur Spitzengruppe der Institute seines Fachgebiets. Seinem **Auftrag** entsprechend betreibt es Grundlagenforschung auf dem Gebiet der Erzeugung ultrakurzer, hochintensiver Laserpulse sowie der ultraschnellen Wechselwirkung von Licht mit Materie und verfolgt daraus resultierende Anwendungsaspekte. Durch die Kombination von Lasertechnologien mit hochsensitiven Methoden der Spektroskopie und Strukturerforschung leistet das Institut bedeutende Beiträge zu Fragestellungen der Physik, Chemie und Materialwissenschaften.

Das Gesamtkonzept des MBI überzeugt in hohem Maße und hat seit der letzten Evaluierung zu bedeutenden **Arbeitsergebnissen** geführt. Diese umfassen neben zahlreichen Publikationen in den führenden internationalen Zeitschriften auch technologische Entwicklungen und den Aufbau innovativer Experimentieranlagen. Bei der Realisierung neuester Laser-Technologien und spektroskopischer Methoden kommt dem MBI herausragende Bedeutung zu. So hat es einen essentiellen Beitrag beim Aufbau des „Freien Elektronenlasers in Hamburg“ (FLASH) am Deutschen Elektronen-Synchrotron (DESY) geleistet und wird zukünftig auch bei der Entwicklung des europäischen *„X-Ray Free-Electron Laser“* (XFEL) eine wichtige Rolle spielen.

Die drei **Forschungsschwerpunkte** (*Topical Areas*) des Instituts werden als sehr gut bis exzellent bewertet. Seine hohen Drittmitteleinnahmen, darunter ein ERC Advanced Grant (2009),

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

bestätigen die hervorragende wissenschaftliche Qualität der Arbeiten am Institut ebenso wie die zahlreichen wissenschaftlichen Auszeichnungen und Preise, mit denen Beschäftigte des MBI geehrt wurden.

In beeindruckender Weise hat das Institut die Empfehlung der letzten Evaluierung umgesetzt, die **Theoretische Physik** zu stärken. Ihre deutliche Aufwertung hat zu bedeutenden strategischen Impulsen für die wissenschaftliche Arbeit geführt. Daher wird empfohlen zu prüfen, ob und ggf. wie die Theoretische Physik auch auf der Leitungsebene des MBI regelmäßig und systematisch repräsentiert werden kann.

Die aufwändige und kostenintensive **Ausstattung mit Experimentieranlagen** des MBI ist unverzichtbare Voraussetzung für seine hervorragende wissenschaftliche Leistungsfähigkeit. Um seine Wettbewerbsfähigkeit auch langfristig zu garantieren und dem Institut einzigartige Möglichkeiten zu eröffnen, weitere hoch relevante Erkenntnisse zu gewinnen, empfiehlt der Senat, die Umsetzung der überzeugend begründeten Pläne, mit zusätzlichen Mitteln neue Geräte anzuschaffen bzw. vorhandene Geräte zu erweitern.

Die **Kooperationen** des MBI mit den drei Berliner Universitäten sowie anderen Berliner Forschungseinrichtungen und Industriebetrieben führen zu einem bedeutenden Wissenstransfer und sind ausgesprochen ertragreich. Darüber hinaus nimmt das MBI deutschlandweit eine Schlüsselposition als Kooperationspartner in DFG- und BMBF-finanzierten Forschungsprojekten ein. Auch international ist es durch zahlreiche Kooperations- und Koordinationsaktivitäten weithin sichtbar und erfolgreich. In den zurückliegenden Jahren koordinierte es beispielsweise das EU-Projekt „Laserlab Europe".

Die Ausbildung und Betreuung des wissenschaftlichen **Nachwuchses** am MBI ist hervorragend und eröffnet nach einem Abschluss die besten Chancen, sowohl in der Wissenschaft als auch in Wirtschaftsunternehmen eine Beschäftigung zu finden.

Das MBI verfolgt eine Reihe sinnvoller Maßnahmen, um den Anteil von Frauen insbesondere unter den wissenschaftlich Beschäftigten zu steigern. Es ist erfreulich, dass trotz eines fachspezifisch vergleichsweise geringen **Anteils von Wissenschaftlerinnen** eine Nachwuchsgruppenleitung mit einer Frau besetzt werden konnte. Das MBI sollte sich weiterhin um die Erhöhung des Frauenanteils im wissenschaftlichen Bereich insbesondere auf der Leitungsebene bemühen.

Die drei Direktoren des MBI haben in den vergangenen Jahren beeindruckende wissenschaftliche Arbeit geleistet und eine hohe Leitungs- und Organisationskompetenz bewiesen. Die weitere Entwicklung des MBI wird auch davon abhängen, ob es gelingt, die **Leitungsposition des Bereichs B** (Licht-Materie-Wechselwirkung in intensiven Laserfeldern) erneut hervorragend zu besetzen. Das MBI steht dabei in einem weltweiten Wettbewerb um ausgezeichnete Wissenschaftlerinnen und Wissenschaftler. Aufgrund seiner Leistungen kann das Institut in diesem Wettbewerb bestens mithalten. Es ist allerdings notwendig, dass die Geldgeber die finanziellen Vorrausetzungen für eine exzellente Weiterentwicklung des Instituts schaffen.

Abschließend hält der Senat fest, dass die Arbeitsergebnisse des MBI von hervorragender Qualität und hoher Relevanz sind. Es bearbeitet eine große Bandbreite von Projekten der Grundlagen- und anwendungsorientierten Forschung, wobei anspruchsvolle Theorie und aufwändige Experimente überzeugend aufeinander abgestimmt sind. Die für die Experimente nötige Infrastruktur kann in dieser Form an einer Hochschule nicht bereitgestellt werden. Der vom MBI geleistete Wissenstransfer ist qualitativ und quantitativ beträchtlich. Das MBI erfüllt damit die Anforderungen, die an eine Einrichtung von überregionaler Bedeutung und gesamtstaatlichem wissenschaftspolitischem Interesse zu stellen sind.

2. Zur Stellungnahme des MBI

Der Senat begrüßt, dass das MBI beabsichtigt, die Empfehlungen und Hinweise aus dem Bewertungsbericht bei seiner weiteren Arbeit aufzugreifen und umzusetzen.

3. Förderempfehlung

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

20 August 2012

Annex A: Status Report

Max Born Institute for Nonlinear Optics and Short Pulse Spectroscopy (MBI), Berlin

Contents

1. Structure and tasks

Development and funding

The Max Born Institute for Nonlinear Optics and Short Pulse Spectroscopy (*Max Born Institut für Nichtlineare Optik und Kurzzeitspektroskopie*, MBI) was founded in 1992. 50% of MBI's institutional funding is provided by the Federation and 50% by the *Länder*. Its national importance was confirmed in external evaluations by the German Council of Science and Humanities (*Wissenschaftsrat*) in 1997 and by the Senate of the Leibniz Association in 2005.

Responsible department at *Länder* level:

- Berlin Senate Department for Economics, Technology and Research

Responsible department at federal level:

- Federal Ministry of Education and Research (BMBF)

Tasks of MBI

MBI conducts basic research in the field of nonlinear optics and ultrafast dynamics of the interaction of light with matter and pursues applications that emerge from this research. It develops and uses ultrafast and ultra-intense lasers and laser-driven short-pulse light sources in a broad spectral range. MBI's research on light-matter interaction addresses problems of physics, chemistry and materials sciences by combining laser technologies with highly sensitive methods of optics, spectroscopy and structure research.

Legal form of MBI as a member of the Forschungsverbund Berlin (Berlin Research Association)

MBI is legally part of the Berlin Research Association (*Forschungsverbund Berlin e. V.* [FVB]) which comprises a total of eight independent research institutes (see appendix 1a). It is their legal entity and also represents the common interests of the otherwise autonomous research institutes. FVB's Board of Members ("*Mitgliederversammlung*") consists of representatives of the *Land* Berlin and the Federation, the directors of the institutes and the administrative director of FVB.

MBI's supervisory body is the FVB Board of Trustees ("*Kuratorium*"). It consists of one representative each of the Federal and the *Länder* Governments as funding institutions, a representative jointly appointed by the Berlin universities, four academic members from outside of Berlin, and three members from the industrial sector. Institute- and subject-specific aspects are dealt with by institute-specific sub-committees. The Board of Trustees decides on matters such as programme budgets and the institutes' business plans, whether research institutes should accede to or leave FVB, the appointment of members of the Scientific Advisory Boards and the appointment of institute directors and leading scientists.

The FVB Board of Directors consists of the scientific directors of the member institutes and the administrative director of FVB.

Organisational structure of MBI

MBI is led by a three-member Board of Directors (see appendix 1b). For a period of three years, one of the directors serves as the Managing Director.

The MBI administration is the part of FVB's joint administration located at MBI. The IT department, the maintenance group, the library, and the mechanical workshop are organised as separate service units and report to the Board of Directors.

The Scientific Advisory Board (SAB) is composed of international scientists who work in the research areas of the institute. It advises the MBI Board of Directors and the Board of Trustees on fundamental aspects of the scientific work programme (see chapter 6 for the work of the SAB).

The organisational structure of MBI (appendix 1b) reflects the established areas of expertise amongst MBI staff. Each of the directors heads one scientific division, each consisting of three departments. In addition, MBI has an independent junior group, working in the area of strong field theory. Furthermore, three PhD-students and one postdoc are members of the group of a full professor (W3) of Theoretical Optics at Humboldt-University, and are located at MBI.

2. General concept and profile

Appendix 2 gives a graphical overview of the MBI research structure. The coexistence of the research structure with four topical areas and the organisational structure (appendix 1b) with three main competence areas is to be seen as a matrix. According to MBI, this ensures that, in their research activities (projects), MBI´s researchers collaborate with colleagues with the core expertise that is most relevant for them, while at the same time, critical mass and institute-wide awareness are created for supporting the strategic research directions considered to be most relevant for the institute. The research structure is the basis for MBI's institutional funding through "programme budgets". All research-related data communicated in this report and in the appendices refer to the following four topical areas (they will be described in more detail in chapter 3):

1. **Laser Research** with a focus on nonlinear optics in the ultrafast time domain or at extremely high intensities, and on laser physics relevant for the generation of ultrashort and/or ultra-intense light pulses, as well as high-average-power short-pulse lasers. Laser research at MBI aims at results which – beyond new scientific insight – hold potential for new approaches and methods in topical areas 2 and 3.
2. **Ultrafast and Nonlinear Phenomena: Atoms, Molecules, and Plasma** aiming at a basic understanding of electronic/nuclear dynamics and ionisation processes in isolated and few-body systems, particle acceleration and relativistic plasma dynamics.
3. **Ultrafast and Nonlinear Phenomena: Condensed Matter** addressing basic interactions and non-equilibrium dynamics in condensed-phase molecular systems, semiconductors and correlated materials, dynamics of electronic and crystalline structure of solids, field-driven processes including charge transport, and light-matter interaction in optoelectronics and materials processing.
4. **Laser Infrastructure and Knowledge Transfer** devoted to the implementation and operation of laser systems and their experimental periphery, as well as transfer of knowledge and technologies.

Development of the institution since the last evaluation

Within the reporting period and after the retirement of the former director in charge of division A in 2010, a re-structuring of that division (now 'Attosecond Physics', see appendix 1a) was initiated by his successor. The main research themes to be pursued in the future are attosecond time-resolved studies of electronic dynamics in atomic and molecular species.

In this context, and to follow up a recommendation made at the last evaluation to strengthen theory at MBI, the newly-appointed head of department A1 (Attosecond Theory) is expected to establish a scientific profile on the theory of attosecond light-matter interactions. The former head of department A1 has been appointed as a full professor at *Freie Universität Berlin* (FU).

Further efforts to strengthen theory have been undertaken by MBI. In January 2009, an independent, junior theory group was established based on funding acquired through the Leibniz Association's competitive SAW Procedure. With the additional acquisition of external funding, this group has meanwhile grown into a team of five postdocs and five PhD students.

As an additional element for strengthening theory, MBI collaborates with the theory group of a new full professor (W3) for "Theoretical Optics" at Humboldt-University. Part of the group is physically located at MBI and the institute acquired additional, dedicated institutional funding for three positions (currently used to pay 1 postdoctoral fellow and 3 PhD students) under the supervision of this professor.

The experimental activities in laser-plasma acceleration are supported on the theoretical side by a scientist from the Institute for Laser Physics in St. Petersburg, Russia, who has been a long-term visitor to MBI since March 2007. Furthermore, since 2004, MBI has hosted one of the early founders of high-field laser physics, now an emeritus professor, and maintains a substantial number of international collaborations with leading theoreticians.

