**Faculteit der Natuurwetenschappen,
Wiskunde en Informatica (UvA)
Faculteit der Exacte Wetenschappen (VU)**

Investment Agenda for University Physics and Chemistry in Amsterdam 2006-2016

Prof.dr. K.J.F. Gaemers, dean FNWI
Science Park 904 (postbus 94216)
1090 GE Amsterdam
Telefoon: 020 – 525 7864
E-mail: K.J.F.Gaemers@uva.nl

Prof.dr. J. van Mill, dean FEW
De Boelelaan 1081- 1087
1081 HV Amsterdam
Telefoon: 020 – 598 7688
E-mail: decaan@few.vu.nl

UNIVERSITEIT VAN AMSTERDAM vrije Universiteit amsterdam

Aan de commissie-Breimer
T.a.v. drs. H.G. van Vuren
FOM-bureau
Postbus 3021
3502 GA UTRECHT

Amsterdam, 1 april 2009

Betreft: Profileringsplan UvA - VU
Bijlagen: 1

Afdeling: faculteitssecretaris
Contactpersoon: E.J. Sennema
Tel: 020-525 7961
E-mail: sennema@science.uva.nl
Ons kenmerk: FNWI_U09 / 912

Geachte heer Van Vuren,

Het doet ons genoegen u hierbij het Profileringsplan van de Vrije Universiteit en de Universiteit van Amsterdam aan te kunnen bieden. Het plan heeft als titel "Profiling Physics and Chemistry in Amsterdam 2006 – 2016" en vormt een eerste uitwerking van de in 2007 verschenen Sectorplannen voor natuur- en scheikunde. Ons plan omvat naar onze overtuiging een goed uitgebalanceerd pakket aan voorstellen voor structurele investeringen in onderwijs en onderzoek, waarmee de doelstellingen van de twee Sectorplannen recht wordt gedaan.

Wij vragen uw bijzondere aandacht voor de volgende hoofdpunten.

- De Amsterdamse instellingen zullen in het bachelor domein *joint bachelor programmes* in de natuurkunde en de scheikunde gaan aanbieden; en streven voor deze programma's naar *joint degrees*.
- Het volledige aanbod van natuurkunde en scheikunde masteronderwijs is ondergebracht in de onlangs opgerichte Amsterdam Graduate School of Science (AGSS), een onderwijsorganisatie die door drie faculteiten van beide instellingen gezamenlijk wordt bestuurd.
- De indieners zorgen in overleg met de in Amsterdam gevestigde para-universitaire instituten voor een effectieve afstemming van hun onderzoeksprogramma's, onder andere door de oprichting van onderzoekscentra die de instellingsgrenzen van UvA en VU overschrijden.

Wij zien uit naar het overleg met uw commissie op 28 mei aanstaande.

Met vriendelijke groet,

Prof.dr. K.J.F. Gaemers
Decaan Faculteit der Natuurwetenschappen, Wiskunde en Informatica (UvA)

Prof.dr. J. van Mill
Decaan Faculteit der Exacte Wetenschappen (VU)

Cc: Colleges van Bestuur UvA en VU, mw. dr. T. Kulkens (NWO)

1. *Applicants*

Prof.dr. J. van Mill, dean FEW
De Boelelaan 1081- 1087
1081 HV Amsterdam
Telefoon: 020 – 598 7688
E-mail: decaan@few.vu.nl

Prof.dr. K.J.F. Gaemers, dean FNWI
Science Park 904 (postbus 94216)
1090 GE Amsterdam
Telefoon: 020 – 525 7864
E-mail: K.J.F.Gaemers@uva.nl

2. *Change and innovation in Amsterdam: a summary*

The joint sectorplan bid from the two Amsterdam universities combines the best of today's strengths – in terms of teaching and research profile that attracts top talent from young students to mature research toppers – with a clear vision for the future aimed to establish "Amsterdam: City of Science". This vision is not just based on the presence of two science faculties, but also on the presence of strong FOM/NWO institutes and the increasing cooperation with the two academic medical centres. Altogether, this makes Amsterdam a natural centre for education and research in the sciences in general, and in particular in physics and chemistry, in a natural symbiosis with the life sciences.

The Amsterdam universities will implement a joint bachelor programme in chemistry and a joint bachelor programme in physics, complemented with a high profile tutoring and counseling system to further improve study success. Master programmes in both disciplines are already successfully organized together, since the introduction of the bachelor/master structure in 2002. By joining forces, the Amsterdam faculties will increase the quality and attractiveness of the various programmes, while at the same time ensuring efficiency. Top scientists from both universities will be involved in the bachelor and master programmes in both chemistry and physics. Combining the "best of both worlds" also offers us the opportunity to implement an attractive honours programme in science.

To stimulate enrollment of new students, the Amsterdam universities already work together to good effect in various outreach programmes, such as *Beta Partners*. These joint activities are well appreciated (e.g. by the Platform Beta & Techniek) and will be continued and intensified in order to address, for example, the special Amsterdam challenge of ethnic diversity. Moreover, the two universities recently joined forces with the city administration to found *Amsterdam University College*, in order to attract new groups of excellent students interested in a broad, liberal arts and sciences bachelor programme of three years' duration.

To further stimulate international enrollment in the Master phase and beyond, the Amsterdam universities will launch the *Amsterdam Graduate School of Science* in September 2009. With this graduate school the Amsterdam universities and the city of Amsterdam bundle their ambitions to attract significant numbers of (inter)national students in the science masters. The graduate school will be the main vehicle *via* which the *brand name "*Amsterdam" and our excellence in research and teaching will be highlighted worldwide. We envision that – given the clear focus on excellence in research and teaching and the Amsterdam commitment to outreach for both – we

will be able to achieve a strong growth in the enrollment of science students in our bachelor and master programmes in physics and chemistry.

On the research front, the Amsterdam chemistry and physics departments have bundled their efforts in order to create *focus* and *mass* in areas of proven excellence, as identified in the specific sectorplans. In these *key research areas*, over and above the staff of the two science faculties, many Amsterdam science partners such as those in FOM/NWO institutes (CWI, AMOLF, NIHKEF) and the medical centres (AMC, VUmc) actively participate and thereby contribute to the ambition of "Amsterdam: City of Science".

The four *key research areas* in Physics in Amsterdam (see section 4.2 for details) are:

- Quantum Universe (focus area 1)
- Complex Systems, Liquids and Matter (focus area 3)
- Physics of Life and Health (focus area 4)
- Physics of Energy (focus area 5)

The four *key research areas* in Chemistry in Amsterdam (see section 4.3 for details) are:

- Synthetic Chemistry & Catalysis (focus area 1)
- Computational Chemistry (focus area 2)
- Analytical Chemistry & Spectroscopy (focus area 2 and 3)
- Chemistry of Life (focus area 3)

With these choices we aim for an excellent future in both the heartland of physics and chemistry as well as at the crossroads of these disciplines with life sciences and engineering. The *key research areas* are in full agreement with the separate plans for physics and chemistry and address fundamental questions (e.g. Quantum Matter, Life and Multiscale Modeling), as well as many of the important societal needs (e.g. Energy, Health, Sustainability, Innovation). These key research areas form the basis of our future Amsterdam master programmes in chemistry and physics within the Amsterdam Graduate School of Science and also have an important impact on the profiles and attractivity of our bachelor programmes.

With the proposed strengthening of the critical mass and the boosting of focus and excellence in our key research areas, the Amsterdam universities will undoubtedly play an important role in the European research landscape. By making clear choices, joining forces and collaborating with the other excellent science institutes in the Amsterdam area, the universities will be able to attract substantial future funding from NWO, FOM EU and international industry.

3. Policy and strategy in education

The Amsterdam universities have a strong commitment to join forces in order to excel in their chemistry and physics education, both at the bachelor, master and PhD training level. The Amsterdam universities will:

- create a joint bachelor programme in chemistry
- create a joint bachelor programme in physics and astronomy
- aim to grant joint degrees within the appropriate legal framework [1]
- improve bachelor study succes up to the level of 70% via a consistent and intensive system of tutoring throughout the programmes
- offer attractive interdisciplinary science-based bachelor programmes (see appendix 3)
- prepare science students for the future challenges of modern society by placing scientific knowledge in relevant context (e.g. Energy, Life & Health, Sustainability)
- attract excellent international bachelor students via the *Amsterdam University College*
- offer a wide range of attractive science masters within the *Amsterdam Graduate School of Science* (see appendix 3)
- increase the enrollment of bachelor students in physics and chemistry programmes by 33 % in 2016 by extending succesful local and national outreach activitities (e.g. *Beta Partners, ITS Academy, Beta 1-op-1, PAL),* with a special focus on minorities
- increase the enrollment of master students in physics and chemistry programmes by 30-50 % in 2016 by means of increased international marketing *via* the *Amsterdam Graduate School of Science.*

To illustrate the commitment of both universities to closely align their science activities, the Executive Boards of the VU and UvA have already introduced a university-wide 8-8-4 semester structure, and have reserved the first semester of the third year of the bachelor for the introduction of joint minors. In the next paragraphs we outline our plans and specify the proposed investments required to implement them.

3.1 Bachelor programmes chemistry and physics & astronomy

The Amsterdam universities will create joint bachelor programmes in physics & astronomy and chemistry. These programmes combine the strengths of both universities and will enhance the quality and efficiency of teaching. By creating an intimate coupling between research and teaching, students will be offered a programme that is designed to challenge and stimulate excellence. Modernized core curricula will be supplemented with elective courses that directly reflect the research strengths of the Amsterdam universities. Most of these elective courses will be offered as coherent minors, providing students with a wealth of possibilities to either broaden or deepen their knowledge in themes such as Sustainability, Energy, the Quantum Universe, Photonics, Complex Liquids, Life & Health, Forensic Sciences, Entrepreneurship or Education.

The Amsterdam universities will implement:

[1] National joint degrees are not yet anchored in Dutch law. With similar future legislation in the pipeline as has been/will be adopted for international joint degrees, we aim to implement joint degrees within the framework of the sectorplan.

- curriculum committees in order to start the joint programmes as soon as possible
- a system of intensive tutoring and study counseling throughout the 3 years of the bachelor
- an honours programme in science (30 EC extra within the nominal 3 years)
- a joint double bachelor programme in physics & mathematics.

The Platform Beta Techniek allocated incidental funds to prepare ground for the ideas proposed here with regard to the inter-university collaboration (starting with joint minor programmes), the increase in study efficiency (tutoring programmes) and for our outreach activities (*Beta Brug, Beta Partners, Beta 1 op 1, national activities)*. Naturally, these activities are to be continued and their continuity guaranteed *via* this sectorplan proposal.

3.1.1 Quality, study success and excellence

Key factors in the improvement of study success rates are an intensive student-staff interaction throughout the bachelor, combined with continuous monitoring of the quality of teaching by an effective evaluation system. Building on best practices in both universities, a consistent system of tutoring throughout the bachelor programme will be developed, to enhance the academic skills and motivation of the students, thereby aiming at achieving a 70% success rate in 2014. This intensive tutoring and mentoring regime also serves as an early identification system for excellent students, who will be offered a challenging, new honours programme in science.

3.1.2 Boosting enrollment of bachelor students: outreach activities

The restructuring of the chemistry and physics programmes will be accompanied by efforts to stimulate enrollment in both bachelor programmes. The Amsterdam universities have already joined forces in the successful *Beta Partners* collaboration of 4 institutes of higher education and 22 secondary schools to stimulate the interest in science at the high school level and thereby increase the number of pupils that choose an N&T or N&G profile. This *Beta Partners* collaboration, supported by - among others - the Platform Beta & Techniek and the City of Amsterdam, has lead to a very successful Amsterdam outreach programme covering for example the ITS-Academy and PAL programmes. The Amsterdam universities have integrated many of the activities initially funded *via* SPRINT into their normal operational procedures, yet a number of specific activities will still require continued funding. A sub-group of such activities will be part of a national plan that is to be actively developed under the auspices of the national 'beta-deans council'.

