REPORT OF THE INTERNATIONAL SCIENTIFIC ADVISORY COMMITTEE NOVEMBER 2017

Members of the InternationaL Scientific Advisory Committee (ISAC) spent Nov 21 – 23 visiting SISSA. During this time we listened to presentations from the Director, from the co-ordinators of the Research Areas, and from faculty running the PhD courses. We visited several groups and labs and talked to representatives of the PhD students and the post-docs. We enjoyed poster sessions presenting the scientific work of the Institute.

We would like to thank the Director and all members of SISSA for their willingness in explaining the many facets of their institution, for their patience in answering very many questions, and for their kind hospitality. We are also grateful for the excellent organisational support from the Director's office.

In our view ISAC's primary role is as an advisory committee, not a way to evaluate individual scientists. Indeed the latter role was recently undertaken by ANVUR and we agree that SISSA fully deserves the excellent ranking obtained in that exercise. The faculty is working at an international level, and many of them are world-leading scientists. There has been impressive success in the most prominent European grant competitions. Indeed SISSA lives up to its role as a flagship institution for Italian graduate training and research.

Many instances of success and international standing are covered in the individual reports on Groups. The founding of Mathlab and the Mechatronics initiative have contributed to the breadth of SISSA research. Links with industry and the surrounding community are being forged. SISSA has attracted several new, outstanding faculty, and the list of final destinations of the PhD students underlines the excellence of both the students SISSA can attract and the PhD programmes.

However, as with any institution SISSA must move forwards and adapt to maintain and improve its standing in a fast-moving and increasingly international environment. ISAC suggests that careful consideration be given to the following:

A. STRATEGIC PLANNING

SISSA is both a graduate school and a research institute and excellence in both is vital. However at present the research structure of SISSA and the graduate courses are too tightly linked. This is tending to have negative effects, most obviously:

- hiring driven by existing teaching needs, rather than research opportunity and excellence. There is the danger that this will hinder the development of research to address the most interesting science.

- teaching that is too tightly defined by the needs and interests of the small group of scientists running a given PhD programme.

- a tendency for the faculty to splinter into small units.

Planning should be driven by research. Outstanding graduate teaching in areas at the forefront of modern science will then follow from the excellence in research.

We recommend that

1. a forward-looking research strategy for SISSA should be constructed at an institutional level. This should aim to identify the innovations and appointments needed to ensure excellence in research across the institute. We suggest 5 and 10 year rolling strategic research plans that are flexible and are updated each year. Although the plans should be realistic, they should not be primarily financially driven. Having them in place will enable a proactive and quick response if additional funding becomes available. The optimal size of the faculty, and implications for space and other resources should form part of the strategic plan.

2. the new directions for hiring should be planned at an institute level with a careful eye to making bridges between the different groups.

3. a radical suggestion, but one which the committee thinks that should be considered, is that the close administrative link between research groups and PhD programmes should be weakened or removed.

4. **Data science appointment:** ISAC applauds the measures that SISSA is taking to ensure that the forthcoming appointment in data science is made very carefully so that the new faculty member can fulfil a bridging role between various groups. Moreover a course in data science, which could bridge PhD's, might be more attractive in the short term than a new PhD with only superficial links to existing programmes.

B. INTERACTIONS

We think that the relative lack of interactions at SISSA is a major factor inhibiting the ability of the faculty to perform even better science. This appears true at every level: there is too little interaction between one PI group and another PI group, and also between one area and another. Finally, the interactions between PI, postdoc and student within a single PI group should be as extensive, and informal as possible, and should not be based only on hierarchy.

5. We would like to encourage both formal and informal interactions to take place both vertically and horizontally between the different parts of the SISSA community. Ideas how this might be achieved include:

- journal clubs and reading groups, particularly those led by students and post-docs, especially those from different areas. It is often a good idea for these to be time-limited so they do not die out.

- we applaud the current initiative to provide common spaces for discussion and for coffee/lunch

- interdepartmental seminars with food

- joint outreach activities

- a small fund to support inter-area initiatives (at the level of cakes provided for journal clubs)

- student-led activities, such as seminars with speakers invited by students

- cross-area thesis committees (see 8 below)

- careful thought about office allocation, so that students from different groups share rooms

- informal events such as football tournaments or BBQs

C. THE PHD PROGAMMES

Many of the PhD programmes are of a high standard so changes should be planned carefully, and we understand that the format of the PhD programmes at SISSA is constrained by national regulations. We also take the point that students equate specialisation with excellence and the current structure helps to attract outstanding students in many areas. However, SISSA should consider the advantages that a broader training might contribute to the cross-fertilisation of research ideas and the adaptability of their graduate students. Different subjects are diverse, and it is quite appropriate that different PhD programmes are run in different ways. SISSA should celebrate and exploit its diversity.