Since the last evaluation, the following topics have been discontinued or scaled back:

- sub-picosecond Raman studies of vibrational relaxation processes in molecules
- non-equilibrium excitations and dynamics in clusters
- surface physics and magnetism
- relativistic plasma dynamics based on picosecond pulses with high pulse energy (from MBI's single shot Nd:Glass-laser, shut down in 2008)
- physics of table-top X-ray lasers

On the other hand, the following new topics have been initiated or extended substantially:

- ultrafast structural dynamics studied by femtosecond X-ray diffraction
- high-field carrier transport and low-energy excitations in solids studied by nonlinear terahertz spectroscopy, including novel multidimensional methods
- hydrogen bond dynamics in and hydration of biomolecules studied by multidimensional nonlinear vibrational spectroscopies
- attosecond time-resolved investigation of electron dynamics in atomic and molecular systems
- proton and ion acceleration with lasers, accompanied by the installation of a new 25 fs / 100 TW laser system, and a radiation shielded laboratory for future electron acceleration
- nonlinear optics in guiding or self-guiding structures (hollow waveguides, filaments, PCF)

Results

Research

In the period 2009-2011, a total of 467 scientific papers appeared in peer-reviewed international journals and books (see appendix 3), including 56 papers published in journals with an impact factor higher than 7. MBI publishes some 120 papers per year in peer-reviewed journals. Highlights of MBI's research in the reporting period are described in more detail in section 3 which is devoted to the four topical areas that constitute the institute's research programme.

Scientific services and infrastructure tasks

MBI offers services and facilities to a regional, national and international community. One example coordinated by MBI is the LASERLAB-EUROPE project, which developed from the European Union's "Transnational Access" programme (see also chapter 3). Under the LASERLAB-EUROPE contract, MBI provided 240 days of access to international users over a period of three years.

Scientific consulting

MBI scientists engage in science policy consulting, e. g., as members of academies (*Berlin-Brandenburgische Akademie der Wissenschaften*), steering committees for federal funding programmes (BMBF), or foreign national funding agencies (the United Kingdom's Science and Technology Facilities Council). Scientists at MBI are involved in the peer review process for journals and funding agencies and serve as members of editorial boards.

MBI regularly advises industrial partners and Small and Medium Enterprises (SMEs) in the context of project collaborations or contracts, and is a partner in the regional network OpTECBB (see chapter 3) which links about 100 members from industry and academia in the area of optics and photonics.

Knowledge and technology transfer

The institute pursues an exploitation and transfer strategy which aims at the systematic development of relationships with industrial partners and customers from other research institutions. Such activities are complemented by joint research projects with companies in which the funding is provided by a third party, e. g. the *Land* Berlin, the BMBF, or others.

MBI mainly files German patents in order to limit the application costs and annual fees. For the same reason, existing MBI patents are checked on an annual basis and – if not licensed to external partners – are usually discontinued after a period of 5 to 7 years. Income from patents is shared with the inventors in accordance with the German law for reimbursing employees for their inventions. As of 31 December 2011, MBI holds 30 patents in the fields of laser technology, optical methods and components, and microscopy (see appendix 3).

Specialised services are sold to companies working in optical technologies, including optoelectronics. Furthermore, MBI develops prototype equipment such as lasers for specialised applications, other laboratory-based photon sources, and devices for optical measurements. MBI's technology transfer is supported by the joint administration of the Berlin Research Association (FVB, see page A-2), including the administration of the patent portfolio, cost and price assessment, and legal support for contracts.

Academic events and public relations

Members of MBI act as organisers, members of programme committees and as lecturers at international conferences. In the period from 2009 to 2011, 274 invited lectures were held at conferences; some 150 invited talks were given at seminars and colloquia. Outstanding results of research at MBI are communicated to the general public via press releases and by actively interacting with journalists working for all media. Some of these activities are supported by the press officers of the Berlin Research Association (FVB, see page A-2). MBI scientists regularly participate in outreach events for senior school students and the general public, explaining about science in general and their research field in particular.

Strategic work planning for the next few years

MBI's long-term scientific goal is to utilise laser-based tools in order to reveal most directly how nature operates on ultra short time and atomic length scales, to understand why functional microscopic processes are ultrafast, and to tailor and control ultra short and ultra-intense light pulses for novel applications. More specifically, MBI has identified three long-term strategic topics:

A. **Fundamental problems of light-matter interactions**: generating new knowledge on light-matter interactions in nonlinear and ultrafast regimes which are essential for the physical and chemical properties of a wide range of systems

B. **Understanding matter by studies using light-matter interactions**: exploiting the potential of light-matter interactions for unravelling basic functional properties and non-equilibrium processes on atto- to femtosecond time scales and for mapping structural changes which are essential for functional properties

C. **Optical techniques for studies of light-matter interactions**: exploring and demonstrating new concepts and methods for generating light pulses and electric field transients in a spectral range from the far-infrared to hard X-rays, and in the atto- to picosecond time domain, including secondary sources that rely on laser-based particle acceleration

Topical areas 1 and 4 of the research structure (see appendix 2) are instrumental in all experimental work at MBI and directly implement the long-term goal C. Topical areas 2 and 3 incorporate the long-term goals A and B and define research work along complementary directions.

MBI's medium-term strategy for the next five years in topical areas 2 and 3 consists of consolidation and expansion of its role in attosecond science and time-resolved condensed matter physics. MBI's future ambitions in laser research and in relativistic laser-matter interactions will be strongly influenced by the successor to the director of Division B who will reach regular retirement age in spring 2014. At the time of preparing this report, the process of recruiting a successor has been initiated.

Appropriateness of facilities, equipment and staffing

The total revenue of MBI in 2011 was approx. 20 M€. Appendix 4 gives a detailed list of MBI's revenue and expenditures from 2009 to 2011.

<u>Institutional funding</u>

In 2011, MBI's institutional funding, 50% of which is provided by the Federation and 50% by the *Länder* was 14.3 M€.

MBI is satisfied with its facilities, which were completely rebuilt between 1995 and 1998. They offer an adequate amount of space, both for offices and for laboratories, and quality infrastructure. Ten to fifteen years after reconstruction, however, an increasing need for building maintenance and renovation can be observed.

According to MBI, the current annual depreciation of the research infrastructure, based on standard depreciation rates, is 4.242 M€ and thus exceeds MBI's usual annual institutional investment budget of 1.5 to 2 M€ for scientific equipment. This financial mismatch does not allow for the appropriate renewal of old equipment or to initiate new developments at the rate that the institute considers necessary. Therefore MBI tries to acquire capital equipment through third party funding, and MBI's strategy for recruiting senior research personnel is influenced by the perceived potential of prospective researchers to attract grants.

The research infrastructure operated at MBI relies on its technical infrastructure. MBI views it as one of the main challenges in the coming years to maintain or even improve on today's standards, notwithstanding the ageing of the buildings and the increasing cost of operating the infrastructure. This is a result of steady increases in the costs of the main utilities, which cannot be covered by the yearly budget increases of 5 % in institutional funding deriving from the Joint Initiative for Research and Innovation *("Pakt für Forschung und Innovation")*.

Revenue from project funding grants

The revenue from project funding grants (in the following always listed in terms of the expenditures from project funding grants) was 3.2 M€ (17 % of the total budget) in 2009, 2.5 M€ (15 %) in 2010, and 4.3 M€ (23 %) in 2011. For the whole period from 2009 to 2011 this adds up to 10 M€. In the same period the share of expenditures from project funding grants from the German Science Foundation (DFG) amounted to 3 M€, while expenditures from grants from the Federal and *Länder* governments amounted to 2.2 M€, and expenditures from grants from the EU, including one ERC Advanced Grant started in 2010, amounted to 2.9 M€.

Revenue from services

Transfer of technology to partners in research and industry is another source of third-party funding. MBI provides optoelectronic services on a commercial basis and sells prototype equipment like near-field scanning microscopes and optical modulators. The direct revenue from these activities from 2009 to 2011 was 225 k€. This amount was complemented by funding for joint development projects provided by external partners which was 1.125 M€ for the same period (included in line 2.7 of appendix 4).

As of 31 December 2011, MBI holds 30 patents in the fields of laser technology, optical methods and components, and microscopy (see appendix 3). In the period from 2009 to 2011, the total patent costs were 78 k€ and the total revenue from licences and patent sales was 75 k€ (see line 3.3 of appendix 4).

3. MBI's topical areas

Each of MBI's four topical areas is divided into different projects (see appendix 2). While the four areas have existed for more than a decade, the specific projects undergo continuous and sometimes rapid change in order to keep MBI research at the forefront. In fact, the project structure of appendix 2 was just introduced in January 2012. Hence, work programme development and results will be presented on the basis of the four topical areas. Future work planning will then be presented on the basis of the new projects.

Topical area 1 (Laser Research, 27 full-time equivalents [FTE])

Work programme

Laser research at MBI concentrates on

- basic research in nonlinear optics in the ultrafast time domain or at extremely high intensities

- laser physics relevant for the generation of ultrashort and -intense laser pulses with cutting edge parameters .

The activities in these two directions are interconnected and instrumental in providing novel light sources and methods for MBI research in topical areas 2 and 3, and vice versa: new insights into light-matter interactions originating from the research on ultrafast and nonlinear phenomena (areas 2 and 3) are relevant for opening up new directions in nonlinear optics.

Whilst commercial laser systems are an integral part of MBI's equipment, new or optimised generation methods in combination with applications in broad areas require a continuous, sustained research effort. This includes research and development towards extraordinary pulse parameters, the extension of the spectral range towards X-ray and far-infrared wavelengths through various nonlinear processes, the investigation of novel laser architectures and materials, and increasing the average power of short-pulse laser systems for enhanced applicability.

Results

The results of this topical area appeared in 140 publications in peer-reviewed journals in the period from 2009 to 2011. In the same period, expenditures from project grants from the German Science Foundation (DFG) totalled 650 K€ while at EU level 370 K€ were raised. In addition, 750 K€ were raised from the Federal or *Länder* governments.

The scientific highlights since the last evaluation include:

- demonstrating pulse self-compression in self-generated plasma channels and development of a method for carrier-envelope phase (CEP) stabilisation which has already been sold as a patent (published in "Nature Photonics")
- new methods for extending the spectral range, e. g. achieving exceptionally high conversion efficiency of Ti:sapphire laser radiation into a supercontinuum, generating sub-20 fs vacuum ultraviolet pulses (160 nm) with more than 100 nJ of energy (published in "Optics Letters")
- generating short pulses with femtosecond mode-locked semiconductor disc lasers (SDL) in the 1 µm spectral range with pulse repetition rates close to 100 GHz and applying single-walled carbon nanotubes in bulk solid-state lasers (published in "Applied Physics Letters")
- generating pulse durations well below 100 fs, or high pulse energies with picosecond pulse duration in the 1 µm wavelength range in Yb-doped laser crystals (published in "Optics Express")
- development of new concepts of Double-CPA (**c**hirped **p**ulse **a**mplification) lasers and Negative-Positive CPA in Ti:sapphire (published in "Laser Particle Beams")
- development of Yb:YAG thin-disk pre-amplifier based on CPA (published in "Optics Letters")

Work planning

To address the medium-term objectives, the work of topical area 1 has been organised in two scientific projects which will work on the following topics:

<u>Project 1.1 (Ultrafast Nonlinear Optics, 12 FTE)</u>

- nonlinear optics down to the few-cycle limit
- extreme wavelengths and attosecond pulse generation

<u>Project 1.2 (Ultrafast Laser Physics, 15 FTE)</u>

- novel ultra-broadband Optical Parametric CPA (OPCPA) systems

- new schemes and materials designed for broadband parametric amplification
- methods for improving the pulse parameters for MBI´s high-field Ti:sapphire laser
- development of Yb:YAG thin-disk amplifiers of high average power
- generating sub-50 fs pulses at wavelengths around 2 μm and phase stabilisation of fibre lasers

Topical area 2 (Ultrafast and nonlinear phenomena: atoms, molecules and plasma, 40 FTE)

Work programme

The research in this topical area focuses on ultrafast and nonlinear processes that are induced by short laser pulses in atoms, molecules, plasma and – until recently – clusters. The external field interaction ranges from dominant down to perturbative, with internal correlations or collective effects accounting for much of the complexity of the phenomena studied. The following three research directions are being pursued:

- relativistic plasma dynamics focusing on the investigation of laser driven ion and proton acceleration
- the response of isolated particles (free atoms and molecules) to strong fields, concentrating on excitation and ionisation processes at laser intensities between 10^{13} and 10^{19} W/cm^2
- attosecond science, mainly targeting the time-resolved elucidation of electron dynamics in atomic and molecular systems

Results

The results of this topical area appeared in 124 publications in peer-reviewed journals in the period from 2009 to 2011. In the same period, revenues from project grants from the German Science Foundation (DFG) totalled 900 K€ while 340 K€ were spent from EU grants and contracts. The scientific highlights since the last evaluation include:

- investigation of ion acceleration from isolated spherical targets by proton imaging (published in "Physical Review Letters")
- ion acceleration dominated by laser radiation pressure, being capable of generating ion bunches with MeV energy and solid density (published in "Physical Review Letters")
- observation of the highest ever observed acceleration of neutral atoms in an external field (published in "Nature")
- observation of mid-infrared strong field ionisation leading to the detection of photoelectron holograms (published in "Science")
- the first example of molecular attosecond pump-probe spectroscopy (published in "Nature")
- observation and explanation of IR-driven control of molecular photoionisation (published in "Physical Review Letters")
- observation of the breakdown of the single-active electron approximation in strong field ionisation (published in "Science" in 2012)
- development of a new, all-optical, multi-pulse experiment that allows the correlated measurement of rotational and mass or photoelectron spectra (published in "Science")

Work planning

To address the medium-term objectives the work of topical area 2 has been organised in three scientific projects which will work on the following topics:

Project 2.1 (Laser-plasma dynamics and particle acceleration, 8 FTE)

- ion acceleration and dynamics of electrons at high density
- electron acceleration

Project 2.2 (Strong field few-body physics, 14 FTE)

- time-resolved single- and multi-electron strong field phenomena
- dynamics of strong field ionisation of ordered structures
- probing molecular dynamics by strong field ionization
- high harmonic generation spectroscopy
- strong field ionisation with mid-infrared and few-cycle laser pulses

Project 2.3 (Time-resolved XUV Science, 18 FTE)

- attosecond electronic and nuclear dynamics and control using IR/XUV pump-probe spectroscopy
- attosecond XUV pump-XUV probe applications
- time-resolved XUV/X-ray photoelectron imaging and spectroscopy of ultrafast molecular processes
- theory of attosecond multi-electron dynamics during XUV photoionisation and its coupling to nuclear motion at the femtosecond timescale

Topical area 3 (Ultrafast and nonlinear phenomena: condensed phase, 37 FTE)

Work programme

The main goal of this topical area is to develop a scientific understanding of the microscopic processes that determine the physical and chemical properties of the analysed systems and, thus, define their functional properties. Two research directions are pursued:

- the dynamics of optically induced elementary excitations of electronic and/or vibrational character, their couplings, decoherence, and eventual relaxation
- direct mapping of photo-induced changes of electronic and crystalline structure by ultrashort structure probes such as hard X-ray pulses.

Results

The results of this topical area appeared in 106 publications in peer-reviewed journals in the period from 2009 to 2011. In the same period, expenditures from project grants from the German Science Foundation (DFG) totalled 1.2 M€ while 970 K€ were spent from EU grants and contracts, including one ERC Advanced Grant which started in 2010. In addition, 940 K€ were spent from the Federal and *Länder* governments. The scientific highlights since the last evaluation include:

- New insights into hydration processes of biomolecular model systems and biomolecules, including measurements on water pools nanoconfined in reverse micelle structures with phosphate head groups (published in “Angewandte Chemie Int. Ed.”)
- first observation of the formation of carbonic acid in solution (published in “Science”)
- first measurement of transient electron density maps in solids by femtosecond x-ray diffraction, based on the implementation of new techniques such as femtosecond powder diffraction and the femtosecond rotation method (published in Proc. Nat. Acad. Sci. USA in 2012)

- observation of partial Bloch oscillations in a bulk semiconductor (GaAs), and of the onset of friction in electron transport due to the presence of an electron-hole plasma (published in “Physical Review Letters”)
- observation of high-field interband tunnelling of carriers, and of quantum coherent polaron dynamics (first results published in “Nature” in 2007)
- development and application of a novel method of collinear 2D THz spectroscopy to analyze polaronic couplings between electrons and optical phonons in a semiconductor quantum well system (published in “Physical Review Letters”)
- carrier dynamics in graphite and single layers of graphene in all-optical experiments with a 10 fs time resolution (published in “Physical Review Letters”)
- exchange scattering as important spin-flip mechanism and time-dependent magnetic moment of 4f electrons in the ferromagnets Gd and Tb (published in "Physical Review Letters")

Work planning

To address the medium-term objectives the work of topical area 3 has been organized into three scientific projects, which will work on the following topics:

<u>Project 3.1 (Dynamics of Condensed Phase Molecular Systems, 14 FTE)</u>

- hydrogen bond dynamics in hydrated biomimetic and biomolecular systems
- transient structure determination of hydrogen bonded acid-base pairs
- charge transport in biomimetic and biological systems
- electronic excited state dynamics in molecular model systems

<u>Project 3.2 (Solids and Nanostructures, 16 FTE)</u>

- nonlinear and time-resolved nano-optics
- high-field charge transport in semiconductors and semimetals and ultrafast processes in correlated materials studied by nonlinear THz methods
- non-equilibrium electronic band structures in femtosecond laser-driven phase transitions of correlated materials studied by XUV time- and angle resolved photoelectron spectroscopy
- time-resolved photoelectron spectroscopy with high harmonics
- material modification with femtosecond laser pulses
- optoelectronic devices

<u>Project 3.3 (Transient Structures and Imaging with X-rays, 7 FTE)</u>

- imaging and spectroscopy in the soft X-ray range
- ultrafast structural dynamics in solids

<u>Topical area 4 (Laser infrastructure and knowledge transfer, 11 FTE)</u>

Work programme

This topical area is divided into the two projects “Implementation of lasers and measuring techniques” (4 FTE) and “Application laboratories and technology transfer” (7 FTE). Whilst being of central relevance for experimental research at MBI, there is no independent research strategy for this subdivision, and thus no publications. Rather, research topics of subdivisions 1 to 3 are addressed with the help of the infrastructure implemented and operated here.

Results

In the reporting period, work in this area focused on implementing new light sources. Three examples are the installation of the new 100 TW high field laser, the setup of an OPCPA system working at near-MHz repetition rates and the setup of an OPCPA system providing pulses at the TW level with a 100 Hz repetition rate.

In the period from 2009 to 2011 expenditures from project grants from the German Science Foundation (DFG) totalled 278 K€, while 1.2 M€ were spent from EU grants and contracts. In addition, 1.15 M€ were spent from revenues from other sponsors.

4. Collaboration and networking

Collaboration with universities

Each of the three Berlin universities – Humboldt-Universität (HU Berlin), Freie Universität Berlin (FU Berlin) and Technische Universität Berlin (TU Berlin) – is linked to MBI by a joint appointment in the form of an S-professorship for one of the three directors. This facilitates collaborative research and the training of students. The academic staff at MBI is involved in teaching at the Berlin universities.

Furthermore, as of January 2012, the new head of department A1 (Attosecond Theory) and jointly appointed S-professor at HU Berlin started working at MBI. Another bond with HU Berlin is the joint MBI-Humboldt theory research group (see above). In addition, MBI plans to strengthen ties with TU Berlin by promoting the head of the Junior Theory Research Group to an S-professorship.

MBI's cooperation with university research groups in the Berlin area also employs the following instruments:

- the "Berlin Laboratory for innovative X-ray technologies (BLiX)", a Leibniz Application Laboratory jointly operated by TU Berlin and MBI (and located at TU Berlin), as a laboratory where Small and Medium Enterprises (SMEs) can gain access to newly developed X-ray technologies for applications and product developments
- the Leibniz Graduate School "Dynamics in new Light (DinL)" (2011 – 2014) where eight PhD students work under the joint supervision of an MBI scientist and faculty from FU Berlin, TU Berlin or HU Berlin
- participation in the Leibniz Graduate School of Molecular Biophysics, coordinated by the Leibniz Institute for Molecular Pharmacology (ended in 2011)
- membership in the Humboldt Centre for Modern Optics (HU Berlin)
- membership in the Integrative Research Institute for the Sciences (IRIS) at HU Berlin

MBI collaborates with universities and other research institutes in the following Collaborative Research Centres (*Sonderforschungsbereiche,* SFB) of the German Science Foundation (DFG):

- SFB 450: "Analysis and control of ultrafast photo-induced reactions" (ended in 2010)
- SFB 658: "Elementary processes in molecular switches" (since 2005)
- SFB 951: "Hybrid inorganic/organic systems for optoelectronics" (since 2011)
- Transregio-SFB 18 "Relativistic laser-plasma dynamics" (since 2004)

In addition, MBI collaborates or has collaborated with universities in the following DFG Priority Programmes (*Schwerpunktprogramme,* SPP):

- SPP 1134: “Transient structures in condensed matter investigated by ultrafast x-ray techniques” (coordinated by MBI, ended in 2008)
- SPP 1133: Ultrafast magnetisation processes (ended in 2008)
- SPP 1327: “Optically generated sub-100-nm structures for biomedical and technical applications” (since 2008)

Other research collaborations with individual university groups exist, amongst others, with the universities of Irvine (UC Irvine), Madrid (Univ. Autónoma de Madrid), Baton Rouge (LSU), Liège, Jerusalem, Bordeaux and Düsseldorf.

Collaboration with other German and international research institutions

MBI collaborates in national and international projects in association with other research institutions and industry funded by the BMBF and the EU. Since the last evaluation, MBI has served as coordinator of the following EU projects:

- LASERLAB-EUROPE – The European Integrated Activity of Laser Research Infrastructures (EU Framework Programme 6 and 7)
- EUROFEL - EU Design Study for European soft X-ray Free Electron Lasers
- BRIGHTER: High-Brightness Laser Diode Systems for Health, Telecom and Environment Use
- DT-CRYS: Double Tungstate Crystals: Synthesis, characterisation and applications
- ELI - European ESFRI Roadmap project “Extreme Light Infrastructure” (Preparatory phase: WP Coordinator on Diode Pumped Lasers, Secondary Sources)
- Marie Curie Chair for Prof. Dr. H. Abramczyk, TU Lodz
- MIRSURG - Mid-Infrared Solid-State Laser Systems for Minimally Invasive Surgery
- ATTOFEL - Ultrafast Dynamics Using Attosecond and XUV Free Electron Laser Pulses (EU Initial Training Network)

In addition, MBI runs various individual projects funded by the DFG, the BMBF, the EU, the *Land* of Berlin and other partners such as DESY Hamburg, *Helmholtz Zentrum Dresden-Rossendorf* and *Helmholtz-Zentrum Berlin*.

Other collaborations and networks

MBI cooperates with industry on a bilateral basis and by participating in larger research networks funded by BMBF or EU. Examples include OpTecBB, a regional network on optical technologies, Laser Optics Berlin, a biennial laser exhibition and congress, and Photonics21, an EU technology platform. There are a number of cooperation agreements with small companies in the Berlin-Brandenburg area and beyond, e. g. IfG GmbH in Berlin-Adlershof (Development of a laser-driven femtosecond hard X-ray source and of a HOPG spectrometer for the hard X-ray range).

5. Staff development and promotion of junior researchers

Personnel structure and staff development

At the end of 2011, MBI employed 168 staff, corresponding to 153 full-time equivalents (FTE). Of the 94 staff involved in research and scientific service, 34 were doctoral candidates (25 FTE) and seven were student research assistants. Seventy-two percent of research and scientific staff had fixed-term employment contracts (see appendices 5 and 6).

The proportion of women on MBI's academic staff is low, but comparable to the overall share of female physicists in Germany. 7 % of the scientific staff (excluding PhD students) and 20 % of the PhD students are female which means that female scientists constitute 12 % overall (see appendix 6).

In the period from 2009 to 2011, a total of 70 employees (30 scientists, 23 graduate students, 12 technicians, five others) left MBI and a total of 76 employees (29 scientists, 26 graduate students, 12 technicians, nine others) were newly hired. These numbers do not include visiting scientists and undergraduate students.

In March 2010, the successor of the director in charge of Division A (Attosecond Physics) was appointed. This was followed by the appointment of the new head of Department A1 (Attosecond Theory). Furthermore, a procedure has been introduced to promote the head of the Junior Theory Research Group to an S-professorship.