The deans of the 'chemistry and physics' faculties have decided to set aside in their plans 55k€ yearly for joint national outreach activities. These activities comprise, amongst others, development of teaching material and modules for high schools, training of high school teachers by involving them in research and education at the universities, and promotion activities. Parts of the initiatives will be conducted nation wide, parts more locally. All the activities will be part of a national plan to be actively developed under the auspices of the national "beta-deans-council".

To increase (physics) or sustain (chemistry) the fraction of women choosing a science bachelor we collaborate with the VHTO (expert centre for women in science education) to develop new strategies. In addition, for both disciplines we aim to increase the fraction of students from ethnic minority groups to at least 10 % of the first year enrollment by 2016. To this end we collaborate with the Cosmicus Montessori Lyceum, a new high school for minority groups, and with

intermediaries such as the Weekendschool, ECHO (Expert Centre in Diversity), Giving Back (a non profit organization for mentoring and tutoring highschool students) and we participate in diverse networks, national as well as international (for instance EAN, the European Access Network).

We aim for an increase in overall enrollment of 33 % in 2016 in the heartland physics (from a level of 82 students in 2008) and chemistry bachelors (from a level of 83 students in 2008). [2]

3.1.3 Addressing new categories of students for science-based bachelors

The Amsterdam universities have two main strategies to attract bachelor students, who do not opt for a mono-disciplinary bachelor in chemistry or physics.

The Amsterdam University College

With a major grant for excellence from the Dutch Ministry of Education & Science's Sirius programme and support from the City of Amsterdam within its program 'Amsterdam Top City', September 2009 sees the opening of the Amsterdam University College (AUC). The AUC is a full-time three-year liberal arts and sciences programme at Bachelor level, taught in English, and is a further example of the concrete and no-nonsense co-operation between the two Amsterdam universities. The AUC expects an annual enrollment of 200 students a year, of which a proportion are expected to enroll in the Amsterdam science masters in 2012.

Multidisciplinary bachelor programmes

To address the interest of secondary pupils in broader-based degree programmes both universities have introduced cross-disciplinary and multidisciplinary studies in which chemistry and/or physics form important components of a broader programme.[3] This has already led to a significant increase in the total number of science students (with this growth including a large fraction of female students) and results in acceptable numbers (50-100) of students in most of the entry-level science or multidisciplinary courses. In particular, currently 20 % of the UvA Beta-gamma students (120 1st year students in 2008-2009) opt for a two-year major programme in the two disciplines, which provides entry to the physics and chemistry research masters. In addition, the total annual enrollment in the VU multidisciplinary, science-based, bachelors degree programmes SBI and MNW is about 60 students. The expected growth in these studies (at least 30% in 2013 based on current developments) provides an additional solid basis for efficiency in many of the introductory courses in chemistry and physics and will also lead to an increase in student numbers in the masters phase with 10-15 students per discipline per year.

[2] Physics has seen an annual increase of 7% per year in the last 4 years, the chemistry figure includes the 100% chemistry bachelor pharmaceutical sciences.

[3] E.g. Beta-Gamma, Science Business and Innovation, Medical Natural Sciences and Bio-exact. See also appendix 3.

Investment scheme (bachelor phase)

Establishment and maintenance of bachelor programmes	2 fte UHD level	Matching
Professional tutoring – study success/excellence	2,8 fte UD level	308 kE/yr
Local and national outreach activities	project funding	142 kE/yr
Staff (4.8 fte) and additional budgets		**450 kE/yr**

3.2 Master programmes

In December 2008 the Executive Boards of the UvA and VU agreed to extend the existing collaboration in master and PhD. education in chemistry and physics and to found the Amsterdam Graduate School of Science (AGSS). Prof. dr Willem J. Stiekema has been appointed to direct the development of the AGSS graduate School, which will start on September 1st, 2009. The graduate school will encompass all master programmes of the science faculties in Amsterdam and will form a spearhead in our recruitment efforts for the various science masters. The AGSS will coordinate ongoing and new promotional activities for all Amsterdam science masters and use the combination of the *brand name* Amsterdam and our excellence in research and teaching as a strong marketing tool. The AGSS will also play an important role in organizing cross-university education for e.g. C-, E- and M-variants of the different master programmes as well as in providing the framework for quality assurance of PhD supervision and for transferrable skills training in the PhD programmes.

The chemistry and physics masters have already been jointly organized by the Amsterdam universities since the start of the bachelor/master structure in 2002 (see, for example, the joint websites www.physicsinamsterdam.nl and www.chemistryinamsterdam.nl). This strong collaboration in chemistry and physics has led to high quality programmes with respect to content and teaching efficiency. Both management and quality control of the chemistry and physics master programmes is already a joint effort and formed an important nucleus around which the broader collaboration within the AGSS could crystallise.

Considering the future research landscape in physics and chemistry in Amsterdam with a clear focus spanning from heartland themes such as Quantum Universe, Synthesis and Catalysis and Life to multidisciplinary topics, like Energy, Health, Computational Science, and Complex Liquids (see the research part of this application), we will re-design the framework of our Master degree programmes in selected areas. At least five tracks will be re-designed, in the area of chemistry of life (new Systems Biology master), in Sustainable Synthesis and Catalysis (where an honours programme in catalysis will be developed), Energy Science, Biomedical Physics and in Molecular Computational Science (application for an Erasmus Mundus grant to start a European master programme). Funding is requested for coordinators in physics and chemistry (total of 1 fte UHD) in order to invest in tracks and future programmes that need revision. At the same time, we will investigate whether new master (tracks) need to be developed, for example, for the large cohort of bachelor students that will be exiting the Amsterdam University College.

Moreover, beyond the programme re-design and fine-tuning, we will also commit ourselves to four long-term activities aimed to increase both the number of master students in the science masters in Amsterdam and their quality.

1) The international component of our science master's programmes will be further intensified and extended. More active recruitment of foreign students will be undertaken, exploiting our network of international (research) contacts and by establishing prestigious scholarships for the best foreign students within the framework of the AGSS. At the same time, Dutch students will utilize this same network to interact with international top scientists in advanced master classes or do part of their research work in other top universities outside the Netherlands. Funding is requested here for a project leader who will be responsible for both continuity as regards the current activities and for the setting up and management of new internationalisation measures.

2) A significant number of students obtaining a professional bachelor (HBO-degree, particularly in chemistry) pursue their further education at the university. Our experience so far, through recent initiatives, is that the differences in background with respect to their academic classmates are best resolved by offering them a set of dedicated premaster courses that can be included in the final year of their HBO-bachelor. This set of courses has the twofold purpose of preparing the students for the academic master, relieving deficiencies and preselecting only those students that have sufficient quality and motivation to enter the academic master. A condensed premaster track will be offered as a summer course for HBO students that do not have the possibility to follow a complete premaster year. We will use sectorplan investments to intensify the current pilot projects by appointing a HBO-coordinator, who will extend and maintain our network of HBO-schools and be responsible for the premaster tracks and summer school. Where relevant, we will export this "good practice" from our chemistry master to the master in physics.

3) Inspiring education of the future secondary school chemistry and physics teachers is a key issue for the future enrollment level in our chemistry and physics bachelors. We aspire to start a new "College for Science Teachers" for the education of high school teachers (E-variant), by combining the existing structures and facilities of the Amsterdam universities, including the AGSS. This college will also meet the strong demand to provide training programmes for "zij-instromers", who lack or posses insufficient academic background in chemistry or physics. These teaching programmes will, of course, also be used to provide academic support and feedback on the introduction of the "Nieuwe Scheikunde en Natuurkunde" that is imminent in the secondary school curricula. For this activity we need to invest in a staff member to ensure the continuity of the programme, and who functions as a first point of contact for the secondary school teachers.

4) A number of the Master students in physics and chemistry aim for a position in society which may well be related to science but is also closely associated with trade, finance, communication, public relations, etc.. Other members of the Master cohort intend to set up their own company. Students who decide from the start that they would like to integrate science with other areas are offered special bachelor programmes (Beta-Gamma, Science, Business & Innovation, Amsterdam University College), while regular physics and chemistry students can later join this '*Science+*' path by choosing a special track in the related master programmes (for example, Science, Business and Innovation). To ensure the high-quality, societal relevance and efficiency of these M- and C- Master tracks, we request funding for a dedicated staff member, operating under the aegis of the AGSS.

Investment scheme (master phase)

Coordination of joint physics and chemistry tracks	1 fte UHD level (UvA – VU)	135 kE/yr
Project internationalization	0.6 fte UD level plus expenses	161 kE/yr
Project HBO premaster and summer courses	0.4 fte UD level	44 kE/yr
Project E-variant	0.6 fte UD level	66 kE/yr
Project M and C-variant	0.4 fte UD level	44 kE/yr
Staff (3 fte) and additional budgets		**450kE/yr**

4. Policy and strategy in research (core funding)

4.1 General

The joint sectorplan bid from the two Amsterdam universities combines the best of today's research with a clear vision for the future aimed at the establishment of "Amsterdam: City of Science". This vision is not only based on the presence of two science faculties with excellent facilities like the VU Lasercentrum and facilities for the creation and investigation of quantum matter at the Van der Waals-Zeeman Institute, joint institutes like the Amsterdam Center for Multiscale Modeling and the Netherlands Institute for Systems Biology, but also on the presence of two academic medical centres, SARA and strong FOM and NWO institutes, like CWI, AMOLF en Nikhef. Altogether, this makes Amsterdam a natural research centre in science in general, and specifically in physics and chemistry.

The Amsterdam chemistry and physics departments have aligned their research efforts in order to create *focus* and *mass* in areas of proven excellence, as identified in the specific sectorplans. In these *key research areas*, many partners at CWI, AMOLF, Nikhef or medical centres AMC and VUmc actively participate, thereby contributing to the ambition of *Amsterdam: City of Science*.

The four *key research areas* in Physics in Amsterdam (see section 4.2 for details) are:
- Quantum Universe (focus area 1)
- Complex Systems, Liquids and Matter (focus area 3)
- Physics of Life and Health (focus area 4)
- Physics of Energy (focus area 5)

The four *key research areas* in Chemistry in Amsterdam (see 4.3 for details) are:
- Synthetic Chemistry & Catalysis (focus area 1)
- Computational Chemistry (focus area 2)
- Analytical Chemistry & Spectroscopy (focus area 2 and 3)
- Chemistry of Life (focus area 3)

These *key research areas* are to be found as important ingredients in the separate plans for physics and chemistry, addressing as they do both basic fundamental science issues (e.g. Quantum Matter, Life or Multiscale Modeling), as well as areas in which society looks to science to meet important needs (e.g. Energy, Health, Sustainability, Innovation). The guiding principles for the selection of the key research areas were: (i) to generate more internal synergy in (and in some cases, between) the selected research areas, and (ii) to create complementarity with and synergy in research at the chemistry and physics departments in Amsterdam. In this way, excellence in science and innovation will be encouraged and facilitated. In addition, we will further intensify the interactions with our 'natural' partners in the Amsterdam area (e.g. Life Science departments, AMOLF, CWI, Nikhef) and the AMC and VUmc. These interactions will result in a strong involvement of our chemistry and physics departments in new interdisciplinary research themes, like Energy Science and Systems Biology.