6. ISAC thinks that future proliferation of PhD programmes is unhelpful; rather there should be strategic planning aimed at harmonisation and co-operation across programmes. Systems of credit could be structured to encourage interdisciplinarity. (The demands of admissions can be partly decoupled from what happens when the students arrive.) In many cases a broader training, at least at first, would provide the students with a wider outlook on science and encourage interdisciplinary ideas.

7. If SISSA is to continue to be regarded as an internationally leading PhD school efforts must be made to increase the number of non-Italian members at every level. This will also increase the pool of strong candidates for PhD programmes and post-docs. The following might help:

- work out the best timing of admissions and acceptances to fit the norm of other countries (eg in much of Europe PhD places are settled by early spring before graduation and students will take other offers rather than wait for the SISSA admissions procedure).

- advertise in countries where strong students find it hard to obtain PhD funding (eg Iran, India): perhaps a 'publicity slide' could be prepared for those giving talks abroad?

- The style and content of any entrance exam should be considered carefully, asking whether it is deterring students and whether it allows choosing appropriate students. Students who are well trained formally do not always equate to the best research scientists, and SISSA has the resources and flexibility available to fill in gaps in the background of a promising graduate student.

- The pre-doctoral Fellowship programmes are a good idea but should be monitored to assess how effective they are. However, even if they don't lead to SISSA applications, they are providing interesting learning experiences.

- Keep a breakdown of students by nationality, and make a concerted effort to understand local barriers to applying to SISSA by talking to current students.

- In adverts stress that SISSA is an EU as much as an Italian institution.

- The impressive list of graduate destinations could be made available on the web page and referred to in any call for applications.

- An alumni association could provide mentoring and links abroad.

8. Appointment of the Ombudsmen was a substantial step in the direction of helping PhD students who have difficulties. However some students are worried that any action to help might exacerbate an already difficult student-supervisor relationship.

A way of overcoming this might be for each student to have a thesis committee as is now common in most universities in the US. This could be a secondary supervisor working in a related field, but distinct PhD programme, who would be able to identify difficulties at an early stage, and write reference letters for the student, or a more extensive committee who would also be responsible for the annual meeting to consider progress. This would also be an opportunity for faculty to learn about the progress and research topics of students in different PhD programmes and hence facilitate interactions between senior researchers.

9. We recommend that SISSA limit the number of PhD students that each PI can supervise at any one time. This would ensure that each student receives sufficient supervision. The limit could be adjusted at the discretion of the Director, if there is evidence that a PI is able to increase their supervision load without compromising quality and attention to students' academic needs.

10. It is an important role of supervisors to encourage independence in their graduate students and post-docs. We encourage SISSA to develop ways to help young scientists to become independent, to work on their own ideas and to enhance their career progression. In particular, we suggest that SISSA consider the following:

- a mentoring scheme, in which early career researchers meet regularly with a neutral mentor at a more senior level from a different PI group, and focussing particularly on navigating the transition to independence,

- encouraging students and postdocs to visit other labs outside SISSA as part of research collaboration, taking advantage of the several Memoranda of Understanding with other institutions internationally,

- training in soft-skills, which can also be used as a way to encourage cohort building within year groups but across disciplines.

11. Several students made the point that their travel funding is limited, and often linked to their supervisor's research income. We recommend setting up a fund that the students can apply to for travel funding via a light-touch application procedure with deadlines, say, every three months.

12. Minor points raised by the students and post-docs include:

- students and post-docs, especially those from non-EU countries, would appreciate more help with Italian bureaucracy to ensure their scientific potential is not limited.

- they appreciate scientific visits and would enjoy more emphasis on collaboration.

- there were occasional problems with the queuing system on Ulysses.

- post-docs would appreciate more opportunities to teach.

- post-docs also asked for more representation on committees. ISAC felt that, although they should be consulted on relevant matters, committee work should be kept to a minimum at this stage of their careers.

13. Masters programmes should be considered carefully. They are a good way to connect with local Universities and attract and evaluate PhD applicants. Set against this, the students attracted are usually local, not international, the

programmes may change the elitist image of SISSA, and they can be a lot of additional work. We recommend periodic reviews with the aim of terminating those not working.