Since the last evaluation, seven members of MBI have accepted calls from universities in Germany and abroad. Three MBI scientists received a *Habilitation* degree from FU Berlin. The director of Division B will reach the regular retirement age in spring 2014. The process of recruiting a successor has been initiated.

Promotion of gender equality

MBI promotes gender equality on the basis of guidelines in the "*Ausführungsvereinbarung Gleichstellung*" (Implementation Agreement on equal opportunities for the Leibniz-Association) and the DFG's "Research Oriented Standards on Gender Equality". In 2006, a gender equality commissioner was elected by the female staff members.

The legal principles are laid down in the "*Bundesgleichstellungsgesetz*", "*Ausführungsvereinbarung Gleichstellung* (AV Glei)", "*Rahmenempfehlung der Leibniz-Gemeinschaft zur Gleichstellung*" and "Vereinbaru*ng zur Förderung der Chancengleichheit zur Umsetzung der AV Glei zwischen dem FVB und dem Land Berlin*".

MBI supports flexible solutions that facilitate the life-work balance. Its commitment encompasses individual agreements on working hours and short-term solutions to bridge gaps in childcare. MBI has created an in-house parent-child office where staff members can combine work and childcare.

MBI is a founding member of a dual career network that is located at FU Berlin. It was founded in April 2011 as a joint project by the Berlin universities, research institutes, private universities, economic institutions and the federal and regional administration. The network offers professional and private assistance for the partners of newly-appointed professors and young managers in the fields of academic research during relocation to the Berlin area. Potential participation in the family services offered by the private service provider "Benefit@Work" is currently being tested.

Promotion of junior researchers

MBI typically employs 30 to 40 PhD students who are distributed amongst the various research teams at the institute. Undergraduate students are accepted both from universities and from universities of applied sciences (*Fachhochschulen*). Work on a PhD thesis usually takes three to four years.

In addition to scientific mentoring, MBI organises language training in English and German at different levels and other courses to improve young scientists' soft skills. In particular, MBI sends PhD students to external seminars organised by the Berlin universities or commercial providers.

MBI encourages and supports excellent young postdocs interested in an academic career. The institute promotes candidates seeking to obtain both a *Habilitation* degree and a junior professorship. Young researchers run their own research projects, typically combining the support provided by MBI with their own third party funding, and – in some cases – establish their own research teams.

In the opinion of MBI, the present salary system for the public sector, TVöD, makes it difficult to hire highly qualified postdoctoral researchers from abroad because it offers a salary level which cannot compete with other countries in Western Europe.

Vocational training for non-academic staff

MBI offers training positions (currently seven) for a physics laboratory assistant, precision mechanic and clerk (together with the administration of the Berlin Research Association). The respective 3-year training is organised together with other institutions in Berlin and follows the curriculum defined by IHK Berlin. Particularly talented trainees are subsequently kept on temporary positions.

For the training of non-academic staff an annual 2-day workshop is held at an outside location for the institute's technicians. Special professional training in new hard- and software tools is provided for the members of the IT departments, in most cases by external companies. In addition, MBI offers language courses in English at different levels.

6. Quality assurance

Internal quality management

All MBI staff members are obliged to act according to the MBI's rules on good scientific practice in accordance with the "Recommendations of the German Science Foundation (DFG) for Safeguarding Good Scientific Practice". Both MBI and the Berlin Research Association (FVB, see page A-2) have an ombudsperson who can be contacted by any staff member to deal with cases of (potential) scientific misconduct. The FVB has established a framework of rules that apply to all eight member institutes in such cases.

Future research is planned jointly by the directors, project leaders and other scientists. Since 1999, MBI has used a full-cost accounting system which also contains scientific output parameters. This system provides some input into project planning. Additional input criteria are derived from the assessment of all projects by the Scientific Advisory Board (see below).

For allocating investment budgets, MBI organises an internal workshop for all MBI scientists at which each project presents both its most recent scientific achievements, future planning, and a budget request. This event is usually held at the beginning of the fiscal year, and decisions are made by the board of directors.

In addition to the full cost accounting, a controlling system for project expenses has been implemented. As part of this system, budgets and expenses for projects and sub-projects, including third-party funding, are included on the MBI intranet and updated on a daily basis.

Quality management by the Scientific Advisory Board

MBI's Scientific Advisory Board (SAB) consists of an international group of scientists working in the same research areas as the institute. One SAB meeting is held at the institute each year during which MBI presents its latest research results. The SAB prepares a report assessing the research strategy and performance as well as other relevant issues. The SAB also conducts the regular audit during the period between evaluations according to the guidelines issued by the Leibniz Association. Furthermore, it advises the Board of Trustees on appointment procedures for the directors and leading scientists.

Implementation of recommendations from the last external evaluation

MBI responded to the recommendations summarised on page B-13 of the 2005 evaluation report (highlighted here in italics) as follows:

1) *Recommendation to retain the new organisational structure of the institute*: The new structure of MBI has been retained.

2) *Recommendation to develop a long-term vision of the Institute*: See chapter 2 for MBI's long-term and mid-term strategy.

3) *Recommendation to strengthen theoretical research and integrating it into the scientific structure of the MBI permanently*: Theoretical research has been strengthened, amongst others, by the creation of a new theory department A1, headed by a joint full professor (W3) appointed together with the Department of Physics at Humboldt-University, by the establishment of a new, independent junior theory group and by collaboration with the theory group "Theoretical Optics" at Humboldt-University, which is partly located at MBI. See page A-4 for all MBI's theoretical research activities.

4) *Recommendation to request for additional replacement funding, backed by a sharpened long-term vision for future MBI research activities*: MBI received a one-time addition of 3 M€ to its investment budget. This budget has been used to upgrade the experimental infrastructure of the institute. MBI points out that renewal of key equipment remains a major issue for the future development of MBI (see A-6 and A-7).

5) *Recommendation to implement a guest programme for senior scientists*: A visiting scientist programme has been implemented.

6) *Recommendation to consider funding possibilities such as the Joint Initiative for Research and Innovation (*Pakt für Forschung und Innovation*)*: Both the *Pakt für Forschung und Innovation* and the *Konjunkturprogramm I and II* have been used to fund new equipment and technical infrastructure at MBI.

7) *Recommendation to reallocate the annual budget properly to compensate the structural deficit in institutional funding for materials and small-scale equipment*: According to MBI, the recommended reallocation has not solved the problem. MBI points out that the situation is becoming more serious because of the ongoing growth in running costs for supplies and substantial salary increases which are not compensated by the funding bodies.

8) *Recommendation to revise the present legal framework for cooperation at the MBI, in particular on patenting issues, with the aim of enabling successful future cooperation and scientific development*: MBI maintains and continuously renews its application labs. MBI does not consider the present legal framework a major issue in enabling successful scientific development.

9) *Recommendation to take the research group that focuses on ionisation dynamics in intense laser fields as a model for the Institute on how theory and experiment can complement each other*: This model has been implemented in other parts of the institute, e. g., in Division A by establishing links between Departments A1 (Theory) and A2 (Experiment), and by linking the theoretical junior research group to experimental work ongoing at MBI.

10) *Recommendation for the research work on free clusters and molecules to conduct more experiments in the gas phase to avoid the potential technical limitations of using X-ray femtosecond experiments to observe internal motions*: Since the retirement of the former director of Division A in 2009 most of this type of research has been discontinued.

11) *Recommendation for the group working on optoelectronic devices to seek new future ideas for its mid-term perspective and to cooperate with the Ferdinand-Braun-Institut für Höchstfrequenztechnik (FBH):* Since the last evaluation, this group has generated results on catastrophic optical damage (COD) of high-power diode lasers which have received international attention. This group collaborates both with other research institutions (including FBH) and with companies in the field of optoelectronics.

12) *Recommendation to include a member from industry in the SAB*: A member from industry has recently joined the SAB.

13) *Recommendation to reorganize the IT-service in order to allow for the improvement of IT-service quality and response times*: MBI has introduced a consulting process in which two external IT experts assess the institute's IT organisation and infrastructure. Based on their report, MBI has reorganised IT staff and added three new positions to the IT department. Over the last four years, IT infrastructure has undergone thorough renewal.

14) *Recommendation to develop a strategy to promote female scientists and attract more female students to the MBI over the next few years*: The strategy for increasing the percentage of women is described on page A-14.

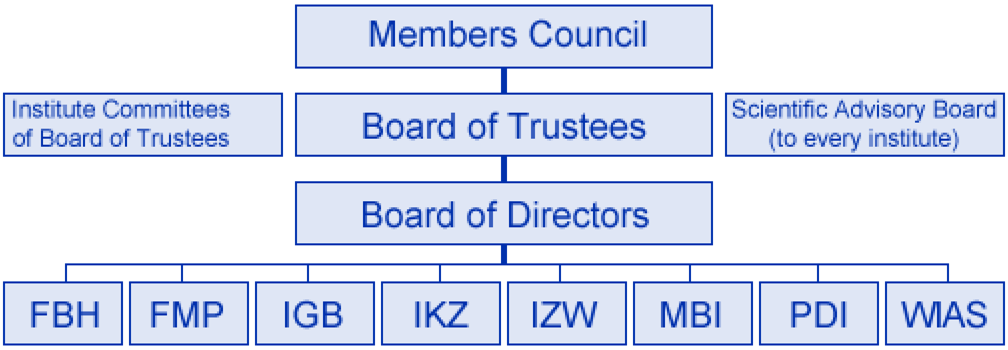
15) *Recommendation to continue the efforts to broaden the recruitment base for students participating in summer student programmes*: To broaden the mid-term recruitment base for students, MBI staff hold lectures at senior schools and institutions promoting science to a wider public. Other instruments include detailed press releases featuring videos and figures on the institute's outstanding research results.

16) *Recommendation to deepen the ties between the Institute and universities by appointments for joint junior professors*: No new, joint junior professors have been appointed. However, MBI maintains ties with former staff members who have been appointed as junior professors at other universities, e. g., with the University of Potsdam and the University of Göttingen.

17) *Recommendation to thoroughly analyse the patenting strategy and in particular compare the time and man-power invested in patent applications with the revenue of patents sold*: MBI has followed this recommendation by first analysing its cost structure for patenting and then revising the patent strategy.

Appendix 1

a) Organisational Structure of the Forschungsverbund Berlin e. V. (FVB)



FBH: Ferdinand-Braun-Institut, Leibniz-Institut für Höchstfrequenztechnik
FMP: Leibniz-Institut für Molekulare Pharmakologie
IGB: Leibniz-Institut für Gewässerökologie und Binnenfischerei
IKZ: Leibniz-Institut für Kristallzüchtung
IZW: Leibniz-Institut für Zoo- und Wildtierforschung
MBI: Max-Born-Institut für Nichtlineare Optik und Kurzzeitspektroskopie
PDI: Paul-Drude-Institut für Festkörperelektronik
WIAS: Weierstraß-Institut für Angewandte Analysis und Stochastik