To illustrate this, together with the CWI and AMOLF, the Amsterdam universities have recently started the Netherlands Institute for Systems Biology (NISB), which is expected to play an important international role at the level of the molecular systems biology. Physics and chemistry, including multiscale modeling, are core disciplines for this endeavour and many of the top scientists in this area are actively participating in the NISB.

The key research areas also form an excellent basis of our future Amsterdam master programmes in chemistry and physics within the Amsterdam Graduate School of Science and also have an important impact on the profiles of our bachelor programmes. The proposed investments in young, top scientists will give an important boost to our teaching programmes, increasing both the quality and attractiveness. Special attention will be given to the recruitment of talented women and minorities as staff members.

The number of women in tenured positions at Dutch science faculties is low and does not reflect the changing population of undergraduate and Ph.D. students. Both Amsterdam universities have already undertaken firm action to tackle this problem and currently actively stimulate the recruitment of female talent *via* local programs, including financial stimuli (*Women in the Faculty* and *Fenna Diemer-Lindeboom chairs*). As a result, the number of female staff members is expected to increase significantly in the coming years. A first success is the recent appointment of two female professors in chemistry (Smit) and physics (Groot) at the VU. In total, in both departments of the two universities, 5.5 fte women (2.6% of all staff) presently hold tenured staff positions. With the investment of the sectorplan the universities aim to employ 17 tenured women scientists by 2016 (see appendix 1).

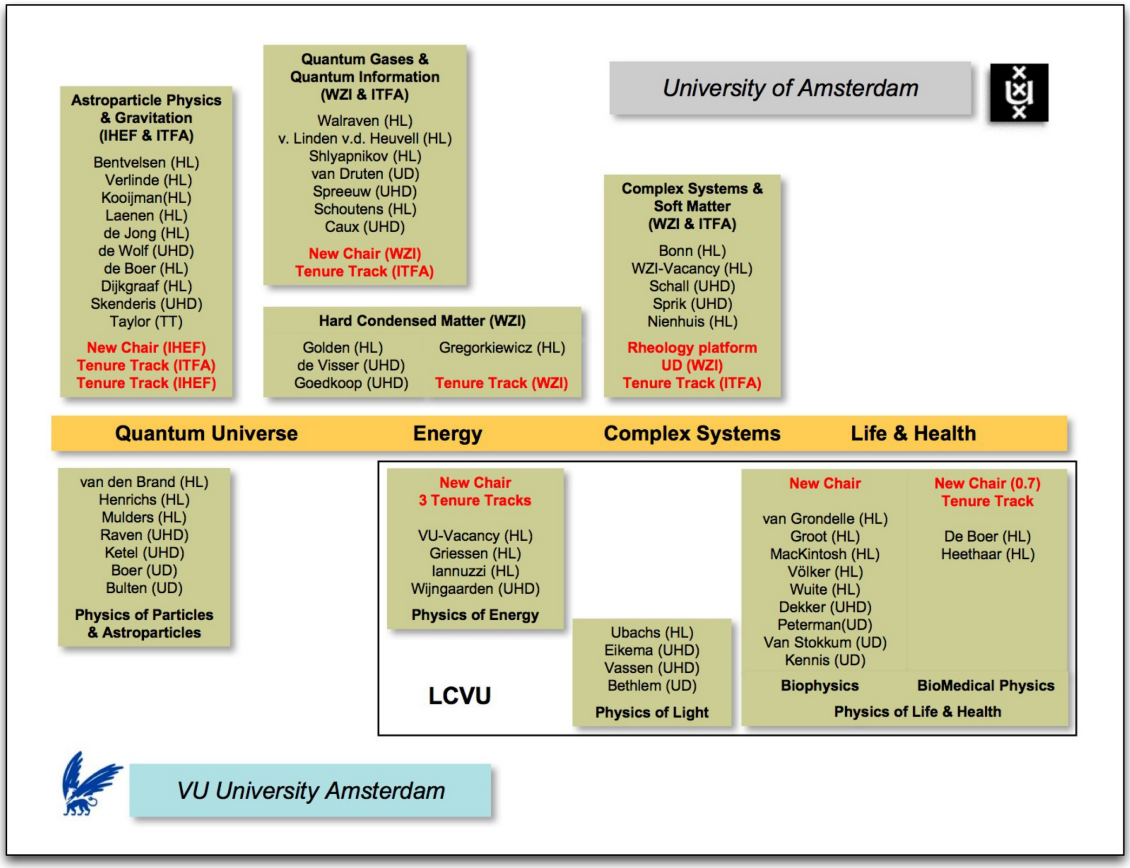
Another area of concern is ethnic minorities in the staff. Many school pupils in Amsterdam have widely differing ethnic origins (although often having Dutch nationality and therefore not registered as a “minority”) and form an interesting pool of future (under)graduate students and staff members. Both universities actively recruit “minority” students via specific (joint) outreach programmes (see section 3.1.2) and stimulate their participation in, for example, the NWO Mozaik programme. The PhD (and to some extent also the master) phase is highly international, and among young researchers from Asia, the Americas and the rest of Europe, there are also a number of recruits from the main ethnic groups seen in Dutch society. Nevertheless, our ambition is to realise a further increase in this number.

In the next paragraphs the proposed investments in the various *key research areas* in physics and chemistry will be covered in more detail.

4.2 Physics research

The Physics Departments in Amsterdam have jointly identified a number of research themes in which they seek reinforcement, aiming at establishing sufficient focus and mass in order to play a leading role on world-wide scale. The selection has been made on the basis of present excellence and of opportunities for synergy between the two universities and with the national research facilities in the Amsterdam area. In addition, expected benefits for students (Bachelor and MSc), impact on student influx and valorisation impact have been deciding factors. The selected research themes are in line with the following sectorplan Physics focus areas:

- Quantum Universe (focus area 1)
- Complex Systems, Liquids and Matter (focus area 3)
- Physics of Life and Health (focus area 4)
- Physics of Energy (focus area 5)



Key research areas in Physics in Amsterdam

The proposed investments in theoretical physics will benefit from a the coordinated Theoretical Physics Initiative of the University of Amsterdam, Leiden and Utrecht, which aims at strengthen-

ing research in theoretical physics nationwide (see appendix 4). There are important ties between the two Amsterdam universities with respect to theoretical physics research and teaching, as witnessed by common research interests (Particle and Astroparticle Physics and Soft Matter in particular) and by the joint Master in Theoretical Physics. In the following sections we present – covering each of the four relevant focus areas in turn – each of the proposed investments, and spell out how they will contribute to achieving the goals set by the sectorplan.

4.2.1 Quantum Universe (focus area 1)

The focus area Quantum Universe is clearly one that - taken together with its natural partner astronomy - has a proven track record and continued potential in providing a source of inspiration and motivation for young people to choose physics as a Bachelors degree programme. This focus area represents an Amsterdam commitment to two major themes: astroparticle physics and quantum gases/quantum information. For astroparticle physics, both universities are important partners in the Nikhef consortium and also profit greatly from the excellence of Amsterdam's astronomy research effort. In the field of quantum matter – both in its atomic and electronic form – Amsterdam is a leading player in the national research landscape. Thus, Amsterdam possesses a unique position across the full spectrum of this focus area.

Astroparticle physics

This theme unites theoretical & particle physicists as well as astronomers in searching answers to 'big questions' such as: how did our universe come to exist? What is dark-matter (and energy) and how are these issues related to the ultimately microscopic world of the subatomic particles? Here, the Amsterdam activities span an ambitious bandwidth from fundamental theoretical work – strings, the asymmetry between matter and antimatter and extreme objects such as black holes – to the experimental investigation of elusive entities such as neutrinos, gravitational waves and the Higgs boson. There is clear benefit from the leading Dutch position in experiments representing powerful consortia working in these areas with the LHC and Antares as prime examples.

The UvA's faculty of science has chosen astroparticle physics as one of her research priorities, building on a symmetrical co-operation between the institutes for theoretical physics (ITFA), high energy physics (IHEF) and astronomy (API), all in close collaboration with Nikhef. In terms of finances, the investment envisaged in this sectorplan covers two-thirds of the total research priority astroparticle physics. The remaining, substantial contribution will involve astronomy activities in the FNWI – e.g. Lofar – as well as existing neutrino research (KM3). Via the VU this focus area benefits from the unique Dutch contribution to the VIRGO interferometer as a detector of gravitational waves. In uniting behind this common priority area, the two Amsterdam universities - teaming up with Nikhef - realise an ideal embedding of this research into the medium and long-term research strategy of the Amsterdam and national physics community, thereby securing the focus and critical mass required to continue to make a globally visible contribution to this high-profile field in the heartland of physics.

Quantum gases and quantum information

Amsterdam forms the clear centre of mass of the Dutch quantum gas research effort. The two universities occupy a strong position both in experiment (five set-ups generating quantum-degenerate bosons or fermions) and theory (low dimensional quantum systems). The Amsterdam groups are the originators of the *Quantum Collective* platform, which the groups from Utrecht will join: an action catalysed by this sectorplan.

The investments proposed here aim at further strengthening the synergies between existing activities and increasing the already considerable focus and critical mass via recruitment of new PI's. An important new line of research will be quantum gases in lattices: a field about to really take off globally. On offer are perfect quantum simulators: enabling the step-wise, experimental realization of a Hamiltonian, with breathtaking control over the dimensionality, density, potentials, spin and many-body interactions in the system. Our level of ambition can be very high: the realization and experimental & theoretical investigation of potentially arbitrary quantum systems with 'designer' quantum interactions, as this new research can build upon a strong foundation in the existing Amsterdam experiments (Fermi or Bose mixtures, the use of atom chips, Rydberg states and ultra cold molecules).

The 'bridge' function of the planned new research line to the physics of quantum electron matter is very clear, as are the synergies within the field of quantum information. Quantum gases in lattices offer the exquisite control required to generate many-body states that can be exploited to investigate topological and cluster-state quantum computing, again an area in which the links to other players such as the CWI in Amsterdam and specialist groups at Microsoft and IBM will be further strengthened and exploited.

Benefits for students and impact on student influx (focus area 1)

From numerous study-choice events and student questionnaires, it is clear that today's BSc influx for the UvA's successful Physics and Astronomy programme (see appendix 3) has an important foundation in fascination for black holes & dark energy, for mysterious superconductors and for Bose-Einstein condensates. The investments proposed here, combined with the optimization of the physics bachelor programme (in this context: new, joint *in-depth* minors Quantum Universe and Quantum Matter) cater to this market, providing a clear path through to the relevant research masters, which are taught jointly by the two universities within the Amsterdam Graduate School of Science.

Valorisation impact (focus area 1)

Quantum Universe, rooted in highly fundamental research nevertheless has a track record of innovations, which, both inside and outside physics, have had an enormous impact (e.g. laser, world wide web). The Amsterdam universities are committed to broadening the horizons of their researchers and students with an eye to valorisation. Almost needless to say, the graduates conversant in the complexities of the quantum universe, be they experimentalists or theoreticians, are sought after material for the Dutch high-tech, medical and energy sectors (e.g. Shell's recent courting of theoretical physics MSc's).