D. DIVERSITY

14. Although there is acknowledgement that the low number of women at all levels is a problem, ISAC is disappointed to see that concrete efforts to address this are still limited. There is no quick fix, but adopting best practice does appear to slowly give results. We suggest that the agenda be driven forward by the appointment of an academic responsible for diversity issues who is given the time and resources to define and implement an action plan.

Resources that might be useful are the Athena Swan awards: see http://www.ecu.ac.uk/equality-charters/athena-swan/ where departments gain a bronze, silver or gold award depending on a self-evaluation document and their adherence to defined criteria. Preparing submissions for the award raises self-awareness and it has now become a matter of pride for departments in the UK to gain recognition.

There is also a growing awareness of the role of unconscious bias in decision making and it is becoming increasingly common for universities to insist on training to make interviewers and decision-makers aware of this. In particular the Royal Society has recently been doing a lot of work in the area, see https://royalsociety.org/topics-policy/publications/2015/unconscious-bias/

15. The soft skills sessions for graduate students should include unconscious bias training and diversity awareness. Post-docs and faculty could usefully be included at least once.

16. We recommend hiring out of sequence if an appropriate female candidate becomes available, i.e. to a post which is planned to be filled in a few years rather than immediately, such as appointing an early successor of a retiring faculty. This would be a good use of special funds.

E. OTHER COMMENTS

17. **Industrial links:** ISAC applauds the current initiatives to engage with local industries and communities. However the balance of this activity and more traditional SISSA scientific activities should be carefully monitored. Links should be driven by the goal of identifying scientific advances in SISSA which can be useful in technological applications and ensuring that the connections and knowledge are in place to fully exploit these. Often real world problems can, in return, initiate interesting ideas for advances in all three of SISSA's Areas, mathematics, neuroscience and physics.

There is currently a long list of initiatives and, given finite time and resources, there will be the need to evaluate which are working best and to concentrate on these. A practical rule of thumb might be that initiative must be interesting to a member of the SISSA faculty. We note that income from industrial initiatives will be minor compared to the SISSA block grant and National and EU research funding so it is important that the fundamental nature of SISSA research is not obscured by a role in technology transfer in the eyes of the Government.

18. **International agreements**: SISSA has an enormous number of 'agreements' with other universities. These do not imply internationality per se, but are an important resource for student travel if used. They should be pruned to a lower number of useful agreements where there are concrete outcomes in terms of scientific collaborations or the possibility of obtaining additional funding for travel.

19. **fMRI** The current contract whereby SISSA pays a considerable sum to use fMRI facilities at Udine is not working as access is being restricted. This is a vital facility for Neuroscientists and the situation must be rectified as a matter of urgency, either by restoring the functioning of the current contract, or by finding a different imaging facility for SISSA's use.

PHYSICS RESEARCH AREA

The **Astrophysics Research Group** (AP) has active and strong research programs in a broad range of topics including stellar evolution, compact objects, gamma-ray bursts, galaxy evolution, galaxy clusters, astrophysical probes of dark matter, dark energy, and the cosmic microwave background and foreground emission. The AP is certainly Italy's leading institute in theoretical astrophysics, and is widely visible in Europe and beyond. The success of the group is also reflected by ample external funding that the group members bring in.

A significant portion of the group activities is on data analysis and theoretical insights and interpretations provided to observational programs. Today in astronomy worldwide there is a growing trend to form bigger collaborations, with individual contributions becoming less visible. The AP did not fall for this trend: they are not simply absorbed into large collaborations but play visible roles in the collaboration by providing key theoretical/interpretational inputs. It seems to us that this has been a correct strategy for preserving the SISSA's distinctiveness. The AP should continue to monitor the balance between participation to large collaborations (e.g., Euclid, Square Kilometer Array) and SISSA's visibility.

The AP maintains a strong connection and collaboration with the Astroparticle Physics Research Group (APP). They are engaged in the planned hiring of a gravitational wave scientist at the APP, and are jointly pushing a new initiative of

"Institute for Fundamental Physics of the Universe". We strongly endorse these collaborations and joint initiatives.

In parallel to the hiring in the APP, the AP plans to hire a scientist in a broad area of Multi Messenger Astrophysics. This is a timely proposal and should be pursued. We recommend that the AP look at candidates broadly without specifying narrow subfields in the Multi Messenger Astrophysics. It would also be good, if possible, to avoid too much scientific overlap with Prof. Celotti, to maximize the impact of a moderately-sized group of the AP.

The **Astroparticle Physics Research Group** (APP) is unique and well-positioned to have an impact in the exciting new field of Multi Messenger Astrophysics. There are not many research groups in the world which are focused on Astroparticle Physics. The GRAPPA (Gravitation Astroparticle Physics Amsterdam) institute in the University of Amsterdam, CCAPP (Center for Cosmology and Astroparticle Physics) in Ohio State University, and the Theoretical Astroparticle Physics group at the Max Planck Institute for Physics come to our mind, but not many more.