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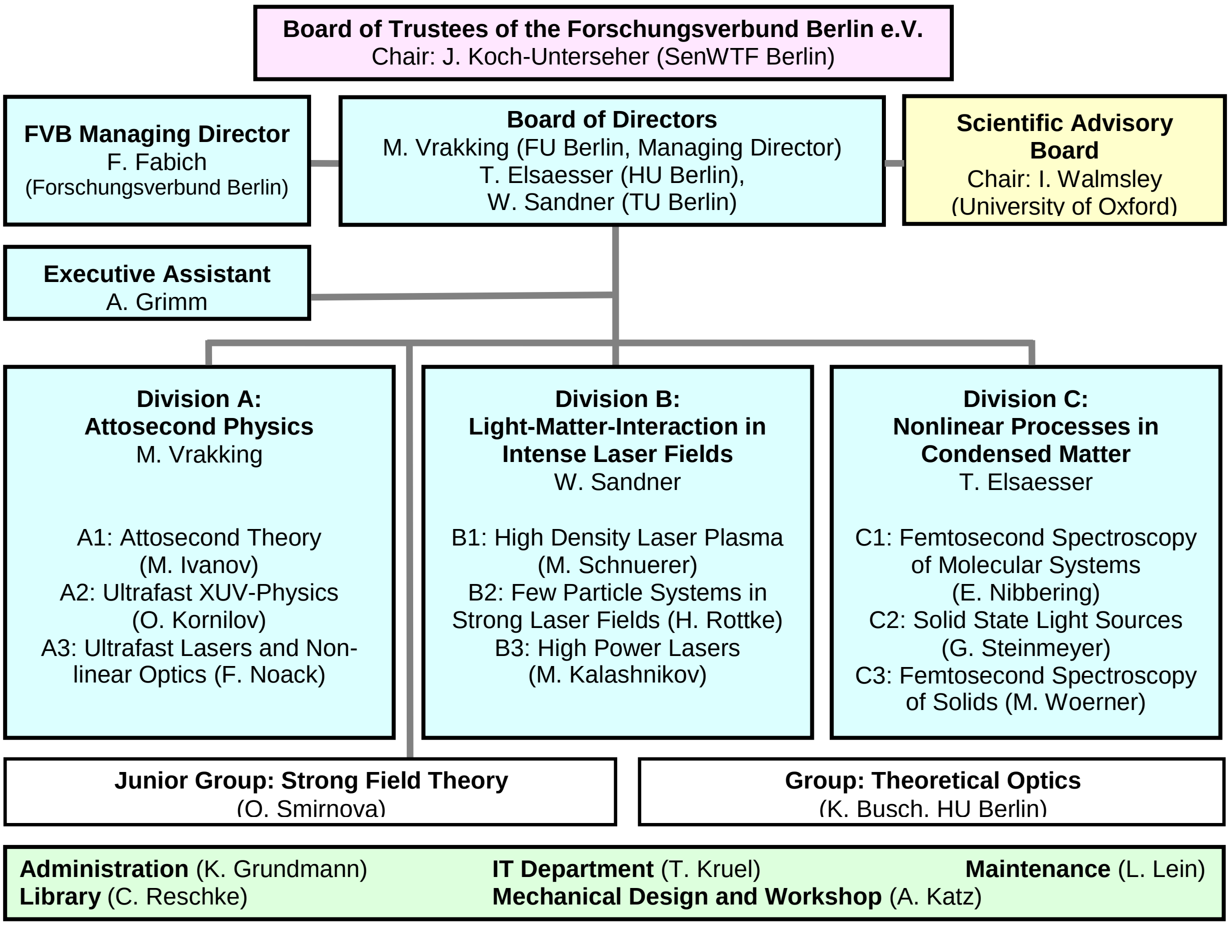
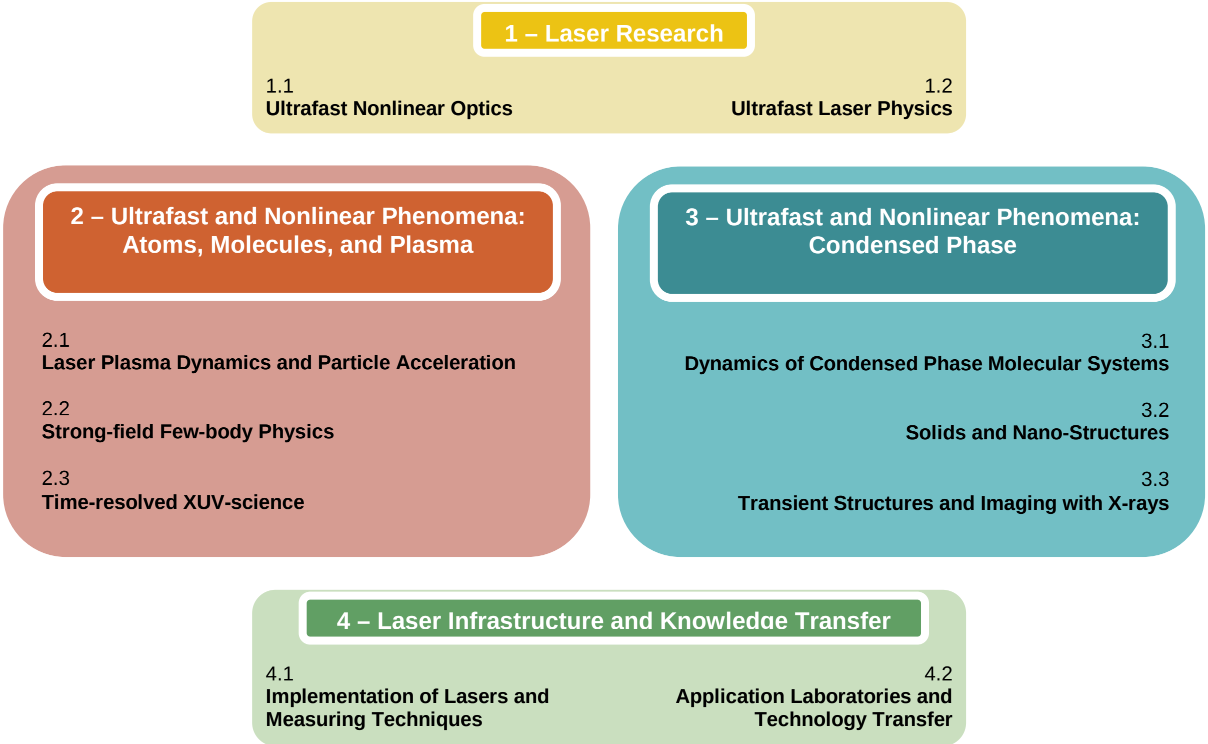
b) Organisational Structure of MBI



Appendix 2

Research Structure of MBI



Appendix 3

Publications and Patents

Publication Types	2009	2010	2011
	158	155	154
Monographs	-	1	1
Individual contributions to edited volumes	15	6	12
Articles in peer-reviewed journals (contributions that have been accepted for publication but not yet appeared may be added in parentheses for the respective year)	124	128	118
Articles in other journals	19	19	22
Working and discussion papers			1
Editorship of edited volumes		1	
Number of publications per full-time equivalent (FTE) in 'research and scientific services' (not including doctoral candidates)	2.86	2.67	2.73

Commercial Protection Rights (2009–2011)	Granted	Registered
Patents	4	30
Other industrial property rights		
Exploitation rights/licences (number)		

Appendix 4

Revenue and Expenditure

Revenue		2009			2010			2011 [1]		
		K€	% [2]	% [3]	K€	% [2]	% [3]	K€	% [2]	% [3]
Total Revenue (sum of I., II. and III.; excluding DFG fees)		**20.106,4**			**17.935,9**			**20.079,2**		
I.	**Revenue (sum of I.1., I.2. and I.3)**	**18.934,7**	**100,0**		**17.237,0**	**100,0**		**18.636,4**	**100,0**	
1.	Institutional funding (excluding construction projects and acquisition of property)	**15.726,3**	**83,1**		**14.709,5**	**85,3**		**14.348,9**	**77,0**	
1.1	Institutional funding (excluding construction projects and acquisition of property) by Federal and *Länder* governments according to AV-WGL	15.200,4			14.183,6			13.823,0		
1.1.1	*Proportion of these funds received through the Leibniz competitive procedure (SAW procedure)*	203,6			392,6			419,6		
1.2	Institutional funding (excluding construction projects and acquisition of property) not received in accordance with AV-WGL	525,9			525,9			525,9		
2.	Revenue from project grants [4]	**3.208,4**	**16,9**	**100,0**	**2.527,5**	**14,7**	**100,0**	**4.287,5**	**23,0**	**100,0**
2.1	DFG	1.004,2		31,3	967,4		38,3	1.112,7		26,0
2.2	Leibniz Association (competitive procedure) [5]	0		0	0		0	58,5		1,4
2.3	Federal, *Länder* governments	625,5		19,5	326,7		12,9	1.253,0		29,2
2.4	EU	850,4		26,5	739,9		29,3	1.327,2		31,0
2.5	Industry (if applicable, break down by source)	31,5		1,0	30,1		1,2	23,6		0,6
2.6	Foundations (if applicable, break down by source)	53,7		1,7	41,4		1,6	83,3		1,9
2.7	Other sponsors (if applicable, break down by source)	643,1		20,0	422,0		16,7	429,2		10,0
3.	Revenue from services [6]									
3.1	*Revenue from commissioned work* [6]	*49,2*			*73,4*			*44,7*		
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.)* [6]	*29,3*			*40,5*			*5,0*		
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)	**1.171,7**			**698,9**			**1.442,8**		
III.	**Revenue for construction projects** (institutional funding by Federal and *Länder* governments, EU structural funds, etc.)									

Expenditures		K€	K€	K€
Expenditures (excluding DFG fee)		**20.106,40**	**17.935,95**	**20.079,07**
1.	Personnel	9.569,10	9.341,11	9.804,00
2.	Material resources	4.556,74	4.260,60	5.016,84
2.1	*Proportion of these expenditures used for registering industrial property rights (patents, utility models etc.)*			
3.	Equipment investments and acquisitions	5.442,36	2.286,12	4.626,40
4.	Construction projects, acquisition of property	0,0	775,22	631,83
5.	"Reserves" (e.g. cash assets, unused funds)	538,2	1.272,9	0,0
6.	Miscellaneous items			
DFG fees (if paid for the institution – 2.5% of revenue from institutional funding)		376,2	363,8	337,3

1 Preliminary data: yes
2 Figures I.1, I.2 and I.3 add up to 100%. The information requested here is thus the percentage of "Institutional funding (excluding construction projects and acquisition of property)" in relation to "Revenue from project grants" and "Revenue from services".
3 Figures I.2.1 to I.2.7 add up to 100%. The information requested here is thus the percentage of the various sources of "Revenue from project grants".
4 The numbers listed in line 2 "Revenue from project funding grants" correspond to expenditures during the corresponding year
5 Competitive procedure of the Leibniz Association: until 31 December 2010, funds allocated through this procedure were designated as institutional funding. Since 1 January 2011, the Leibniz Association has granted these funds as project grants.
6 The numbers listed in line 3.1 and 3.2 are for information purposes only; they have been extracted from the total "revenues from project grants" (2.3 and 2.5) and from "miscellaneous revenue" (line II).

Appendix 5

Staff Financing

Actual numbers in full time equivalents and number of employees

Basic financing and third-party funding (as of: 1/1/2012)

	FULL-TIME EQUIVALENTS			PERSONS
	Total	Proportion of third-party funding		Total employees
	Number (100%)	Number	Percent	Number
Research and scientific services	**80.99**	**23.10**	**29.14**	**94**
Professors/directors (C4, W3 or equivalent)	4	0	0	4
Professors/directors (C3, W2, A16 or equivalent)				
Academic staff in executive positions (A15, A16, E15 or equivalent)	8	0	0	8
Junior research group leaders/junior professors/ post-doctoral fellows (C1, W1, A14, E14 or equivalent)	1	0	0	1
Scientists in non-executive positions (A13, A14, E13, E14 or equivalent)	43.42	9.70	22.34	47
Doctoral candidates (A13, E13, E13/2 or equivalent)	24.57	13.90	56.57	34
Service positions	**48,09**	**3,86**	**8,03**	**55**
Laboratory (E9 to E12, upper-mid-level service)				
Laboratory (E5 to E8, mid-level service)				
Animal care (E5 to E8, mid-level service)				
Workshops (E5 to E8, mid-level service)	6,51	0	0	7
Library (from E13, senior service)				
Library (E9 to E12, upper-mid-level service)				
Library (E5 to E8, mid-level service)	0,62	0	0	1
Information technology - IT (E9 to E12, upper-mid-level service)	5,6	0	0	7
Technical (large equipment, service)	35,36	3,86	10,92	40
Administration*	**14,5**	**2,5**	**18,5**	**15**
Head of the administration	1	0	0	1
Staff positions (from E13, senior service)	1	0	0	1
Staff positions (E9 to E12, mid-level service)	2,5	2,5	100	3
Internal administration (financial administration, personnel etc.) (from E13, senior service)				
Internal administration (financial administration, personnel etc.) (E9 to E12, upper-mid-level service)	4	0	0	4
Building services	6	0	0	6
Student assistants	**1,92**	**0,59**	**30,73**	**7**
Trainees	**7**	**0**	**0**	**7**

Scholarship recipients at the institution	**1**	**1**	**100**	**1**
Doctoral candidates				
Post-doctoral candidates	1	1	100	1

Appendix 6

Temporary Employment Contracts and Proportion of Women on Academic Staff[1]

Actual number of employees; basic financing and third-party funding (as of: 1/1/2012)

	Total staff members	on temporary contracts		Total staff members	proportion of women		Total of female employees	on temporary contracts	
	Number (100%)	Number	Percentage	Number (100%)	Number	Percentage	Number (100%)	Number	Percentage
Research and scientific services	**94**	**68**	**72.3**	**94**	**11**	**11.7**	**11**	**10**	**90.9**
Professors/directors (C4, W3 or equivalent)	4[2]	0	0	4	0	0			
Professors/directors (C3, W2, A16 or equivalent)									
Academic staff in executive positions (A15, A16, E15 or equivalent)	8	0	0	8	0	0			
Junior research group leaders/junior professors/post-doctoral candidates (C1, W1, A14, E14 or equivalent)	1	0	0	1	1	100	1	0	0
Academic staff in non-executive positions (A13, A14, E13, E14 or equivalent)	47	34	72.3	47	3	6.4	3	3	100
Doctoral candidates (A13, E13, E13/2 or equivalent)	34	34	100	34	7	20.6	7	7	100
Additional categories, if required									

	Total staff members	proportion of women	
Scholarship recipients at the institution	**1**	**0**	**0**
Doctoral candidates			
Post-doctoral candidates	1	0	0

[1] Employment acc. to BAT, TVöD or classification according to other pay and wage tariff schemes (e. g. for medical staff) for persons who are financed from institutional resources (incl. vocational trainees and visiting scientists, provided that they are paid from basic institutional funding or from third-party funding, etc., but not incl. internships (0), diploma students (16), ancillary staff (12), scientists without payment (7), PhD students without payment (3), and persons under other contracts for work and services (1)). In the case of joint appointments: persons whose salaries are reimbursed proportionately by the institute.