Investment scheme (focus area 1)

Staff member astroparticle physics (full range)	full professor UvA (IHEF)	180 kE/yr
Staff member beyond standard model phenomenology	tenure track position UvA (ITFA)	150 kE/yr
Staff member KM3 instrumentation	tenure track position UvA (IHEF)	150 kE/yr
Staff member quantum gases in lattices	full professor UvA (WZI)	180 kE/yr
Staff member quantum gases and quantum information	tenure track position UvA (ITFA)	150 kE/yr
Additional budgets quantum gases	investments / running costs (WZI)	30 kE/yr
Staff (5 fte) and additional budgets		**840 kE/yr**

4.2.2 Complex Systems, Liquids and Matter (focus area 3)

The dynamics of liquids plays a key role in both society and industry. Within the Netherlands, the large field of classical fluid mechanics is the terrain of the Burgers Center, yet owners of rheological questions in complex liquids relevant to society and industry essentially have nowhere to go. This fact, combined with a great number of spectacular new developments in the experimental sphere means that within the Dutch academic and industrial community a great need exists for a *rheology platform*. Physicists have driven experimental innovations such as rheo-microscopy and rheo-MRI, thereby taking rheology well beyond its classical form as a straightforward measurement of viscoelastic properties, and yet the same physicists are often short on rheological background knowledge.

The mission of the proposed rheology platform is to bring together all the existing forces in this area, thus creating a multidisciplinary centre which can play a natural, national coordinating role as regards rheology and rheological research, both in terms of the measurements themselves as well their theoretical interpretation. To this end, there should not only be the necessary apparatus, but the platform should play home to the appropriate expertise enabling successful prosecution of the mostly difficult experiments on the rheology of complex liquids and their equally challenging interpretation. This investment will create supercritical mass by combining the talents of young, up-and-coming experimental groups such as those at UvA, UL, AMOLF and UT with theoretical expertise and multiscale modelling at VU, UvA and TUe, in order to be able to tackle challenging problems of great industrial relevance, such as rigidity percolation and non-affine deformations.

Amsterdam is the natural location for this initiative, thanks to the bundling of the groups at both universities, and to the international visibility they enjoy, illustrated in the Amsterdam-New Amsterdam [NY] meetings series, the existing collaborations the Amsterdam groups enjoy with practically all other interested research groups in the Netherlands, and the numerous ongoing joint research projects with Dutch and European industry partners (Unilever, SKF, Michelin, NXP, etc.). Furthermore, this Amsterdam rheological effort will also add extra value to the activities in

the focus area *Life and Health*, as the rheophysics of complex liquids is full of biological, living or life-inspired systems waiting to be investigated and understood. For example, the rheology of blood is of great relevance to numerous activities at both the AMC and VUmc.

Benefits for students and impact on student influx (focus area 3)

In view of the sectorplan's ambitious objectives regarding the growth in student numbers, we believe that the societal relevance of the rheology platform and the almost ubiquitous character of soft/complex matter in our daily lives, will attract a substantial number of new students at present choosing a study outside Physics.[4] Students following e.g. the Beta-Gamma bachelor who are not yet choosing for a physics major are an obvious hunting ground, and the evident relevance to Forensic Science (blood splashes are a nice example of the rheology of a very complex liquid) presents new avenues for the recruitment of young people looking for something different than the quantum universe clientele we cater to with such success. The two Amsterdam universities will therefore offer a joint minor in *Complex Liquids*, will facilitate study link-ups to the activities in the biomedical and 'physics for life' sectors and will provide a clear complex liquids study path through the joint MSc programme.

Valorisation impact (focus area 3)

Complex fluids research is intimately linked to real-life problems confronted in Dutch and European industry and SME's. There is no compromise whatsoever inherent in terms of fundamental interest or challenge when choosing to investigate a problem of practical, societal significance. The strengthening of the Dutch research in this area, *via* the national co-ordination and concentration of resources will be of direct and lasting benefit to Dutch industry and society, and, in turn will offer content-rich, hands-on training for young physicists in applying their particular skills to address a number of society's most pressing needs.

Investment scheme (focus area 3)

Rheology platform: diverse rheological apparatus and accessories, depreciation, pure solvents and chemicals	research infrastructure and running costs UvA (WZI)	75 kE/yr
Coordinator rheology platform: *matchmaker* function for interaction with external partners (academia, industry, SME's)	1 fte UD level UvA (WZI)	110 kE/yr
Staff member theory of complex liquids and granular matter	tenure track position UvA (ITFA)	150 kE/yr
Staff (2 fte) and additional budget		**335 kE/yr**

4.2.3 Physics of Life and Health (focus area 4)

[4] Demonstrations involving quicksand and 'walking on water' (water+cornstarch) have attracted such numbers of young people - for example in NEMO's recent contribution to the MuseumN8 in Amsterdam - that we are convinced that via this kind of theme a new group of potential students can be won for physics and for the substantial part of Dutch industry which exploits the rheology of complex liquids.

The sectorplan identifies 'Physics of Life and Health' as one of the spearheads of future research in physics. Indeed, it is the task of the physics community to provide a physical basis for the fantastic phenomenology displayed by the living world, including the relation with health and medicine. Furthermore the 21st century is identified as the 'century of the photon', with the VU-Lasercentre (LCVU) as one of the main players in the Netherlands and in Europe. The investments proposed here will guarantee Amsterdam a leading role in bringing the combination of 'life/health+photon' to maturity.

Also the Netherlands Royal Academy of Arts and Sciences (KNAW) foresees great opportunities for physics of life and health as described in their report "De appel van Newton". The goal is not just to deliver 'new technology', but to apply such technology for the study of living matter, and addressing the theme Health and Disease. Recent developments in microscopy and molecular imaging make it possible to follow metabolic processes at the cellular and even molecular level. Modeling of such processes is the challenge for Physical Systems Biology and this activity finds its ideal embedding within the NISB (UvA, VUA, Amolf and CWI). Transfer of these physical-technological developments to the hospital is a major goal. This foreseen role of physics in the study of life and health and the opportunities offered by the VU-campus explain why the VU has chosen this profile for her physics training. The fact that the Amsterdam area is the location of two academic medical centers (with their own departments of biomedical technology and physics) and two faculties of science provides a unique opportunity to create an excellent Amsterdam Physics of Life & Health cluster.

During the past decade the VU has made strong commitments in focus area 4, both in terms of reshaping the teaching programs (physics of life and energy) as well as in new staff appointments. Investments have been made in Biophysics, and Complex Systems (including a collaboration with UvA and AMOLF) and recently, Biomedical Physics research was initiated. This development is closely connected to the projected future of the section 'Fysica en Medische Technologie' of the VUmc, which plans to significantly strengthen the ties between VU-physics and VUmc.

Recently LCVU was granted 3.4 M€ by NWO to set up a facility for advanced laser-microscopy with applications in the life- and health sciences. This provides a unique opportunity to create focus and mass around the existing staff and at the interface of Physics and VUmc by installing a chair in Molecular Imaging (shared with VUmc), a position in Biomedical Microscopy and a theory chair Systems Physics of Life. Furthermore VU will create chairs in Physics of The Living Cell and in Femtophysics and Biophotonics. These appointments, coupled to the existing staff at both the VU, VUmc and UvA/AMC will indeed make Amsterdam an international centre for research and education in the area of Physics of Life and Health

Benefits for students and impact on student influx (focus area 4)

The resulting strength in research will enable an up-to-date contribution to the bachelor degree programmes, notably to the 'Life and Health'-profile. Furthermore, the new staff positions will strengthen the VU teaching in the multidisplinary, science-based programs in Medical Natural Sciences (MNW) and in Science Business and Innovation (SBI).

On the MSc level, the proposed new positions, together with existing staff at VU, UvA, VUmc and AMC, will anchor the Biomedical Physics study-path as an essential part of the joint VU-UvA masters programme, thereby creating one of the outstanding master programmes in this area in Europe. Finally, Amsterdam also fosters the ambition to play an essential role in the teaching program for clinical physicists in the Netherlands.

Valorisation impact (focus area 4)

Translating new physical concepts and methods into clinical applications is probably one of the greatest challenges of the near future. New microscopic and scanning techniques are becoming available that in combination with a systems-modeling approach will lead to a revolution in the diagnosis and treatment of disease. In VU-physics, together with VUmc, a variety of innovative projects have been initiated such as optical coherence tomography, fiber-top technology, non-linear microscopy, single cell manipulation etc. Innovation is a key element in the bachelor's programmes in physics and chemistry as well as in the new VU bachelor programme SBI. In total, these activities also motivate the appointment of a new VU professor (outside the sector-plan) in 'Physics and Innovation'.

Investment scheme (focus area 4)

Staff member molecular imaging, physical and chemical techniques, incl. clinical application	full professor VU (0.3 co-financed by VUmc)	125 kE/yr
Staff member biomolecular non-linear micros-copy for biomedical research	tenure track position VU	150 kE/yr
Staff member systems physics of life for mod-eling large, multi-component networks of in-teracting biomolecules and genes	full professor VU	180 kE/yr
Additional budgets (optics, optical tables, laser maintenance contracts)	investments and exploitation VU	100 kE/yr
Staff (2.7 fte) and additional budgets		**555 kE/yr**

4.2.4 Physics of energy (focus area 5)

In the sectorplan, physics of energy has been defined as a key research area and Amsterdam has been identified as a nucleus for new initiatives. Utilising this sectorplan as a catalyst, the Amsterdam universities have decided to position, intensify and concentrate significant research and teaching resources into the physics and chemistry of energy over the next decade. Specifi-cally, research will be focused on the discovery of new methods and materials to collect, convert and store solar energy.

Major improvements can be expected in photovoltaics through the application of recently dis-covered nano-materials, either based on new carbon structures (carbon nanotubes enhanced with catalytic components), silicon and other semiconductor nanocrystals/nanoclusters, or self-assembled nano-photonic structures exploiting the morphological and self-organizing properties of biological macromolecules like DNA or polymers. In this area, UvA's successful research into improving the efficiency of solar cells by spectral shaping and photon management using semi-

conductor nanocrystals will be strengthened, thus further boosting the Amsterdam effort brought by the complementary FOM-programme Nanophotovoltaics at AMOLF.

On the next level, many expect a revolution within photovoltaics if we can combine our fundamental insight regarding catalytic events taking place at photonic surfaces with our knowledge of the process of photosynthesis and other energy related processes in the living cell, leading to implementation in artificial energy-generating devices, including systems that could directly generate a fuel.

Finally, it must be possible - using a systems-physics/biology model of the photosynthesis - to 'engineer' a photosynthetic organism (using synthetic biology or by genetic modification) that converts solar energy with more than 10% efficiency into biomass or, even better, directly into a fuel. Here there exist obvious synergies with the focus area Life & Health and the Systems Biology focus within the Amsterdam chemistry part of this sectorplan (section 4.3.4).

We propose to use the sectorplan investments to initiate a VU-UvA Physics of Energy section, based on the current activities in VU-condensed matter and VU-biophysics and UvA-solid state physics. This consortium will form one of the pillars of the future 'VU Sustainable Earth and Sustainable Energy' Institute. Furthermore, the joint research and teaching program will be integrated with complementary activities in the departments of chemistry at both universities. These activities will form a spring plank for joining forces with biology and AMOLF to cover the whole spectrum from fundamental science to applied energy research.

Benefits for students and impact on student influx (focus area 5)

The proposed investments aim to significantly strengthen the physics of life and energy profile of the Amsterdam physics bachelor program. On the basis of these investments a master programme 'Energy Science' will be initiated. The development sketched above will lead to a significant renewal of the physics practical classes, which will combine physical knowledge with an increasing dose of concepts from adjacent disciplines.

Valorisation impact (focus area 5)

This focus area has an evident relation to the pressing societal need for a clean, sustainable energy supply. Good contacts with industry (as seen, for example, in STW, FES-nano and other grants) will both be broadened and deepened via the investments planned here. The kind of research envisaged here is also a natural feedstock for the students of the two universities' SBI and Entrepreneurship educational programmes, as part of their training in making the link between science and valorisation. The VU will appoint a professor of physics & innovation (see focus area 4) to further strengthen her initiative in this area (making a total investment of 2.5 FTE in innovation).