The APP covers a broad range of research topics in Astroparticle Physics including the search for dark matter at collider, indirect detection of dark matter, cosmic rays, high-energy neutrinos, and cosmological effects of neutrinos and warm/fuzzy dark matter. The recent detection of gravitational waves from colliding neutron stars completes Multi Messenger Astrophysics: we can now use electromagnetic waves, cosmic rays, neutrinos, and gravitational waves to probe the Universe. We fully endorse APP's plan to hire a scientist in the area of fundamental physics with gravitational waves.

With appointment of Prof. Matteo Viel in December 2016 and (hopefully) successful hiring of a gravitational wave scientist, the APP will have a critical mass. It has a potential to become the center for Multi Messenger Astrophysics; namely, the APP can become "the place to go to" to do research in Multi Messenger Astrophysics. At the moment the members of the APP use one or two messengers to study specific targets, e.g., gamma and cosmic rays to study dark matter annihilation/decay (Ullio), high-energy neutrinos to probe Lorentz violation (Liberati), large-scale structure to probe the nature of dark matter (Viel), but they can seize this opportunity to use all the messengers to have an impact in the field.

In addition to being a unique research group on its own, the APP collaborates strongly and effectively with the Astrophysics Group (AP; Baccigalupi, Salucci) and the Theoretical Particle Physics Group (TPP; Percacci, Petcov, Romanino) at SISSA, as well as with the Abdus Salam International Centre for Theoretical Physics (ICTP; Creminelli) and the Trieste Observatory (Sefusatti). The positive impact of the APP on these groups is obvious, and this is one of the strengths of SISSA's Physics Research Area. They also act as a "bridge" (or "gluons") between AP and TPP. Other universities/research institutions also try to promote an effective collaboration between astrophysics and particle physics groups, but

they often do not succeed. SISSA's APP is one successful model, which the others would envy. The research in APP is supported well also by external funding.

Together with AP, the members of APP are pushing a new initiative "Institute for Fundamental Physics of the Universe". They are fully committed to this initiative, and the participating members of TPP support it. The ISAC strongly endorses this joint initiative.

The **Theoretical Particle Physics Group** (TPP) comprises 9 staff members, 22 PhD students and 8 postdocs. 6 staff members of the Istituto Nazionale di Fisica Nucleare INFN) and of ICTP are affiliated to the group, and collaborate on all activities. The three recent INFN hires integrated in the group (Marzocca, Nardecchia, Urbano), are a superlative addition and strengthen the group's profile in beyond the Standard Model and collider physics. The fraction of non-Italian students is large, at 45%, reflecting the international visibility of the group.

The group's research covers a very rich and very diverse spectrum of topics, from phenomenology to the non-perturbative structure of field and string theories. In all its subjects, the TPP group works on problems at the forefront of the research, and enjoys strong international collaborations and undisputed international leadership, as confirmed by a solid publication and citation record, and by the invitation of TPP scientists to all major international workshops or conferences. This environment provides the ideal conditions for a structured and broad curriculum of PhD studies. The faculty offers a total of 600 hours of lectures distributed over several courses, which cover the foundations (quantum field theory (QFT), Standard Model (SM), group theory, etc) as well as more advanced topics (physics beyond the Standard Model, conformal field theories, string theory, AdS/CFT correspondence, etc). Several of the basic courses (eg QFT and SM) are also attended by astroparticle physics students. The overall lecture programme is a fantastic resource, and a system of credits ensures the proper balance between courses providing the required common basic knowledge, and those building the more specialized skills necessary for advanced research. The students often follow courses from other groups in the Physics area and from Mathematics. This is positive, and we think it should be formalized with the explicit requirement that all students should include at least one course in their curriculum outside of the TPP group. The lectures' schedule should be properly coordinated with the other groups, to limit the possible conflicts among courses of broad interest. We praise the introduction of the visiting student programme, which allows PhD students from other institutions to follow one term of lectures at SISSA.