2 The three MBI Directors have permanent contracts at their respective universities and are appointed as Directors of MBI for five years.

17 December 2012

Annex B: Evaluation Report

Max Born Institute for Nonlinear Optics and Short Pulse Spectroscopy (MBI), Berlin

Contents

Appendix:
Members of review board and guests; representatives of collaborative partners

1. Summary and main recommendations

The *Max-Born-Institut für Nichtlineare Optik und Kurzzeitspektroskopie* (MBI) is a research institute with a global reputation in its field. MBI conducts fundamental research in non-linear optics and ultrafast dynamics of the interaction of light with matter at the highest scientific level and pursues the resulting potential for applications. By combining laser technologies with highly sensitive methods of optics, spectroscopy and structural research, the institute makes significant contributions to addressing issues deriving from physics, chemistry and material sciences.

Already in 2006, the Leibniz Association Senate confirmed the outstanding quality of science at MBI. Since then, the institute has been able to continue developing its portfolio and to maintain its high level of performance. The institute's three Topical Areas are rated as very good to excellent. MBI's general strategy is convincing and has produced numerous important results since the last evaluation. These do not only include excellent publications in leading journals and other forms of knowledge transfer, but also the construction of brilliant experimental facilities and technological developments. MBI's high level of third-party funding, including an ERC Advanced Grant acquired in 2009, endorse the outstanding scientific quality of the work conducted at the institute, as do the numerous scientific honours and awards granted to members of staff at MBI.

The institute has impressively implemented a recommendation made at the last evaluation to promote theoretical physics at MBI. On the basis of a project funded under the Leibniz Association's competitive procedure (SAW), a very successful junior theory group was set up in 2009, and has since established itself; the head of the group is to be appointed to a joint professorship with TU Berlin. In addition, in 2012, the institute recruited an internationally distinguished theoretical physicist as the new head of Department A1. Furthermore, a theory working group was established at MBI in 2011, the head of which was appointed to a W3 professorship at Humboldt-Universität zu Berlin.

As a result of the new appointment at the top of Division A, an extremely convincing and forward-looking restructuring of this section with a new focus on attosecond physics took place in 2010. In combination with the outstanding theoretical expertise already available at the institute, MBI now has an extremely favourable point of departure for excellent work in theoretical and experimental attosecond physics.

MBI's regional collaborations with the three Berlin universities, as well as with other research institutions and industry in Berlin, generate significant knowledge transfer and are highly productive. The training and supervision of junior researchers at MBI is remarkable and opens up optimal employment opportunities for students who have completed their degrees – not just in academia but in business, too.

Nationally, the institute is of highest importance, particularly with regard to developing the newest, application-related methods and laser technologies. For example, MBI played an essential part in the development of the large-scale free electron laser facility FLASH (Free Electron Laser Hamburg) at DESY (*Deutsches Elektronen-Synchrotron*) and will also play an important role in the development of the European XFEL (X-ray Free Electron Laser). MBI also holds a key position as a collaborative partner in numerous research projects financed by DFG and BMBF.

Internationally, the institute's many collaborative and coordinating activities are highly visible and successful. It coordinates the EU "Laserlab Europe" project, a consortium that brings together 28 leading organisations in laser-based interdisciplinary research from 16 countries.

MBI's major success rests on the one hand, on its outstanding scientific performance and its directors' expertise in leadership and organisation and on the other, on its sophisticated, cost-intensive experimental facilities which use state-of-the-art technology. Thus the institute's plans for acquiring new equipment are emphatically endorsed. It would open up unique opportunities for MBI to gain new insights of great relevance into the fundamental issues touching on light-matter interaction.

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

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.

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.

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

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.

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.

2. General concept and profile

MBI pursues an uncompromising scientific strategy focusing on issues and methods that are pathbreaking, even in international terms, and position it at the forefront of international research and development in laser physics. The work of the institute ranges from investigating and developing novel sources for ultrashort and ultraintensive light pulses via measuring techniques for ultrafast processes in a broad spectral range to ultrafast, non-linear phenomena in atoms, molecules, clusters and plasmas as well as surfaces and solid state. In this combination, fundamental research and applications, theory and experimentation achieve a convincing balance.

MBI's organisational structure (see Status Report, Appendix 1b) reflects the scientific staff's areas of expertise. The three divisions are each headed by one of the three directors of the institute. Research is structured (see Status Report, Appendix 2) according to the three Topical Areas: Laser Research; Ultrafast and Nonlinear Phenomena: Atoms, Molecules and Plasma; and Ultrafast and Nonlinear Phenomena: Condensed Phase. In addition, there is a fourth Topical Area, Laser Infrastructure and Knowledge Transfer, which provides the experimental infrastructure required for the other areas. These Topical Areas also equate to the programme areas contained in MBI's programme budget. The research structure facilitates effective allocation of funding and is flexible enough to be able to respond appropriately to new scientific challenges.

MBI's general concept is convincing and has produced numerous important results since the last evaluation. The three Topical Areas in which research is conducted are rated as very good to excellent. The review board recommends the institute to examine whether, and possibly how, the addition of adjacent research fields such as chemistry or biophysics could benefit the current focus areas.

Development of the institute since the last evaluation

Already in 2006, the Leibniz Association Senate confirmed MBI's "outstanding scientific quality." Since then, the institute has been able to continue developing new, promising research themes, such as experimental and theoretical attosecond physics, under the new head of Division A (since 2011) and has maintained its overall high level of performance. On a global scale, MBI belongs in the top group of institutes working on laser physics.

By implementing one particular recommendation made at the last evaluation, MBI has decisively strengthened the field of theory: first of all, in 2009, a junior theory group was established under the Leibniz Association's competitive procedure (SAW), headed by a very promising female scientist; the group now comprises ten, mainly third-party funded scientists (five doctoral candidates and five postdocs). The fact that the positions of group leader and two postdocs have been extended for an indefinite period and that the leader will now be appointed to a joint professorship with TU Berlin is seen as particularly forward-looking and is highly appreciated. In addition, since the beginning of 2012, the institute has benefited from the joint appointment of an internationally distinguished theoretical physicist as the new head of Department A1 together with Humboldt-Universität zu Berlin (HU Berlin). Furthermore, following the appointment of a theoretical physicist at HU Berlin in 2011, a theory working group was established under his leadership at MBI which includes positions for three doctoral candidates and one postdoc financed from MBI's institutional funding.

This 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.

Results

Research

MBI's research results flowed into excellent publications in leading journals and are also exceptionally good in terms of quantity. In the period 2009 to 2011, a total of 467 scientific papers appeared in international, peer-reviewed journals and books, including 56 papers published in journals with an impact factor higher than 7. The institute has received numerous scientific honours and awards for its achievements.

Scientific services and infrastructure tasks, knowledge and technology transfer

MBI's excellent activities and results in scientific services and infrastructure are presented in Chapter 3 (Topical Area 4: Laser Infrastructure and Knowledge Transfer).

MBI's development of methods and laser applications for collaborative partners such as the large-scale free electron laser facility FLASH (Free Electron Laser Hamburg) at DESY (Deutsches Elektronen-Synchrotron) will be addressed in Chapter 4 (Collaboration and Networking).

Beyond that, MBI sells specialised services to companies working in optical technologies, including optoelectronics. The institute develops prototype equipment such as lasers for specialised applications, other laboratory-based photon sources, and devices for optical measurements. It is seen as positive that the institute's technology transfer activities are supported by the joint administration of the Berlin Research Association (FVB). FVB efficiently handles the administration of the patent portfolio, cost and price assessment, and legal support for contracts, employing a convincing patenting strategy. As of 31 December 2011, MBI held 30 patents in the fields of laser technology, optical methods and components, and microscopy.

MBI quite legitimately concentrates on fundamental research but, at the same time, does not lose sight of interesting opportunities for applications. In the context of the industrial exploitation of research results with application potential, MBI should discuss, and possibly support, spin-off options.

Scientific consulting

Members of staff at MBI are significantly involved in scientific consulting and decision-making bodies. The head of Division C is a member of the Berlin-Brandenburg Academy of Sciences and Humanities; from 2010 to 2012, the head of Division B was the President of the German Physical Society and will continue as Vice President from 2012 to 2014. Furthermore, MBI scientists work on steering committees for the Federal Ministry of Education and Research and for foreign research funding organisations such as the United Kingdom's Science and Technology Facilities Council. Many of the staff are members of the editorial boards of distinguished journals and are involved in their review procedures.

On the basis of formal collaborative relations, MBI also regularly advises small and medium-sized enterprises. It is a member of OpTecBB, (Competence Network for Optical Technologies in Berlin and Brandenburg) which connects some hundred stakeholders in industry and science.

<u>Academic events and public relations</u>

In the period from 2009 to 2011, scientists from MBI gave 274 talks at major international conferences. Particular research results are communicated to a broader public through press releases and information events. The robust support MBI's press and public relations work receives from the Berlin Research Association is welcomed.

Strategic work planning for the next few years and appropriateness of funding

As a result of the new appointment at the top of Division A (now Attosecond Physics) an extremely convincing, new thematic focus has been introduced. In combination with theoretical physics, which has been recognisably strengthened in the last few years, MBI now has the best preconditions for producing pathbreaking results in this field. **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.** It makes sense that this position should, once again, be a joint appointment by MBI and TU Berlin. In addition to their equal representation on the appointment board, external reviewers should, as planned, be involved in appointment procedures.

<u>Institutional funding</u>

The range and quality of MBI's scientific infrastructure, together with the scientific excellence of its principal investigators, are crucial for its ability to compete and thus for its success, which has gained it a place at the international forefront in the last few years. Thanks to solid institutional funding, additional third-party funding and other investments by the *Land* Berlin, the institute currently has outstanding, internationally unique, and thus highly competitive, state-of-the-art experimental facilities. These include the laboratories for femtosecond x-ray diffraction, for nonlinear terahertz spectroscopy and the high-field laser laboratory.

For MBI to be able to continue developing and updating these facilities systematically so that it can maintain its leading position, the institute's investment approach is too tightly calculated (not least in view of predictable increases in the core budget). The review board welcomes the fact that, in its future planning, MBI grapples with potential scenarios in which the desired amount of investment would not be forthcoming and still manages to set scientific priorities. In a scenario of this kind however, MBI would have to make compromises which could endanger its competitive edge.

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** (see Topical Area 1)

b. **upgrade of the 400 kHz OPCPA system after which the system could reach output energy levels of about 40-50 micro-Joule** (see Topical Area 2)

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** (see Topical Area 3)

In addition to the experimental facilities, computing capacity plays an ever more important role in theoretical work, which correlates with the upgrading of theory at the institute. The review board recommends the institute to plan ahead and ensure that the physicists working on theory are provided with sufficient computing capacity to fulfil expectations.

Revenue from project funding grants

MBI's high third-party income, including an ERC Advanced Grant acquired in 2009, endorse its outstanding scientific quality. The institute has raised funding for numerous projects from the *Deutsche Forschungsgemeinschaft* (DFG), the Federation and the *Länder,* as well as the EU.

Revenue from services

Knowledge and technology transfer to partners in science and industry is another source of income for MBI. It provides optoelectronic services on a commercial basis and sells prototype equipment like near-field scanning microscopes and optical modulators.

As of 31 December 2011, MBI held 30 patents in the fields of laser technology, optical methods and components, and microscopy. The review board welcomes the fact that during the reporting period, 2009 to 2011, the income from licences and the sale of patents roughly covered the cost of the patents.