Investments (focus area 5)

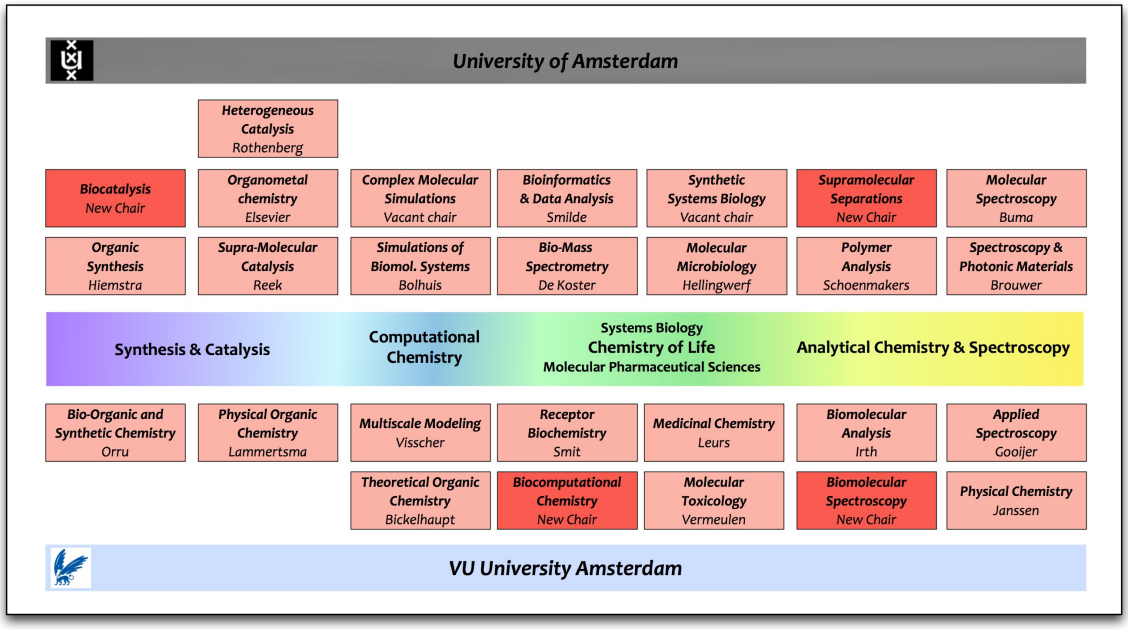
Staff member electronic properties of photonic surfaces	tenure track position VU	150 kE/yr
Staff member photonic nanomaterials, focus on artificial photosynthesis	full professor VU	180 kE/yr
Staff member nanophotovoltaics	tenure track position UvA (WZI)	150 kE/yr
Staff member bio-mimicked solar cells for solar fuels	tenure track position VU	150 kE/yr
Staff member theory of photonic materials, focus on description of electronic processes in (bio)-photonic nano-materials	tenure track position VU	150 kE/yr
Exploitation costs for solar fuels and energy-related research practicals	exploitation VU	140 kE/yr
Staff (5.0 fte) and additional budgets		**920 kEuro/yr**

4.3 Chemistry research

The Chemistry Departments in Amsterdam have decided to realign the total number of 15 research divisions under four *key research areas* that present both excellence and critical mass in chemistry at the two universities and will form the basis of our future bachelor and master programmes. Moreover, by investing in these areas of excellence the Amsterdam universities will be able to compete internationally and further boost their ambition with respect to valorisation. The four selected key research areas are in line with the Sectorplan Chemistry and the recent discussions with the Regiegroep Chemie regarding the Top Institute COAST (Analytical Chemistry & Spectroscopy).

The selected key research areas in chemistry are:

- Synthetic Chemistry & Catalysis (focus area 1)
- Computational Chemistry (focus area 2)
- Analytical Chemistry & Spectroscopy (focus area 2 and 3)
- Chemistry of Life (focus area 3)



Key research areas in Chemisty in Amsterdam.

In the following sections we will describe the suggested alignment of the chemistry resources in Amsterdam in more detail, and will show how the proposed sectorplan investments will further stimulate excellence in these research areas.

4.3.1 Synthetic Chemistry & Catalysis

The integrated study of chemical synthetic pathways and their underlying catalytic mechanisms lies at the heart of the discipline of chemistry. This discipline plays a key role in maintaining the competitive strength of the Dutch economy, *via* - amongst other processes - continued innovation within Dutch industry.

The combined activities in catalysis and synthetic chemistry possess a long history as major themes in chemistry at the Amsterdam universities. Catalysis is a key research area at the UvA, with activities in supramolecular catalysis (Reek), homogeneous catalysis (Elsevier), heterogeneous catalysis (Rothenberg), biocatalysis (Wever), photocatalysis (Brouwer) and computational catalysis (vacant chair). In synthetic organic chemistry, efforts concentrate on organocatalysis, new synthetic methodologies and on total synthesis (Hiemstra). Synergistically with these activities, work at the VU is carried out in the groups of Lammertsma (Physical organic chemistry) and Orru (synthetic and bio-organic chemistry). The Amsterdam research groups active in the field of synthesis and catalysis have acquired an excellent position with respect to participation in research schools and science council-funded programmes. They are well organized in the regional research school HRSMC, play a leading role in the central research program of the top-research school NRSCC 2009-2013, and participate in CATCH-BIO. Furthermore, particularly the catalysis groups play a leading role in NIOK and have strong ties with the Dutch chemical industry, bilaterally, but also through VIRAN.

With the aim of providing maximal leverage to the sectorplan investments, the Amsterdam universities will create a chair in synthetic biocatalysis (UvA, successor of Prof. Wever) bridging

organic synthesis and supramolecular catalysis by focussing on the development of new biocatalytic cascade processes, while simultaneously improving the predictability of biocatalysts (as recently recommended in the Dutch Biocatalysis Report). Furthermore, two associate professor and one assistant professor positions are foreseen focussing on photocatalysis (UvA; sustainable energy, together with the spectroscopy and physics groups), total synthesis of natural compounds based on innovative developments from supramolecular catalysis (UvA) and one position aiming at the rational introduction of efficiency and diversity in organic synthesis, based on inspiration obtained from medicinal and computational chemistry (VU). The new line of sustainable energy and photocatalysis research and teaching will be integrated with complimentary activities within the new 'Physics of Energy' section that will be set up between the departments of physics of both universities.

Benefits for students and impact on student influx

The existing, successful, and joint master track “Molecular Design, Synthesis and Catalysis” of the Amsterdam universities will be redirected towards “Sustainable Synthesis and Catalysis”, to provide an optimum fit to the corresponding research theme and to the interest of a large fraction of bachelor students. In addition, in the bachelor a minor in *Sustainable Chemistry* will be introduced, while in the Science, Business and Innovation bachelor *Sustainability* is one of major teaching profiles. In our outreach activities towards high school students this topic will significantly enhance the attractiveness of studying chemistry in Amsterdam.

The most talented students in this master track will be encouraged to participate in a special honours programme in catalysis, that builds upon our participation in existing European networks in catalysis teaching with contributions from top scientists from the Netherlands and abroad. This program will also be accessible for Erasmus Mundus master students in "ATOSIM/Molecular Computational Science" that have a specific interest in catalysis.

Valorisation impact

The key research area of Synthetic Chemistry & Catalysis, in particular after the investments foreseen in this sectorplan, is excellently positioned to play an important role in the area of valorisation. Through appointment of additional extraordinary professorial appointments for researchers from industry, valorisation efforts will be further intensified. This may lead to even more spin-off companies than those initiated recently, i.e. CAT-It, CAT-Fix and Yellow Diesel.

Investment scheme (focus area 1)

Investment	**Personnel**	**Funding**
New chair biocatalysis (UvA)	1 full professor + 1 associate Professor	315 kEuro/yr
Sustainable energy and photo-catalysis (UvA)	1 assistant professor	110 kEuro/ yr
Synthesis and catalysis (UvA)	1 associate professor	135 kEuro/ yr
Synthetic efficiency and diversity (VU)	1 associate professor	135 kEuro/yr
Total	**5 staff positions**	**695 kEuro/yr**

4.3.2 Computational Chemistry / Multiscale Modeling (focus area 2)

In Amsterdam the integration of computational chemistry research and teaching activities has been achieved with the start of the Amsterdam Center for Multiscale Modeling (ACMM) in 2008. The three-fold mission of this Center includes (i) the development of computational methods and models for the study of complex physical and (bio)chemical processes, (ii) init ation of collaborations with industry and academia to tackle major societal problems (in areas of energy, sustainability and health), and (iii) dissemination of cutting-edge knowledge in *Multiscale Modeling* through a challenging master curriculum and the training of PhD students. The ACMM is firmly embedded in European and national computational networks. Together with the Lorentz Center (supported by NWO and Leiden University) it forms the Dutch node of the CECAM (*i.e.* "Centre européen de calcul atomique et moléculaire") network. Nationally it has strong collaborative links with research schools like the HRSMC, NIOK and NRSC-C, and with several chemistry research groups from other universities.

The core of the ACMM is formed by the joint staff of the groups centred around Baerends, Visscher and Bickelhaupt at the VU and Bolhuis, Krishna and Frenkel at the UvA. Within Europe this combined expertise of the ACMM is unique; internationally few institutes exist of comparable depth and breadth, as is evident from accepted quality indicators in the sciences, like publication impact, recognition through prizes (Spinoza, four VICI's), memberships of academies, spin-off activities.

Particularly at the interfaces of chemistry with biology and physics, challenging opportunities appear that make it possible to use a computational approach to further progress in predictive science. This applies especially to the description of 'life', and of new, complex-, and bio-mimetic materials such as those appearing in catalysis and photosynthesis. For this reason we aim at strengthening the activities in the ACMM via three scientific staff positions, two of which will be allocated to the VU (focusing on Electronic Multi-scale Modeling and Computational Biocatalysis in order to strengthen the research groups of newly appointed professors Visscher and Bickelhaupt, respectively) and the third one at the UvA, focusing on Molecular Multiscale Modeling. This is complemented with the new chair in Biocomputational Chemistry described in section 4.3.4 that will also be an integral part of the ACMM.

Benefits for students and impact on student influx

The current international MSc program ATOSIM will form the basis, and the initial phase, for a new (inter)national MSc/PhD teaching/training program in the field of Molecular Computational Science. The Amsterdam Graduate School of Science will be instrumental in this respect. The ATOSIM master program will be at the heart of the theme of computational and materials sciences and fills a distinct gap in the current educational landscape. Furthermore, it will have an international status and aim to attract a significant fraction of students from abroad. Already now, ACMM is an important node in the European CECAM network that provides advanced training to master and Ph.D. students. By applying for an extension of the current ATOSIM programme in 2011 *via* an Erasmus Mundus grant, the program aims to attract highly qualified non-European students to the Amsterdam masters curriculum. With the AGGS in place, these activities will significantly contribute to the attractiveness and success of this new curriculum in Molecular Computational Science.

Valorisation impact

One of the "holy grails" of numerical modeling is the *de-novo* development of specific, functional (bio-)materials. Using the approach of multiscale modeling, simulation of large and complex models has now become feasible. This is of utmost importance both for industry and the health sector. The initiation of the "Multiscale Modeling Laboratory" will facilitate this transfer of knowledge-based products. The first step in this approach is the spin-off company SCM, that has already sold research software, developed at the VU, to more than 1000 industrial, academic and governmental organizations from all over the world.