The TPP group holds seminars and journal clubs on a daily basis, reflecting the diverse research directions covered by the group. The Wednesday seminar is however colloquium-style, accessible to all group members. All the events are held in conjunction with ICTP, occasionally at ICTP. TPP acts as a well-integrated team, in spite of the diversity of its research. It enjoys fruitful collaborations with other groups within the Physics area, with Geometry and Mathematics, and with

the nearby Institutions (University of Trieste, INFN, ICTP). These lead to sharing or co-organization of lecture series, workshops, or joint supervision of students. We fully endorse the creation of the Institute for Geometry and Physics, which will strengthen the cooperation with ICTP. TPP will also greatly benefit from the creation of the Institute for Fundamental Physics of the Universe. In view of the forthcoming retirement of Professor Petkov, we support the TPP's desire to maintain active the crucial activity in neutrino physics, via a dedicated faculty appointment. We encourage the group to initiate a search as soon as possible, and to exploit possible opportunities, particularly if they can contribute to improve the gender balance of the group.

The **Molecular and Statistical Biophysics Group** comprises 4 PIs. They form a relatively young and dynamic group who are publishing in leading journals and receiving invitations to speak at international meetings. They use a range of numerical approaches to study biopolymers such as DNA and RNA at both molecular and coarse-grained levels. A particular highlight of the past review period is Professor Alessandro Laio's work on novel approaches to data analysis. The PIs exploit their complementary expertise to work together and this has led to strong joint publications.

It is a difficult time for the Group because of the funding situation. They have obtained significant external funding, from ERC and AIRC, in the past, but these large grants are at an end and work must be put in to finding alternative post-doc funding. In the current climate, and in this field, this is not easy, but the group has a good track record and should be optimistic and support each other in this task. An advantage of SISSA is the internal funding for at least some junior group members.

Indeed the funding climate might be seen a good excuse to broaden the Group's research base. They are working in an interdisciplinary area and have several skills that could be useful outside their own discipline and it would be exciting to explore working with Mathlab and contributing to links with local industries. The group forms the natural link within SISSA with the Neuroscience area and further bottom-up initiatives with that area, perhaps run by graduate students or post-docs, might lead to interesting research topics. Exploiting the local CECAM-IT-SIDE connection would be a way to explore new topics to work on. It is also important to maintain close links to experiment: good problems are often those suggested by experiment, as an alternative to statistical physics problems that later find an experimental application.

The Group looks forward to close links with the new PI in bioinformatics, and commented that the hiring process has gone (so far) very smoothly, and to their satisfaction.

The PhD in the Physics and Chemistry of Biological Systems provides interesting courses. This is an area where it is difficult to attract students throughout Europe as undergraduate programmes do not often focus on this interdisciplinary area.

The number of applicants is impressive: to improve the quality we hope that some of the ideas listed in the main part of the proposal might prove helpful.

It seems a missed opportunity that the biological systems, condensed matter and statistical physics PhDs are so independent. An improved model, aiming at students better able to be flexible in their scientific careers, would be a broader first half common to all the programmes, followed by the more specialist courses.

The **Statistical Physics Group** does excellent/outstanding research on the statistical physics of classical and quantum systems. The group focuses on basic science with emphasis on issues such as the equilibration and thermalisation of quantum systems, quantum entanglement of many-body systems, the Casimir effect, disordered quantum systems and many-body localization, critical phenomena, quantum computation, conformal field theory and AdS/CFT correspondence, interfaces, wetting and defects at phase transitions and cold gases. The faculty members are world leaders in their respective fields. Since the last ISAC review there have been many important research achievements and several highlights have been presented to the ISAC panel. In the period 2014-2017 the group strengthened considerably in the areas of quantum entanglement, cold atoms, and non equilibrium dynamics with the addition of a junior faculty member on a tenure track position, Erik Tonni, and of two senior faculty members, Stefano Ruffo, who is also the current director of the School, and Pasquale Calabrese, who is the current coordinator of the group.

The group shares research interests with the condensed matter physics group but relative to the latter it adopts a more formal theoretical perspective. Good collaborations exist between the two groups. In addition, the statistical physics group collaborates closely with groups at the National Research Council (CNR) in the Trieste area and with groups at the International Centre for Theoretical Physics (ICTP). Two researchers from these institutions, Andrea Trombettoni (CNR) and Antonello Scardicchio (ICTP), are affiliated faculty in the group.

The PhD program developed by the group is very successful and enrolls many talented students who are attracted by the very advanced courses in statistical physics offered under the program. Some coordination is in place with the PhD program in condensed matter physics and the PhD program in theoretical particle physics, but some wider coordination with other programs in the other areas of research at the school should be encouraged. In particular, it is worthy of further thought what should be the right balance between the highly specialized training currently offered by the program and a broader training in theoretical physics.