3. Topical Areas at MBI

Topical Area 1 (Laser Research)

Topical Area 1 is the backbone of the institute and fundamental in providing novel light sources and methods for MBI research in Topical Areas 2 and 3. But also vice versa: new insights into light-matter interactions originating from the research on ultrafast and nonlinear phenomena are relevant for opening up new directions in nonlinear optics and laser physics as pursued in Topical Area 1. Though commercial laser systems are an integral part of MBI's equipment, it is making a remarkable, continuous and sustained effort to develop novel or optimised methods based on existing systems, and pushing those new methods as far as possible. MBI's laser research enjoys high international visibility and has attained world-class level, which is also reflected in outstanding scientific publications. All in all, the publication output is very good, and the increase in the number of publications in the top-ranked scientific journals is remarkable.

There are several highlights in this research area: The development of OPCPA and thin disk laser technologies for high average power short pulse lasers are at the forefront of global mid-IR laser developments and promise to increase the average power (through per pulse energy and repetition) and decrease the pulse length (through dispersion control and phase manipulation and pulse shaping).

In the control of individual cycles of laser light, the development of feed-forward stabilisation techniques for controlling the carrier envelope phase (CEP) has led to the best results in stabilisation of the phase of the laser cycles anywhere in the world. This should have a strong positive impact on the understanding of higher order and nonlinear effects of light interacting with matter. The patent for the newly developed method has already been sold.

The control of optical cycles of laser light is also reaching the point where MBI lasers can generate stable attosecond laser pulses through non-linear interactions. The extension of this work to isolated attosecond pulses and longer wavelengths is an excellent development and should impact on the understanding and development of novel optical materials.

The thin-disk laser amplifier technology being spearheaded at MBI for both Joule-level with lower repetition rate and milli-Joule level with higher repetition rate systems is very good. The focus on good mode quality and shorter pulse duration makes this effort internationally competitive. The laser system is all solid-state and is based on diode-pumped Yb-doped materials – a most promising direction in terms of high average power. The project has great potential for new scientific discoveries in important research areas such as proton radiation which is used as a medical therapy to fight cancer. The review board therefore supports MBI's plans for a new thin disk driver for OPCPA for attosecond science and high field experiments with output parameters of 1 to2 Joule and 100 to 200 Hz repetition rate (see one-off investment a. in Chapter 2).

Finally, MBI has pioneered the development of lasers at high intensity with exceptional temporal, leading edge, contrast for applications such as short-scale-length plasmas. Additionally, the projects for the extension of diode-pumped systems to longer wavelength systems (beyond titanium-sapphire) could be extremely important for harmonic generation.

In summary, Topical Area 1 is rated as very good to excellent.

<u>Topical Area 2 (Ultrafast and Nonlinear Phenomena: atoms, molecules and plasma)</u>

Topical Area 2 (as well as Topical Area 3) provides the scientific and intellectual bridge between the development and maintenance of cutting-edge lasers and their application to fundamental problems of light-matter interactions.

In this Topical Area MBI has made important contributions to the field of laser plasma physics. The thrust of these studies has been in understanding the fundamental mechanisms underlying the interaction of an intense, ultra-short pulse with relativistic plasmas, particularly for ion and proton acceleration. Particles accelerated by laser plasma are a topic of great interest since it impacts on a broad range of science from future accelerator designs to medical applications in proton therapy. In this area, MBI's ability to generate intense pulses at high repetition rates has resulted in a strategic advantage over other laboratories. In the short-term future, the institute is also well positioned for extending these studies, as well as for exploiting new opportunities in staged electron acceleration, using the newly developed synchronised dual high-power lasers.

In the area of strong field few-body physics, MBI has published several highly visible results over the past few years. This project is well integrated, providing synergy in experiment and theory. The acceleration of neutral atoms has revealed a new strong-field mechanism that was detected only after several decades of investigation.

These activities are closely linked to the research done in the field of time-resolved XUV science, which have also led to several highly visible publications. Using imaging electron spectroscopy, MBI has shown the richness of information contained in the interference of different quantum paths and the possibility of exploiting this to probe molecular structure on the femtosecond time-scale.

The new effort in attosecond science has begun to make significant progress in understanding electron dynamics. The plans for building the capability for performing attosecond pump-probe experiments by exploiting MBI expertise in high-average power laser technology are very promising. The current performance of the 400 kHz OPCPA system lies at a pulse energy of 3 micro-

Joules, a pulse duration smaller than 8 fs and about 200 mrad carrier envelope phase (CEP) stability. The review board supports MBI's plans for an upgrading of the system, after which output energy levels of about 40-50 micro-Joule could be reached (see one-off investment b in Chapter 2). With the availability of such pulse energy, experiments with isolated attosecond pulses become possible with only one count per shot in many applications, which would be the upper limit in reaction microscope experiments. In addition, running the reaction microscope experiments with isolated attosecond pulses at this repetition rate will also open up new research directions. As the performance of the upgraded system will be unique, this will allow the research team to attain a leading position at international level in attosecond research.

The theoretical work done in this Topical Area is outstanding. Also, the decisive and quick response in building a first-class theory group with the addition of the new head of Department A1 and the junior research group is a major merit of MBI's leadership. There is no doubt that the combined elements of experiment and theory under the leadership of the new director of Division A will make MBI a premier institution in attosecond science.

In summary, Topical Area 2 is rated as very good with very promising prospects for development. The theoretical work is excellent.

Topical Area 3 (Ultrafast and Nonlinear Phenomena: condensed phase)

The research on the interaction of ultra short pulses with condensed matter systems at MBI is carried out at the ever-evolving forefront of this field. MBI has pioneered a number of areas and is a world leader in others, as witnessed by several high profile publications in the world's leading physics and multidisciplinary journals as well as excellent third-party funding including one prestigious ERC Advanced Grant, which started in 2009.

In the pioneering category, most noteworthy is the work on terahertz spectroscopy. Approximately a decade ago, MBI produced the first high field terahertz sources and began to use them to investigate nonlinear and ultrafast transport effects in semiconductors. Several groups around the world have followed. Among the physical effects observed most recently are Bloch oscillations in GaAs, a bulk semiconductor. It was the first time this effect had been observed in anything other than a structured material. They were also able to show how the presence of n-doping leads to damping of the oscillation.

Another area in which the group is producing world-leading results is femtosecond x-ray diffraction, where the first measurement of transient electron density maps in solids has been made. This is based on the implementation of new techniques such as femtosecond powder diffraction. The new techniques allow the study of ultrafast electron relocation in ionic crystals, or changes in the magnetisation density in ferromagnetic materials, and the relationship to structural changes. The development of a new generation of ultrafast x-ray plasma sources was done in collaboration with a company on the *Adlershof* campus. This outstanding example of technology transfer received the Innovation Prize Berlin-Brandenburg 2010. Furthermore, this pioneering development and its application to studies of ultrafast structural dynamics have put the group into an internationally leading position, which is also reflected by the ERC Advanced Grant. Of essential importance for the further development of the structural dynamics work will be an investment in a 1 kHz 5 µm OPCPA laser system as an X-ray plasma driver (see one-off investment c in Chapter 2). A predicted tenfold increase in X-ray flux would allow a drastic shortening of measurement times, which in turn would make more complex materials and molecular systems accessible for study. This would therefore further establish and strengthen the position of MBI as world-leading in the ultrafast structural dynamics field.

Furthermore, very good results have been produced by members of this Topical Area in developing and applying a novel method of collinear 2D terahertz spectroscopy to analyse polaronic couplings between electrons and optical phonons in a semiconductor quantum well system.

The collaboration with the theory group located at MBI in the course of the appointment of a new full professor for "Theoretical Optics" at *Humboldt-Universität* and leader of this group is also very good. MBI acquired additional, dedicated institutional funding, currently used for one postdoctoral fellow and three doctoral candidates, who are located at MBI but are supervised by this external professor. The institute is encouraged to further intertwine their theoretical work with the experimental work of this Topical Area.

In summary, Topical Area 3 is rated as very good to excellent.

Topical Area 4 (Laser Infrastructure and Knowledge Transfer)

This subdivision comprises scientific infrastructure at the highest standard together with supporting activities, including knowledge and, to a lesser degree, technology transfer to collaborative partners. As a service unit, it is crucial for the experimental implementation of the other areas' projects and thus of central relevance.

In the last years, work in this area focused on implementing new light sources. Important examples are the installation of the new 100 TW high field laser, the setup of an OPCPA system working at near-MHz repetition rates and the setup of an OPCPA system providing pulses at the TW level with a 100 Hz repetition rate. It is a remarkable strength of the institute that it not only possesses top level scientific infrastructure, but also disposes of adequate, excellent scientific and technical personnel to guarantee continuity in the maintenance and improvement of the facilities.

The technology and knowledge transfer activities comprise access for internal and external users to some unique facilities at MBI. The High Field Laboratory (HFL) and the Femtosecond Application Laboratories (FAL) are mainly devoted to users from science. Furthermore, MBI offers about 85 days of access per year in various research projects to European users in the context of Laserlab Europe. The Berlin Laboratory for innovative X-ray technologies (BLIX) is a special infrastructure operated together with TU Berlin to support the transfer of methods and technologies developed at MBI in the field of x-ray science to industry.

4. Collaboration and networking

Collaboration with universities

The cooperation with the three Berlin universities – *Humboldt-Universität zu Berlin* (HU Berlin), *Freie Universität Berlin* (FU Berlin) and *Technische Universität Berlin* (TU Berlin) – is excellent. MBI has appointed one director in conjunction with each of these universities. In addition, in 2012, the head of Division A1 (Attosecond Theory) was a joint appointment with HU Berlin. Another Humboldt professor, appointed in 2011, also became head of the theory working group at the institute which currently finances four positions for junior researchers from its institutional funding.

Many of the scientists employed at MBI are heavily engaged in university teaching and are involved in third-party funded research projects. The institute also cooperates closely with university research groups as a member of the Humboldt Centre for Modern Optics and the Integrative Research Institute for the Sciences (IRIS, both at HU Berlin).

In the context of promoting junior researchers, MBI made a successful bid for the Leibniz Graduate School “Dynamics in new Light (DinL)” for the period 2011 to 2014 (under the Leibniz Association’s competitive procedure, SAW). FU Berlin, TU Berlin, the University of Potsdam, *Helmholtz Zentrum Berlin* (HZB) and the Max Planck Society’s Fritz Haber Institute are also involved.

Finally, the review board welcomes MBI’s cooperation with TU Berlin in the Berlin Laboratory for innovative X-ray technologies (BLIX), already described in the section on Topical Area 4.

Collaboration with other research institutions in Germany and abroad

Due to its outstanding scientific expertise and ultramodern infrastructure MBI is sought-after as a collaborative partner, not only by German research institutes. The competence of its staff in the development of technology and methods for laser-system applications is in particular demand. In this context, MBI played an essential part in the development of the large-scale free electron laser facility FLASH (Free Electron Laser Hamburg) at DESY (*Deutsches Elektronen-Synchrotron*), for example, and will also play an important role in the development of the European XFEL (X-ray Free Electron Laser). Other important national partners of MBI include Helmholtz Zentrum Berlin (HZB) and *Helmholtz-Zentrum Dresden-Rossendorf* (HZDR).

A particularly successful example in the international arena is the European project, Laserlab Europe, which MBI coordinated during the 6th and 7th Research Framework Programmes. Now, Laserlab Europe is in the third phase of its successful cooperation. It brings together 28 leading organisations in laser-based inter-disciplinary research from 16 countries. Together with associate partners, Laserlab Europe covers the majority of European member states. 20 facilities offer European research teams access to their laboratories.

Another successful example is the coordination of the Specific Targeted Research Project MIRSURG (Mid-Infrared Solid-State Laser Systems for Minimally Invasive Surgery). Last but not least, MBI’s reputation at international level is witnessed by its involvement as a project partner in the two Pan-European projects ELI (Extreme Light Infrastructure) and HiPER (High Power laser Energy Research).

Other collaborations and networks

MBI cooperates closely with industry. Examples include:

- Competence Network for Optical Technologies in Berlin and Brandenburg (OpTecBB) – an initiative of companies and scientific institutions in Berlin and Brandenburg working together to exploit the potential and use of optical technologies
- Laser Optics Berlin – an international trade fair run by the laser optics industry flanked by a scientific-technical congress
- Photonics21 – a technology platform and voluntary association of industrial enterprises and other stakeholders in the field of European photonics, bringing together most of the leading photonics industries with relevant R&D stakeholders

On top of this, there are also numerous collaboration agreements with small and medium-sized enterprises in the Berlin-Brandenburg region and beyond. A long-standing, highly successful collaboration exists with Femtolasers in Vienna, which recently purchased an MBI patent for a new method for carrier-envelope phase (CEP) stabilisation after MBI had published the relevant research findings in a high-impact journal.