Investment scheme (focus area 2)

Investment	**Personnel**	**Funding**
Staff position electronic multi-scale modelling (VU)	1 associate professor	135 kEuro/yr
Staff position computational biocatalysis (VU)	1 associate professor	135 kEuro/yr
Staff position molecular multi-scale modeling (UvA)	1 associate professor	135 kEuro/yr
Total	**3 staff positions**	**405 kEuro/yr**

4.3.3 Analytical Chemistry and Spectroscopy (focus areas 2 and 3)

Analytical sciences find widespread application in vital areas of the Dutch economy, like chemistry and polymers, life sciences, food/nutrition, health care, the semiconductor industry, safety & forensics, environment & legislation, logistics and trade & transport. Therefore, innovation in analytical sciences can be considered crucial for the quality and innovative character of the Dutch industry and society as a whole. The sectorplan cites Analytical Chemistry as being a discipline contributing to all three focus areas.

Both Amsterdam universities have a strong history and track record in the area of analytical chemistry and spectroscopy. Currently, six chairs (three in analytical chemistry, three in fundamental spectroscopy) are active in this area, whereas there are also substantial spectroscopy activities at AMOLF. The research theme comprises activities in molecular spectroscopy (Buma, Brouwer, UvA), ultrafast photodynamics and spectroscopy in the gas phase (Janssen, VU), applied spectroscopy (Gooijer, VU), polymer analysis (Schoenmakers, UvA), and biomolecular analysis (Irth, VU). Research in the area of analytical chemistry and spectroscopy is dedicated to both fundamental science (indicated by a substantial number of NWO grants such as NWO VICI, Middelgroot, ECHO, etc.) and applications, with a close connection to industry (indicated by participation in Dutch Top Institutes such as the Dutch Polymer Institute and the Top Institute Pharma). The spectroscopy groups at the VU and the UvA group molecular spectroscopy play an important role in the VU Laser Centre. Each of the three groups brings in complementary expertise that allows them to cover the full range of chemical-spectroscopic research. Recently, a consortium of both universities has been selected as lead university for the establishment of a Top Institute covering comprehensive analytical sciences and technology (TI-COAST).

Within the framework of this sectorplan, the Amsterdam universities intend to create new chairs in Supramolecular Separations and Biomolecular Spectroscopy, thereby strengthening their position in important, emerging areas, particularly in the development of analytical technologies for *functional* analysis in Material and Biological/Pharmaceutical Sciences. The Biomolecular Spectroscopy chair focuses on the development of spectroscopic techniques for the generation of structural protein information, enabling the detailed characterisation of protein-ligand interactions. This chair will further strengthen the interactions with the Chemistry of Life area (key research area 4). With the Supramolecular Separations chair, we establish a new research line for the characterization of supramolecular complexes stimulating the interaction with the Synthetic Chemistry & Catalysis and the Chemistry of Life areas. A further strengthening of the fundamental spectroscopy area is envisaged by establishing a new research line in ultrafast photonics. The focus here is on time-resolved polarisation studies for investigating structural changes in biomolecular systems. This new research line has strong interactions with the biophysical research performed in the (VU) Laser Centre (van Grondelle, Wuijte) and the new chemistry chair in Biomolecular Spectroscopy.

Benefits for students and impact on student influx

The area has a strong track record in education, with ca. 140 active or graduated master students since the establishment of the bachelor and master programmes in 2002 (see http://www.analyticalsciences.nl). With new investments in the area of separation sciences and biomolecular spectroscopy, the Amsterdam universities are able to provide a unique education program in analytical sciences - both nationally and internationally. Furthermore, a substantial strengthening of the master programmes covering Drug Discovery and Safety, Systems Biology (to be established) and Sustainable Synthesis and Catalysis will be achieved. The master of Analytical Sciences will comprise all elements of modern analytical chemistry, including quantitative (trace) analysis, structure elucidation and functional analysis of both small organic molecules and (bio)macromolecules. It is highly likely that such a Master program will attract even more than the current number of students from national and international bachelor and HLO programs. Furthermore, in the preceding joint bachelor a minor in *Forensic Sciences* will be introduced, which will significantly enhance the attractiveness of studying chemistry in Amsterdam.

Valorisation impact

The role of the Amsterdam universities in the strongly industry-funded TI COAST will position both universities optimally to act as prime partner for industry collaborations with a focus on the chemical and pharmaceutical industry. Moreover, in this area opportunities for new spin-off companies will be actively pursued.

Investment scheme (focus areas 2 and 3)

Investment	Personnel	Funding
New chair supramolecular separations (UvA)	1 full professor + 1 associate professor	315 kEuro/y
New chair biomolecular spectroscopy (VU)	1 full professor + 1 associate professor	315 kEuro/y
Ultrafast photonics (VU)	1 associate Professor	135 kEuro/y
Total	**5 staff positions**	**765 kEuro/y**

4.3.4 Chemistry of Life (focus area 3)

The key research area Chemistry of Life is embedded in the Amsterdam universities in two complementary themes, Systems Biology (UvA) and Molecular Pharmaceutical Sciences (VU). Systems biology has emerged from the application of innovative *omics* technologies (such as transcript profiling, proteomics and metabolomics), in combination with major advances made in information technology and multiscale modeling. Molecular pharmaceutical sciences is strongly focused on the molecular characterisation of drug targets, the design of new drug leads and the establishment of key toxicological and pharmacological profiles in the early stages of drug discovery and development. In recent years we have seen a strong synergy develop between the two themes systems biology and molecular pharmaceutical sciences, whereby the mutual interactions between both areas lead to novel ways to identify and validate potential drug targets and systems biology challenges.

The Amsterdam universities possess seven chairs active in the chemistry of life area (three chairs in molecular pharmaceutical sciences and four chairs in systems biology). Molecular pharmaceutical sciences represents an important part of the molecular research in the Leiden-Amsterdam Center for Drug Research and is supported by the chairs in pharmacochemistry (Leurs), computational and molecular toxicology (Vermeulen) and target & system biochemistry (Smit). These areas are further strengthened by chairs in related disciplines such as bio-organic chemistry (Orru) and biomolecular analysis (Irth). The research area is recognized nationally and internationally as a leading centre for pharmaceutical research, with substantial revenues from both governmental research programs (NWO, STW) and industry (TI Pharma, national and international pharmaceutical companies). Two spin-off companies (IOTA en Griffin Discoveries) have recently been started, demonstrating the strong valorisation potential of this theme.

The research theme systems biology has an equally strong performance record, illustrated by the recent establishment of the Netherlands Institute of Systems Biology (NISB) in Amsterdam (see section 4.1). Systems biology research is performed in the chemistry department by the chairs devoted to biochemistry of complex systems (Van Driel), molecular microbiology (Hellingwerf), biomolecular mass spectrometry (De Koster) and bioinfomatics & data analysis (Smilde). This research is further strengthened by additional chairs in chemistry (UvA and VU), physics (several research groups from Amolf and VU, see section 4.2.3), mathematics (CWI and VU groups), bio-informatics (VU) and life sciences (UvA, VU, AMC and VUmc). Research in systems biology has led to the establishment of several spin-off companies/initiatives (i.e. Chromogenics, Sensocom, Photanol, and Center for Advanced Microscopy).

To strengthen the key research area chemistry of life, the Amsterdam universities will create new chairs in Synthetic Systems Biology and in Biocomputational Chemistry. In synthetic systems biology, a new innovative research line will be established regarding synthetic systems biology of mammalian cells, which will be central to the NISB, and will focus on cellular regeneration (in medicine) and adjustment (in biotechnology). The establishment of a new chair in biocomputational chemistry creates bridges between the strong experimental disciplines in molecular pharmaceutical sciences, the new chair in biomolecular spectroscopy (see key research area 3) and computational chemistry (key research area 2, within ACMM). The main focus will be on the accurate description of interactions between protein systems (receptors, enzymes) and other actors (other proteins, ligands, light). Finally, an investment is requested in the area of Systems Biochemistry and Therapeutics in order to create a bridge between molecular pharmaceutical sciences and systems biology. The new research line is positioned within the chair of target & system biochemistry and focuses on the quantitative and computational analysis of molecular interactions involved in cell signaling pathways.

Benefits for students and impact on student influx

The new synthetic systems biology chair will play a key role in the reshaping of the master curriculum Chemistry of Life. Furthermore, we foresee a new joint masters programme in the area of Systems Biology, in combination with the 'topmaster' Systems Biology at the Life Science faculty (FALW) at the VU. The new research lines established will also result in a stronger, mutual interaction with the VU MSc programme Drug Discovery and Safety (40 BSc, 25 MSc students annually). These education programmes are very successful at present and form an important ingredient of the interdisciplinary bachelor Science Business and Innovation. The innovation in research lines and creation of synergies between systems biology and molecular pharmaceutical sciences will significantly improve the attractiveness of the entire chemistry of life Masters education at the Amsterdam universities. The groups involved will also develop a high-profile minor for the bachelor programme.

Valorisation impact

The chemistry of life topic is very well positioned to work closely together with industry (big pharma, biotechnology companies, SME's). The present spin-off initiatives at both universities underline the already strong valorisation potential of this research area.

Investment scheme (focus area 3)

Investment	**Personnel**	**Funding**
New chair synthetic systems biology (UvA)	1 assistant professor 1 associate professor 1 technician + investments	315 kEuro/yr
New chair biocomputational chemistry (VU)	1 full professor + 1 associate professor	315 kEuro/yr
Tenure track systems biochemistry & therapeutics (VU)	1 tenure track position	150 kEuro/yr
Total	**6 staff positions**	**780 kEuro/yr**

5. Budget

This sectorplan has provided the inspiration for change resulting in significant steps towards a concrete realisation of "Amsterdam: City of Science", within the physics and chemistry domains of the two universities. At the same time, it lays the basis for a real and sustainable growth in the number of students (and in the number of PhD's realised). Both of these facts underpin a consolidation, or even a growth of the income of the two science faculties, based on each university's allocation model. This win-win situation can only be realised if the unique opportunity presented by this sectorplan for physics and chemistry is grasped with both hands and exploited to the full. Commitments regarding future levels of academic staffing and budgets are indicated in appendix 1 and have a more conditional character. [5] Yet, two things can be made clear: i) that the new investments covered by this sectorplan will be made and (ii) the science faculties at the two universities will do everything in their power to keep the non-sectorplan budgets and staffing levels in physics and chemistry at the present levels, so as to ensure the 'booster' character of the sectorplan investment impulse towards further excellence and growth in both education and research.

The proposed sectorplan investments in chemistry and physics teaching, outreach and in the key research areas are tabulated in Appendix 2. In summary, the Amsterdam universities request:

- Additional support for outreach and education (e.g. NEMO lectures, ITS-Academy, PAL programmes, Beta Partners, the development of joint degrees in chemistry and physics, active recruiting measures to promote the enrolment of foreign and minority students) is requested by the two universities jointly at a level of 900 k€ p.a. in total.
- Additional support of 2650 k€ p.a. per discipline in order to enable creation of optimal focus and mass in four key research areas both in physics and chemistry, leading to a substantial strengthening of these eight areas of identified excellence in research, which in turn feeds back into the educational, outreach and valorisation programmes.

In coming to these financial figures, the two universities have used the standard rates for full (180 k€ p.a.), associate (135 k€ p.a.) and assistant professors (110 k€ p.a.) earlier agreed upon by all deans of the science faculties in the Netherlands. In addition to the standard rates, a sum of 150 k€ p.a. has been adopted for tenure track positions, which have been requested in a number of specific key research areas.[6]

[5] The budget and staff targets for 2013 and 2016 include the requested sectorplan funds in the VU factsheet, but do not include these figures in the UvA factsheet.