The **Condensed Matter Physics Group** does excellent/outstanding research in a broad range of topics of current interest. These include: (1) materials modeling from quantum mechanical theory using advanced density functional theory and quantum Monte Carlo methods, (2) strongly correlated systems and quantum fluids, (3) dynamical properties of classical and quantum systems in equilibrium and out-of-equilibrium, (4) microscopic theory of adhesion and friction. The

group combines strengths in numerical methods with strengths in analytical theory and experimental interpretation. The faculty members are world leaders in their respective fields. Since the last ISAC review there have been many important research achievements and several highlights have been presented to the ISAC panel. Recently, Erio Tosatti, a distinguished theorist and one of the founders of the condensed matter activity in Trieste, retired and moved to emeritus status, but still contributes strongly to the research of the group. To compensate for the loss of a senior faculty a new full professor (Massimo Capone) has been hired. This is an excellent move that strengthens the group in the field of strongly correlated systems and quantum fluids.

The group maintains good collaborations with the statistical physics and the statistical biophysics groups, and with other institutions in the Trieste area, such as the IOM (Istituto Officina dei Materiali) of the National Research Council (CNR), the Abdus Salam International Centre for Theoretical Physics (ICTP), and the Elettra Synchrotron Radiation Facility. The group benefits in particular from the proximity of the Democritos Centre of the IOM, which is located in the SISSA building. A stronger integration between SISSA and Democritos was encouraged in the report of the previous ISAC panel, a recommendation that we would like to make our own. The presence of Democritos adds value to the activity in condensed matter physics. SISSA and Democritos should work harder to build bridges, which would mutually benefit both institutions. As suggested in the previous ISAC report a possible option for strengthening the synergy between SISSA and Democritos would be to identify a future theoretical hire more focused on applications than methods development, with possible emphasis on energy materials, chemical physics, materials science, or a similar applied field. Interdisciplinary collaborations with the mathematics area, particularly applied mathematics, and the neuroscience area should also be encouraged. The future initiative on data science could provide a possible venue for these developments. Overall the group is well integrated in the European and in the international research activity in condensed matter physics. It takes active part in initiatives such as CECAM of which SISSA is a node. CECAM promotes a wide -ranging and successful series of workshops on computational physics across a European network of academic institutions. The condensed matter group and the Democritos Centre manage Quantum Espresso, an integrated suite of codes for materials modeling and simulation that is widely utilized by the academic community worldwide.

The condensed matter group mentors excellent PhD students and postdoctoral collaborators, who do not have difficulties in finding positions at top international research and academic institutions after completing their term at SISSA. The PhD program in condensed matter physics is closely linked to the research activity of the group. While this has the merit of preparing competent scientists in the disciplines of interest for condensed matter theory at SISSA, an academic program with a broader vision touching also other areas of physics and even contiguous disciplines represented at the school should be encouraged. To achieve this goal the condensed matter group has instituted a meritorious credit program that facilitates the attendance of courses beyond the strict domain of

the research interests of the students. Further steps in this direction should be encouraged. In particular, a better coordination among all the groups in the physics area and at the level of the school should be pursued.

NEUROSCIENCE RESEARCH AREA

Formally, the Neuroscience Area of SISSA is composed of three sub-areas, corresponding to distinct PhD programs: Functional Genomics, Neurobiology, and Cognitive Neuroscience. In our review, we consider the area in two sections, corresponding to scientific themes rather than administrative subdivisions – Cellular neurobiology, which deals with neuroscience from the level of molecules to cells and circuits (and therefore includes Functional Genomics) and Cognitive Neuroscience, which deals with neuroscience from the level of neural systems to behaviour.

The **Neurobiology sub-area** includes seven groups (Ballerini, Menini, Torre, Lagname, Mallamaci, Taccola and Gustincich); we looked into the reported research activities of all, and visited the labs of four (Ballerini, Menini, Mallamaci and Torre). Importantly, Taccola is on leave at UCLA since 2015, and Gustincich is serving part time since 2016 and will very soon move full time to Genova (IIT).

Overall, the members of the neurobiology group conduct very solid scientific research. Several PIs publish original studies that describe novel approaches to new and old open issues, abstract\conceptual and engineering\technological, at various scales. The attention of others is dedicated to in-depth documentation of microscopic mechanisms underlying well-established physiological\developmental or clinical phenomena (largely surrounding degenerative diseases). The variance between the seven groups in terms of academic performance, to an extent measurable by their published records, is reasonable. The activity of some is completely focussed inside SISSA, others are intensively active in joint programs and initiatives external to SISSA.