5. Staff development and promotion of junior researchers

Personnel structure and staff development

As of 1 January 2012, MBI employed 179 staff (154 full-time equivalents) including 34 doctoral candidates. At 72 percent, the proportion of research and scientific staff on fixed-term employment contracts is appropriate. In the last few years, MBI has developed into an international research institution employing numerous postdocs from other parts of Europe, Asia and North America. Moreover, approximately half the doctoral candidates come from abroad.

The new appointments to the leadership of the "Strong Field Theory" junior research group in 2009, Division 1, "Attosecond Physics", in 2011, and Department A1, "Attosecond Theory", in 2012, have strengthened MBI significantly. It is astute of the institute to have started preparing for the appointment of a successor to the leadership of Division B, "Light Matter Interaction in Intense Laser Fields", the current director of which will retire in 2014 (see Chapter 2: Strategic work planning for the next few years).

The review board strongly welcomes the creation of positions financed from institutional funding in the "Strong Field Theory" junior research group as well as the "Theoretical Optics" theory working group, which is located at MBI and headed by a professor appointed at HU Berlin in 2011. Furthermore, the fact that the positions of junior research group leader and two postdoctoral researchers in her group have been extended for an indefinite period is seen as a forward-looking indication of the upgrading of theory.

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.

Promotion of gender equality and compatibility of career and family

The overall proportion of female scientists at MBI, including doctoral candidates, increased from 8.5 percent in 2010 to 12 percent in 2011. 20 percent of the doctoral candidates and 7.8 percent of the scientific staff below doctoral level are female. **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.**

The review board also welcomes MBI's efforts to improve the compatibility of career and family by introducing flexible working times, for example, and providing a working space for parents and children at the institute. As many experiments require researchers to be present for long periods of time, the review board also recommends the institute to investigate the feasibility of a relaxation room.

Promotion of junior researchers

The training and supervision of junior researchers at MBI is excellently organised at all levels and produces pleasing results, as numerous recent awards and honours for junior researchers demonstrate. Staff at MBI are intensively involved in teaching at the universities in Berlin.

At any one time, 30 to 40 doctoral candidates are usually employed in the various different research projects at the institute. Most of them belong to graduate schools such as the Leibniz Graduate School “Dynamics in New Light” (from 2011 to 2014), which was granted to MBI and partners under the Leibniz Association’s competitive procedure (SAW).

In addition to academic training, young scientists at MBI have the opportunity to take courses in languages and soft skills whereby use is made of courses offered by the universities. Given the high percentage of foreign staff at MBI, the review board recommends the institute to examine whether a better range of German language courses could be provided.

MBI actively supports postdocs who opt for a career in academia. Between 2006 and 2009, three of the institute’s scientists completed their *Habilitation.* The review board welcomes the fact that MBI has initiated a process to create a professorship for the leader of the junior theory group at TU Berlin.

Generally, the career prospects of scientists who have trained or worked at MBI are very good indeed. Since 2006, for example, ten former employees have become university professors or received a comparable offer from a research institute. However, MBI does not just train excellent junior researchers; it also produces outstanding specialists for industry.

Vocational training for non-academic staff

Vocational training for non-academic staff at MBI is just as professional and successful as the training of junior researchers. As of 1 January 2012, seven trainees were employed in physics laboratory assistance, precision mechanics and administration/accountancy.

6. Quality Assurance

Internal quality management

The tools MBI uses for internal scientific quality assurance (such as input-output performance control and performance-related distribution of funding) are very effective. Publications are monitored to ensure they observe the rules of good scientific practice and are subject to review before being submitted. Both MBI and the Berlin Research Association have an ombudsperson who can be called upon to mediate in case of disputes or problems. The review board recommends the institute to ensure that all the staff are aware of this.

The MBIs Board of Directors provides excellent scientific leadership. In addition to the directors, other managerial-level scientists are involved in the efficient planning of research. The institute’s leadership is supported by an efficient administration. The organisation of funding allocation is conducted smoothly and appropriately on the basis of the programme budget.

Quality management by the Scientific Advisory Board and MBI’s supervisory body

MBI’s Scientific Advisory Board, which is composed of distinguished international scientists, fulfils its tasks very diligently and fairly. In line with recommendations, an additional member has been appointed from industry.

The Board of Trustees of the Berlin Research Association carries out its tasks as MBI's supervisory body in accordance with the statutes.

Implementation of recommendations from the last external evaluation

MBI took the recommendations from the last evaluation seriously and implemented most of them (briefly given here in italics; see Status Report, p. 16):

1) *Retain the new organisational structure of the institute*: MBI's new research structure has been retained and meaningfully developed at project level.

2) *Develop a long-term vision of the Institute*: The institute's long-term research planning is convincing (see Chapter 2).

3) *Strengthen theoretical research and integrate it into the scientific structure of the MBI permanently*: This recommendation has been impressively implemented with great success (see Chapter 2).

4) *Accord additional replacement funding, backed by a sharpened long-term vision for future MBI research activities*: In 2009 and 2010, MBI was granted considerable additional funding to modernise its equipment infrastructure. Thanks to this investment MBI was able to enhance its international competitiveness substantially.

5) *Implement a guest programme for senior scientists*: MBI has introduced the relevant programme.

6) *Consider funding possibilities such as the Joint Initiative for Research and Innovation (Pakt für Forschung und Innovation)*: In line with the agreements between the Federation and the *Länder,* MBI's core budget was regularly increased. In addition, MBI managed to raise funding under the Leibniz Association's competitive procedure (SAW). Furthermore, MBI acquired funding through the Economic Stimulus Packages I and II to restore its buildings.

7) *Reallocate the annual budget properly to compensate the structural deficit in institutional funding for materials and small-scale equipment*: There is still a structural deficit in the field of investment. In the long term, it will not be possible for MBI to maintain the state-of-the-art technical facilities currently available on the basis of its investment budget from institutional funding. If the institute does not manage to raise additional third-party funding for equipment – which is relatively difficult – it will be forced to make compromises in future which might impact on its competitiveness (see Chapter 2, Appropriateness of funding).

8) *Revise the present legal framework for cooperation at the MBI, in particular on patenting issues, with the aim of enabling successful future cooperation and scientific development*: The review board welcomes MBI's manifold, intensive and successful collaborative activities with scientific institutions and companies (see Chapter 4). In its considered opinion, the legal framework does not encroach on the successful transfer of knowledge in any way.

9) *Take the research group that focuses on ionisation dynamics in intense laser fields as a model for the Institute on how theory and experiment can complement each other*: MBI has very successfully linked theory and experimentation at various points in its research structure (see Chapter 2, Development of the institution since the last evaluation).

10) *In the research work on free clusters and molecules, conduct more experiments in the gas phase to avoid the potential technical limitations of using X-ray femtosecond experiments to observe internal motions*: Due to the retirement of the former head of Division A in 2009, this work has not been continued for obvious reasons.

11) *Invite the group working on optoelectronic devices to seek new future ideas for its mid-term perspective and to cooperate with the Ferdinand-Braun-Institut für Höchstfrequenztechnik (FBH):* Since the last evaluation, this group has produced interesting research results, published in high-impact journals, on "catastrophic optical damage (COD) of high power diode lasers." It cooperates with various research institutions like FBH.

12) *Include a member from industry in the SAB*: MBI has implemented this recommendation.

13) *Reorganize the IT-service in order to allow for the improvement of IT-service quality and response times*: MBI has implemented this recommendation. IT-service has been extended by three positions.

14) *Develop a strategy to promote female scientists and attract more female students to the MBI over the next few years*: MBI has a strategy for increasing the percentage of female scientists. It has managed to appoint a woman to the leadership of the junior theory group in which 40% of the members are female. MBI has also increased the percentage of women doctoral candidates in the last few years. There is still a deficit at leadership level. The review board calls on the institute to intensify its efforts to increase the percentage of women scientists at leadership level.

15) *Continue the efforts to broaden the recruitment base for students participating in summer student programmes*: In the framework of its generally very successful promotion of junior scientists, and in combination with engaged public outreach, MBI continues striving to interest as many school students as possible in studying physics.

16) *Deepen the ties between the Institute and universities by appointments for joint junior professors*: Since the last evaluation, no further junior professorships have been established with Berlin universities but they have with the universities of Potsdam and Göttingen. Irrespective of this, collaborative relations with the Berlin universities are very good (see Chapter 4).

17) *Thoroughly analyse the patenting strategy and in particular compare the time and man-power invested in patent applications with the revenue of patents sold*: MBI has implemented this recommendation. The review board welcomes the fact that income from patents roughly covers the costs of registration and maintenance.

Appendix

Participants:

1. Review board members

Chair (Member of the Senate Evaluation Committee)

Prof. Dr. Manfred **Bayer**	TU Dortmund, Chair in Experimental Physics

Vice Chairman (Member of the Senate Evaluation Committee)

Prof. Dr. Regine **Hakenbeck**	TU Kaiserslautern, Chair in Microbiology

External Experts

Prof. Dr. Louis **Di Mauro**	Atomic Physics Research Group, Department of Physics, Ohio State University,
Prof. Dr. Todd **Ditmire**	The High Intensity Laser Science Group, Department of Physics, University of Texas at Austin
Prof. Dr. Henry **van Driel**	Institute for Optical Sciences, University of Toronto
Prof. Dr. Ciaran **Lewis**	Centre for Plasma Physics, Queens University Belfast
Prof. Dr. Roger **Falcone**	University of California and Director of the Advanced Light Source, Lawrence Berkeley National Laboratory
Prof. Dr. Sandro **de Silvestri**	Department of Physics, Politecnico di Milano
Prof. Dr. Villy **Sundström**	Department of Chemical Physics, Lund University
Prof. Dr. Jan-Michael **Rost**	Division Finite Systems, Max Planck Institute for the Physics of Complex Systems, Dresden

Federal Representative

Dr. Dieta **Lohmann**	Federal Ministry of Education and Research, Bonn

Representative of the Länder (Member of the Senate Evaluation Committee)

MinDirig Jörg **Geiger**	Saxon State Ministry for Higher Education, Research and the Arts, Dresden

2. Guests

Representative of the responsible Federal Department

Dr. Ralph **Dieter**	Federal Ministry of Education and Research, Bonn

Representative of the responsible Länder Department

Dr. Katharina **Spiegel**	Senate Administration for Economics, Technology and Research, Berlin

Representative of the Scientific Advisory Board

Prof. Dr. Ulrike **Woggon** (4 September)	TU Berlin, Institute for Optics and Atomic Physics
Prof. Dr. Ian A. **Walmsley** (5 September)	University of Oxford, Clarendon Laboratory

Representative of the Leibniz Association

Prof. Dr. Ludwig **Schultz**	Leibniz Institute for Solid State and Materials Research, Dresden

Representative of the Joint Science Conference (GWK), Bonn

Dr. Hans-Gerhard **Husung**

3. MBI's collaborative partners (present for a one hour discussion with the review board)

Prof. Dr. Majed **Chergui**	Laboratory of Ultrafast Spectroscopy, Ecole Polytechnique Fédérale de Lausanne
Prof. Dr. Helmut **Dosch**	Chairman of the DESY Board of Directors, Hamburg
Prof. Dr. Peter A. **Frensch**	Vice President Research, Humboldt-Universität zu Berlin
Andreas **Stingl**	President of Femtolasers, Vienna
Prof. Dr. Christian **Thomsen**	Dean of School II, Mathematics and Natural Sciences, TU Berlin

January 7, 2013

Annex C: Statement of the Institution on the Evaluation Report

Max Born Institute for Nonlinear Optics
and Short Pulse Spectroscopy (MBI), Berlin

MBI has gratefully and proudly taken note of the Evaluation Report and 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 most 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. The process to identify a globally renowned, successful research personality for the leadership position of Division B of MBI is meanwhile well advanced and the present spectrum of applicants looks very promising.

Finally, MBI agrees with and thanks the Review Board for its endorsement of MBI´s plans for use of additional funding to guarantee the institute´s long term competitiveness.

In this context MBI would like to express its strong agreement with the statement by the Review Board on page B-14 to the effect that "*there is still a structural deficit in the field of investment. In the long term, it will not be possible for MBI to maintain state-of-the-art technical facilities currently available on the basis of its investment budget from institutional funding*". This may force MBI "*to make compromises in future which might impact on its competitiveness*".