[6] A full *tenure track* scheme (such as that in use at the Van der Waals-Zeeman Institute) involves an assistant professor position for the first 4-5 years, plus a PhD grant (110+60 kE per annum), as 'delivery' of a dissertation within 5 years of starting is part of the evaluation matrix of the tenure track scientist. At year 5 to 6 - given positive evaluation - follows conversion to associate professor, with a view towards full professorship. Long-term average costs: 165 kE per annum. Other schemes are similar but without the prospect of a full professorship. Therefore, for the sectorplan, we adopt an average rate of 150 kE per annum per tenure tracker.

In order to reach our ambition in education, research and valorisation, the new staff members recruited to the new positions should be of outstanding quality. The natural process of recruiting can involve chains (first the full professor, then the associate and assistant professors), which can lead to financial overcapacity in the early stages of the sectorplan time-span. The Amsterdam universities would therefore like to propose to the Breimer committee to allow the use of such 'overliquidity' to invest in the necessary experimental infrastructure for the rapid and effective roll out of the new research lines within the key research area in question.

6. Milestones

The *milestones* or numerical ambitions attached to our joint sectorplan bid are largely summarized in appendix 1a (UvA) and 1b (VU).

In 2016 the Amsterdam universities aim for the following milestones:

- Full implementation of an effective outreach programme, also specifically adressing minorities and female students (at least 10% of the first year enrollment from minority groups)
- A new joint bachelor programme in chemistry
- A new joint bachelor programme in physics & astronomy
- An increase of 33 % of first year bachelor students in physics and chemistry
- An overall 70% study success in the bachelor
- An honours program in science for excellent students
- The introduction of new master tracks in our joint physics and chemistry masters
- The AGSS as effective international marketing tool for our master programmes
- An increase of 32 -50 % in the number of master students
- 8 world-class research clusters (4 in chemistry, 4 in physics), which effectively compete for (inter)national grants (EU-KP7, ERC, Vernieuwingsimpuls, FOM/CW programmes, etc).
- Increased number of female staff members
- Increased number of trained Ph.D's, including a larger percentage of females

Detailed figures, for example on the calculation of the enrollment figures for students in physics and chemistry, are available on request. As can be seen we commit ourselves to realising a growth in the total number of first year bachelor students by 33 % between 2008 and 2016, namely from 287 (2008) to 381 (2016). These absolute figures are the sum of both (physics and chemistry) cohorts, weighted per programme by a factor that describes the amount of *pure* chemistry and physics participation. At this moment – regarding the 2008 cohort – about 55 % of the freshmen are physics students and 45 % are chemistry students. We think that the ratio between the disciplines will not significantly change in the next six to eight years. From this assumption follows that in 2016 we will aim to welcome 210 freshman students in our physics programme of which 70% will follow a joint programme in heartland physics. By the same token, we strive to accommodate 171 bachelor students in our chemistry programmes by 2016, of which 60 % will follow a joint programme in heartland chemistry.

We also commit ourselves to growth in the total number of master students (all programmes are two year) of 32-50% between 2008 (295 master students) and 2016.

Appendices

1. Management data 2006 – 2016
2. Budget summary
3. Chemistry and physics programmes (bachelor and master) in Amsterdam
4. Theoretical Physics Initiative

Appendix 1a

Management data UvA

	REALISATION						TARGET					
	2006		**2007**		**2008**		**2010**		**2013**		**2016**	
	physics	**chem.**	**physics**	**chem.**	**physics**	**chem.**	**physics**	**chem.**	**physics**	**chem.**	**physics**	**chem.**
Input finance (in M€)												
• university	8.3	14.6	8.0	14.1	8.6	15.1	8.3	14.5	8.3	14.5	8.3	14.5
• Platform Bèta Techniek	0.6		0.9		1.5		p.m.		0.2	0.2	0.2	0.2
• Sectorplan									1.3	1.3	1.3	1.3
Total direct funding	8.3	14.6	8.0	14.1	8.6	15.1	8.3	14.5	9.8	16.0	9.8	16.0
Academic staff (in fte)												
• direct funding	47	73	51	68	51	65	47	63	45	60	45	60
• research grants	52	44	40	34	37	32	40	35	45	40	50	45
• contract research	2	25	3	26	3	34	3	30	5	30	10	35
Total academic staff	**101**	**142**	**94**	**128**	**91**	**131**	**90**	**128**	**95**	**130**	**105**	**140**
of which women tenured staff	1	3	1	2	1	1	1	1	3	3	4	5
of which 'allochtoon' in ten. staff	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Education												
• no. first years, total BSc	**132**		**132**		**150**		**154**		**169**		**186**	
of which: - women	38		43		52		68		74		82	
of which: - 'allochtoon'*	7%		7%		n/a		8%		10%		10%	
• total number of students	**518**		**552**		**585**		**651**		**712**		**722**	
BSc	351		405		464		511		562		562	
MSc	91		114		121		140		150		160	
old style'	*76*		*33*		*0*		0		0		0	
• no. of degrees awarded	**73**		**97**		**118**		**132**		**157**		**177**	
BSc	17		46		61		82		97		107	
MSc	23		30		43		50		60		70	
doctoraal'	*33*		*21*		*14*		0		0		0	
Research												
• total no. of PhD dissertations	6	16	10	10	11	29	12	20	13	21	14	22
of which: - by women	0	4	1	4	2	7	3	7	4	8	4	9
of which: - 'allochtoon'	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
• no. of academic publications	175	223	184	216	160	233	175	225	175	225	175	225
• impact	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

*: 'niet westerse allochtoon'

Management data VU University Amsterdam

	REALISATION						TARGET					
	2006		**2007**		**2008**		**2010**		**2013**		**2016**	
	physics	**chem.**	**physics**	**chem.**	**physics**	**chem.**	**physics**	**chem.**	**physics**	**chem.**	**physics**	**chem.**
Input finance (in M€)												
• university	5,4	6,2	4,5	6,0	4,7	5,8	4,5	5,0	4,5	5,1	4,8	5,4
• Platform Bèta Techniek	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1				
• Sectorplan							0,1	0,2	1,4	1,4	1,4	1,4
Total direct funding	5,5	6,3	4,6	6,1	4,8	5,9	4,7	5,3	5,9	6,5	6,2	6,8
Academic staff (in fte)												
• direct funding	33,4	50,5	34,3	51,6	38,9	51,3	38	52	48	54	50	56
• research grants	62,8	32,2	58,8	29,33	59,3	27,4	62	29	68	31	74	34
• contract research	8	9	9,1	12,2	9,5	18,5	10	19	11	21	12	23
Total academic staff	**104,2**	**91,7**	**102,2**	**93,13**	**107,7**	**97,2**	**110**	**100**	**127**	**106**	**136**	**113**
of which women tenured staff	1,9	1,6	1,9	1,7	1,9	1,7	2	2	3	3	4	4
of which ethnic minority. Staff	0	0	0	0	0	0	0	0	1	1	1	1
Education												
• no. first years, total BSc	**106**		**147**		**137**		**159**		**178**		**195**	
of which: - women	41		58		57		63		67		70	
of which: - ethnic minority*	6		4		2		13		18		19	
• total number of students	**476**		**548**		**575**		**605**		**685**		**772**	
BSc	348		400		401		386		414		473	
MSc	128		148		174		219		271		299	
• no. of degrees awarded	**95**		**73**		**107**		**164**		**202**		**233**	
BSc	54		44		54		96		104		115	
MSc	41		29		53		68		98		118	
Research												
• total no. of PhD dissertations	15	15	17	14	14	16	15	17	16	18	17	19
of which: - by women	3	3	4	3	2	3	3	4	4	4	4	4
of which: - ethic minority	na	na	na	na	na	na	2	3	3	6	3	6
• no. of academic publications	194	170	205	118	261	123	224	130	251	141	264	147
• impact												

* registration incomplete

Budget summary "profiling Physics and Chemistry in Amsterdam 2006 - 2016"

Appendix 2

focus area	*discipline*	*focusgebied (Sectorplan terminology)*	*UvA budget*	*VU budget*	*Amsterdam budget*
Quantum universe (#1) * Astroparticle physics * Quantum gases and quantum information	P	Quantumuniversum	k€ 840	0	k€ 840
Complex systems, liquids and matter (#3)	P	Complexe systemen, vloeistoffen en materie	k€ 335	0	k€ 335
Physics of life and health (#4)	P	Fysica van levensprocessen en gezondheid	0	k€ 555	k€ 555
Physics of energy (#5)	P	Duurzame energie en chemische biotechnologie	k€ 150	k€ 770	k€ 920
budget summary Physics research			*k€ 1325*	*k€ 1325*	*k€ 2650*
Synthetic chemistry and catalysis (#1)	C	Duurzame energie en chemische (bio)technologie	k€ 560	k€ 135	k€ 695
Computational Chemistry / Multiscale Modeling (#2)	C	Materiaalwetenschappen, fysische chemie en nano	k€ 135	k€ 270	k€ 405
Analytical chemistry and spectroscopy (#2 + #3)	C	Materiaalwetenschappen, fysische chemie en nano	k€ 315	k€ 450	k€ 765
Chemistry of life (#3)	C	Levens- en biomedische wetenschappen	k€ 315	k€ 465	k€ 780
budget summary Chemistry research			*k€ 1325*	*k€ 1320*	*k€ 2645*
Bachelor programmes	P+C	actielijn onderwijs	pm	pm	*k€ 450*
Master programmes	P+C	actielijn onderwijs	pm	pm	*k€ 450*
budget summary education			*pm*	*pm*	*k€ 900*
budget summary Amsterdam plan			***k€ 2650***	***k€ 2645***	***k€ 6195***

Overview of bachelor and master programmes in Amsterdam (per September 1, 2008) Appendix 3

university	*faculty*	*CROHO number*	*programme*	*phys & chem signature*	*fulltime or parttime*	*credits (ECTS)*	*start date programme*	*accreditation descision date*	*accreditation expiration date*
UvA	FNWI	50012	B Bio-exact	50 - 65% *	VT	180	1-sep-2003	8-apr-2008	31-dec-2013
UvA	FNWI	50250	B Betagamma	10 - 65% **	VT	180	1-sep-2003	19-mrt-2008	31-dec-2013
UvA	FNWI	56857	B Scheikunde	100%	VT	180	1-sep-2003	8-apr-2008	31-dec-2013
UvA	FNWI	56984	B Natuur- en Sterrenkunde	100%	VT	180	1-sep-2003	28-mei-2008	31-dec-2014
UvA	FNWI	60202	M Physics	100%	VT	120	1-sep-2003	28-mei-2008	31-dec-2014
UvA	FNWI	60225	M Life Sciences	50%	VT	120	1-sep-2003	29-apr-2005	28-apr-2011
UvA	FNWI	60232	M Mathematical Physics	50%	VT	120	1-sep-2003	5-nov-2008	31-dec-2014
UvA	FNWI	60338	M Forensic Science	60% ***	VT	120	10-nov-2006	5-jun-2006	4-jun-2012
UvA	FNWI	66857	M Chemistry	100%	VT+DT	120	1-sep-2003	8-apr-2008	31-dec-2013
VU	FEW	56857	B Scheikunde	100%	VT	180	1-sep-2002	14-apr-2008	31-dec-2013
VU	FEW	56984	B Natuur- en Sterrenkunde	100%	VT	180	1-sep-2002	13-okt-2008	31-dec-2014
VU	FEW	56989	B Farmaceutische Wetenschappen	100%	VT	180	1-sep-2002	23-apr-2008	31-dec-2013
VU	FEW	50800	B Medische Natuurwetenschappen	80%	VT	180	1-sep-2002	14-apr-2008	31-dec-2013
VU	FEW	60202	M Physics	100%	VT	120	1-sep-2003	28-mei-2008	31-dec-2014
VU	FEW/FALW	60616	M Biomolecular Sciences	50% ***	VT	120	1-sep-2002	21-feb-2007	31-dec-2013
VU	FEW	60800	M Medical Natural Sciences	75% ***	VT	120	1-sep-2004	14-apr-2008	31-dec-2013
VU	FEW	66857	M Chemistry	100%	VT	120	1-sep-2003	8-apr-2008	31-dec-2013
VU	FEW	66989	M Drugs Discoverry and Safety	100%	VT	120	1-sep-2002	23-apr-2008	31-dec-2013

* Afhankelijk van de invulling van de vrije keuzeruimte in de opleiding.
** Afhankelijk van de gekozen major. De meerderheid van de studenten kiest een major Scheikunde of Natuur- en Sterrenkunde. Voor hen geldt het maximum percentage.
*** Afhankelijk van het bachelor diploma. Een deel van de studenten heeft een Scheikunde of Natuurkunde achtergrond. Voor hen geldt dit percentage.