The groups split to two clusters, a split that impacts on the nature of PhD education within and across clusters. One cluster (Gustincich, Legname, Mallamacci) focuses on molecular neurobiology (genomics, prion and developmental neurobiology), and the other on a wide range of cellular\network neurobiological topics: from protein dynamics through modern interfacing technologies, to the statistics of activity in neural populations and impacts of genetic manipulations on sensory performance.

We identified some serious issues with the structure and management of the neurobiology area. First, the neurobiology sub-area is almost completely decoupled from the cognitive neuroscience sub-area. Second, the molecular neurobiology cluster has intensive “outward-facing” activities (i.e., joint graduate programs with Universities; research areas without direct relevance to

neuroscience). These activities may well have merit in themselves, but they take staff time and research capacity away from SISSA's own neuroscience programmes. As such, they distract from the need for a refoundation of SISSA's overall neuroscience vision. Both students and PIs pay a very high scientific price for these unfortunate features of the way neuroscience research is currently structured

The **Cognitive Neuroscience sub-area** forms the second part of SISSA's neuroscience research area. There are seven PIs representing some core research areas within cognitive neuroscience. The ISAC members spoke to all PIs (or lab members, where the PI was absent). Importantly, the methodological range is wide, including human and animal (rodent) experimental approaches, neuroimaging, stimulation, recording of both single neurons and EEG, and a strong tradition of computational/mathematical modelling. The co-presence of human and animal expertise in the same group is unusual in cognitive neuroscience centres internationally (human work normally predominates), and is a major asset for SISSA.

The different PI groups within cognitive neuroscience are all operating at an internationally-competitive level. The level of innovation and scientific creativity is generally high, and in a clear majority of groups it is very high or outstanding. The publication records are largely between good and very good, with a few PIs having outstanding publication records.

The group is distinguished by a number of new hires, at associate professor level (Bueti, Crepaldi, Zoccolan) and at tenure track assistant professor level (Mathys).
This promises an energetic wave of new research activity: there are already impressive levels of grant funding from some of these newer researchers. Overall, the grant funding level of the group is very strong.

The cognitive neuroscience group faces a fundamental scientific block regarding fMRI access. Several PIs noted that the current contract with Udine for fMRI access is not working, due to a breakdown in relations with personnel at Udine. It is now basically impossible to scan. In the modern era, cognitive neuroscience research requires reliable and well-supported access to neuroimaging. The ISAC recommends that SISSA do everything possible to unblock this situation. Since the current contract with Udine appears not to work, it should be renegotiated or revoked. SISSA PIs are currently doing their scanning outside of Italy, but this is not a desirable arrangement, and it is not good for either SISSA or Italian science in the long run.

There is an interesting technology transfer initiative related to the mechatronics workshop, which is heavily linked to the scientific research of the Diamond group. This is a successful and innovative service element within SISSA, which may also add commercial value over the longer term.

The main point of serious concern for the cognitive neuroscience area is the absence of any linkage to the neurobiology sub-area. The lack of integration reduces the attractiveness of SISSA as an international PhD school, and as a research centre. Joint activities across the whole neuroscience area would promote interactions, and integrative activities, including strategic hiring of personnel in areas that can bridge cognition and systems to cells and circuits.

Even within the sub-areas, the different PI groups work relatively independently. There could be more synergy between the PI groups, since there are several common interests (e.g., in perception, neuroimaging methods, impacts of genetic manipulations on network activity and behavioural measures). The PI groups are fed by the PhD programmes, which have a judicious and interesting offer of courses, but lack integration across scales, from genetics, through proteins, cells, networks and tissues, to whole brain and behaviour.

The bulk of the scientific workforce consists of PhDs and postdocs. There are a few early career researchers with a different status (excellence fellowships, ricercatori). In general, the students appear focussed and happy: however, comments made in the introductory cross-area section are highly relevant here as well. In addition, mentoring and career progression planning appears to be neglected. The ISAC suggests that the neuroscience area develop a system for advising early career researchers and junior staff at the critical stages of transition to independence and transition to leadership. This could be offered by more senior scientists within the group, in a light-touch, informal manner.

Recommendations for the Neuroscience area

Currently, the relations between the sub-areas of the Neuroscience area are dysfunctional. This is a very unfortunate situation, which negatively impacts the quality of PhD students' experience, and presents very grave risks for the Neuroscience area as a whole. The PIs across the Neuroscience area need to come together as an integrative unit, to define a broad research strategy and research plan. The development of the strategy should include inputs from all the PIs in the area, and should be guided by a coordinator who is acceptable to all parties, integrative in outlook. The research strategy should define the identity of SISSA's neuroscience offer, and promote a synergic and comprehensive view of neuroscience activity. The strategy should cover future strategies for integration between sub-areas, interaction between PIs, and future hiring. It should be related to the cross-area hiring strategy. The Director of SISSA should be involved in establishing and implementing the research strategy, and should strongly support a drive to integrate.