Appendix 4

THEORETICAL PHYSICS INITIATIVE
IN THE SECTORPLAN NATUUR- EN SCHEIKUNDE

This brief document presents the case for a coordinated Theoretical Physics Initiative, and summarizes how the initiative, though developed independently of the *sectorplan Natuur- en Scheikunde*, is proposed to fit in and contribute to the *profileringsplannen* prepared by the deans of the Science faculties at the Universities of Amsterdam, Leiden and Utrecht. This document after the fine-tuning based on the exchange of ideas with the deans is intended as a joint appendix to be included in the individual *profileringsplannen* of the three universities. The main commitment of the Theoretical Physics Initiative, coordinated among the three major Institutes for Theoretical Physics, will make a significant contribution to the goals set out in the sectorplan.

Theoretical Physics Initiative

Theoretical physics embodies the human strive for knowledge about the physical world. Invoking the power of mathematical methods it aims to describe physical phenomena from the tiniest elementary quantum particles to the vastness of our universe as a whole in terms of elegant theoretical frameworks with general applicability. Its groundbreaking ideas – from black holes to quantum teleportation – continue to fascinate young people and the general public alike and provide a magnet for some of our most talented and creative students. Subjects from theoretical physics, taught by theoretical physicists, constitute key components in the current physics bachelor education, and students who have specialized in theoretical physics are in high demand in a range of professions because of their imagination, versatility and analytical skills.

The individual Institutes for Theoretical Physics at the Universities of Amsterdam, Leiden and Utrecht are recognized as world class. The current generation of scientists carries on a century-long tradition of excellence, expressed also in several Nobel prizes. The core interests of the three institutes branch out into complementary research directions that are mutually enhancing. Taken together, they cover a very substantial part of the whole field of theoretical physics. Cooperative relations among the three institutes have always been strong, while at the same time their theoretical physics research is increasingly embedded in themes and focal areas identified and stimulated within the local settings of the three universities.

The core recommendation to the deans is to each include in their profileringsplan three faculty positions in theoretical physics, coordinated both within the Theoretical Physics Initiative and within the local settings of research and teaching in the three departments.

Towards a joint institute for theoretical physics

The present Theoretical Physics Initiative is closely linked with the establishment, in due course, of a joint institute for theoretical physics, which will serve as a common platform for cooperation and coordinated activities in research, education and outreach. Together the three institutes will constitute one of the premier research institutes of theoretical physics in the world and a major European player in attracting and retaining top students and researchers. This effort is critical to consolidating and increasing the influx of national and international students into physics Bachelor and Master programs, maintaining past and current highest standards in research excellence, and preserving the attractiveness of choosing a career in the natural sciences. Implementation of the Theoretical Physics Initiative will represent a major boost towards these goals. The plans for the joint institute for theoretical physics are presently being worked out. Already now the three theory institutes have collaborations and organize joint courses with other institutes and universities. Such collaborations will be intensified, and their impact will be strengthened by the foundation of the joint theory institute. For this purpose an associate membership status will be created for relevant theory groups at other institutions, as well as a special visiting fellowship for colleagues of the Dutch theoretical physics community outside the three institutes.

Below we summarize the implications for the *profileringsplannen* and how the initiative will contribute to achieving the specific goals of the *sectorplan.*

Theoretical physics research: quality, focus and mass

The coordinated hiring of three times three faculty members will represent a crucially needed structural strengthening of theoretical physics in the Netherlands. The proposed reinforcements will be sought in the following three areas

- Theoretical high-energy physics and cosmology;
- Quantum matter and quantum computing;
- Soft condensed matter and physics of life processes.

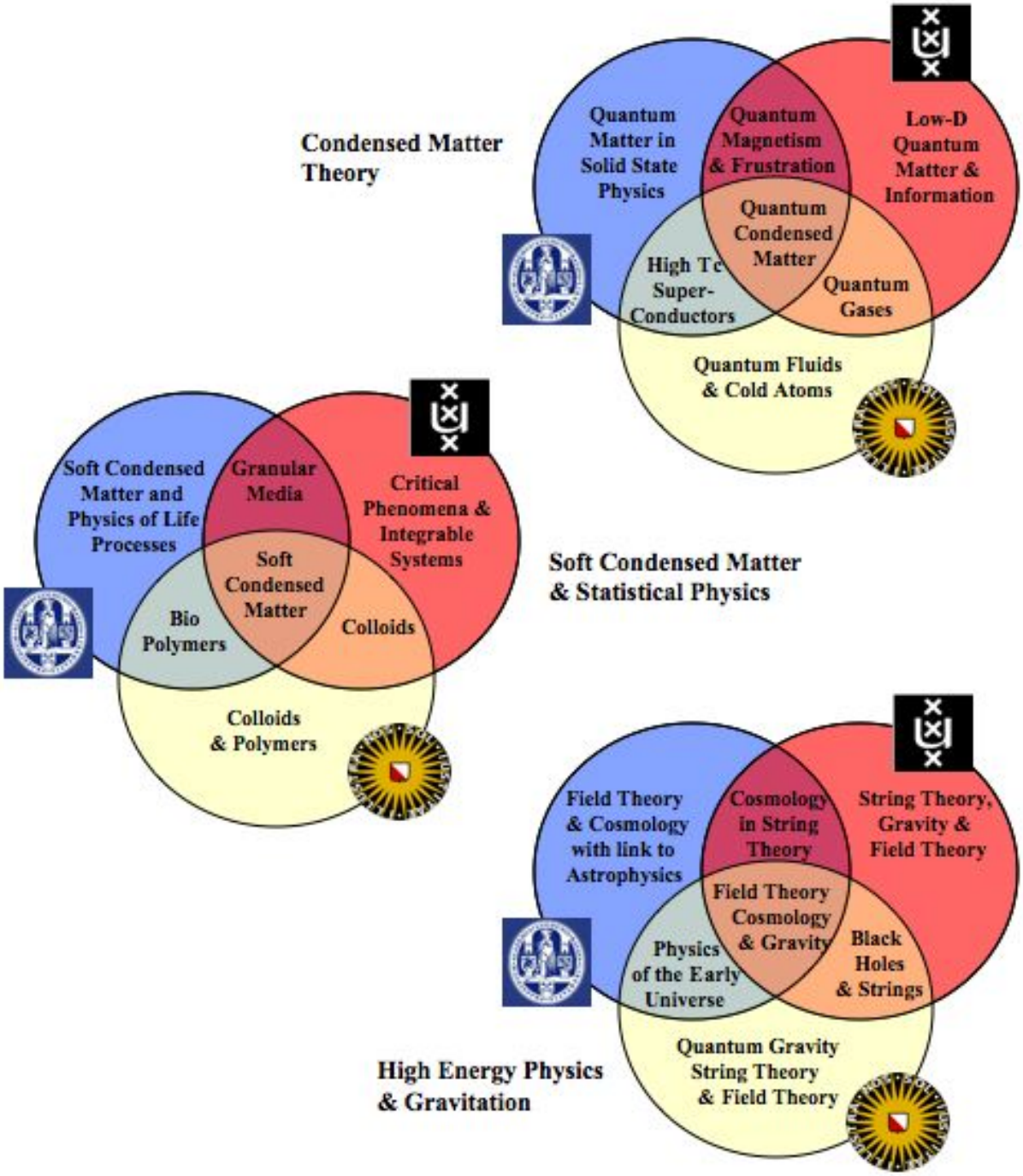
These fields directly connect with the focus areas identified in the *sectorplan*: Quantum universe (high-energy physics and quantum matter), Nanophysics and technology (quantum computing), Complex systems, fluids and matter (soft condensed matter) and Physics of life and health. In addition, these three areas offer excellent opportunities for multidisciplinary ties (within physics and beyond). The enclosed figure illustrates the existing strengths of the three institutes in these areas. Close coordination in hiring of permanent staff will avoid duplication and help enhance the unique scientific profile for each of the institutes, while optimizing complementarities and maintaining coherence in the overall effort. Increasing the number of women in theoretical physics is an explicit goal, with the UvA committing to hiring at least one woman as a faculty member in theoretical physics.

Education

The newly recruited staff will help to attract and accommodate an increased influx of Bachelor, Master and PhD students in the Physics Departments of each one of the three universities and contribute to internationalization in both the Bachelor and Master programs. Coordination of Master level teaching will give students access to a highly diverse and attractive range of courses. The label of a joint institute will enhance the (inter-)national visibility of Dutch theoretical physics, and support its recruiting efforts from among “the best and brightest” students. One realistic ambition, to which the initiative will commit itself in order to achieve the goals of the *sectorplan*, is a total influx of at least 90 Master students per year in the Master programmes (up from around 60 as of 2008), another is a target of a yearly total of 18 PhD’s in theoretical physics (up from around 12) at the three institutes. It should be noted that the success rate of students specializing in theoretical physics at Bachelor, Master and PhD level tend to be well above average. Society will clearly benefit from an increased number of students graduating in theoretical physics, because of their unique skills that are applicable in a wide range of professions in the innovative job market.

Public awareness

Theoretical physics has great potential as a ‘crowd-puller’ as witnessed by the public appearances of Gerard ’t Hooft, Robbert Dijkgraaf, Carlo Beenakker and others. Coordinating such efforts and presenting them from a joint, national platform will further raise their profile with the general public, and the young in particular. In this way the Theoretical Physics Initiative presented in this document can make an important contribution to establishing ‘Science as Culture’, and increasing the public awareness of the power and beauty of the scientific method and its crucial role in innovation.


Condensed Matter Theory
Quantum Matter in Solid State Physics
Quantum Magnetism & Frustration
Low-D Quantum Matter & Information
Quantum Condensed Matter
High Tc Super-Conductors
Quantum Gases
Quantum Fluids & Cold Atoms
Soft Condensed Matter and Physics of Life Processes
Granular Media
Critical Phenomena & Integrable Systems
Soft Condensed Matter
Bio Polymers
Colloids
Colloids & Polymers
Soft Condensed Matter & Statistical Physics
Field Theory & Cosmology with link to Astrophysics
Cosmology in String Theory
String Theory, Gravity & Field Theory
Field Theory Cosmology & Gravity
Physics of the Early Universe
Black Holes & Strings
Quantum Gravity String Theory & Field Theory
High Energy Physics & Gravitation