- A hiring strategy should be developed in order to better integrate the different sub-areas, and build bridges between the various programmes and PI groups. For example, groups in neuroscience of circuits and systems, in network physiology, or in genetics of cognitive aging could provide such bridging research.

- ISAC encourages the neuroscience area to consider one integrative entry exam to the PhD programmes in the area (choice of 3 of 12 questions). The exam should cater to students from a variety of backgrounds, but with an interest in neuroscience.

- The multiple PhD programmes within the area should co-operate in providing one foundational behavioral and brain science course, syllabus discussed and agreed by all neuroscience area PIs, regardless of sub-area, and of specific PhD programme.

- There should be an all-area bi-weekly neuroscience seminar, which should be used as a vehicle for integration across areas. The participation of members of all the PI groups within the area in this seminar is considered very important.

- There could be stronger links to research in other areas of SISSA, and perhaps to condensed matter physics in particular.

- Joint programs that focus outside of SISSA, should be discouraged: these currently serve as an escape route (for some) from the sad situation inside the area, and detract from the need for a refoundation of SISSA's overall neuroscience vision.

MATHEMATICS RESEARCH AREA

This department has hosted for many decades one of the most visible analysis groups in Italy, perhaps the most visible after the institutions in Pisa. Its graduate school is eye-to-eye with Scuola Normale Superiore, Pisa. The group has been very successful in personnel renewal on the highest level internationally, e.g. by attracting rising stars back from permanent positions in top French institutions (Gigli, De Philippis). This is all the more impressive given the difficult national environment, and has received international applause.

The geometry and mathematical physics group is also very successful. The combination of these two fields into a single program is unique in Italy and close to unique in the world. The topics being studied and taught fit well together, and harmonize well with some of the activity in theoretical particle physics. The recruitment of Stoppa has had a positive impact on the group. Of some concern is the retirement in the near future of two senior members (Reina and Dubrovin); care should be taken to ensure the continued strength of mathematical physics.

The renown of members on all career levels continues to be apparent through international recognition (ICM sectional talks for De Philippis), European grants (ERC-Consolidator for Rozza), European prizes (EMS-prize for De Philippis), European-level memberships (EuroMech fellow for De Simone), as well as

important Italian prizes (e.g. Magenes for Bianchini, Finzi for Berti) and honors (Lincei for Dal Maso). This is based on high-level scientific work, as witnessed by publication in top journals (eg PRL for De Simone, Noselli, Lucantonio; Annals of Math. for De Philippis), and of high impact (e.g. Seminaire Bourbaki on Cavaletti's work).

The department should continue to be very careful with internal promotions. To facilitate further internationally competitive hirings, SISSA might consider speeding up the internal decision process.

Within the Italian Excellence Initiative, the mathematics groups have applied for several new faculty positions to which rather specific fields have been attached. On the one hand, this is good since it signals a quest for scientific diversity beyond the existing sub-groups; on the other hand, it should not narrow down the field of potential applicants too much.

ISAC applauds the plans for the new Institute in Geometry and Physics, which takes advantage of existing strengths in geometry, mathematical physics, and theoretical physics at both SISSA and ICTP to construct a new program which should be advantageous to students, postdocs, faculty, and visiting researchers.

The mathematics department should get involved in the envisioned build-up of a group and program in data science; there are natural sub-areas for potential junior hirings that would build a bridge to existing activities (e. g. manifold learning with its connection to metric geometry, compressed sensing with its connection to random matrices and integrable systems).

The department has already taken measures to attract more international students by shifting the application deadline a year ago. Installing an English-language joint Masters program with local universities is also an excellent measure in that direction. The proposal to create internationally attractive postdoctoral positions within the Italian Excellence Initiative is very good; not just because of its direct effect, but also because of its side effects like an increased attractiveness for faculty, and a stronger perception of SISSA as a European institution that operates on the international job market at all levels without handicap.

The PhD program in mathematics offers a rich and very attractive portfolio of courses on various levels. The PhD students praise the course program and do not at all feel overwhelmed by the course requirements (there was a wish for a basic course in algebraic topology). The written entrance exam for the program of analysis is of a very high level and tests a broad culture in analysis and neighboring fields. The PhD students appreciate the fact that there are two somewhat more specialized entrance exams in mathematics.

Mathlab, with its connection of biological table-top experiment, innovative mechanical modelling, numerical simulation and mathematical theory, is a quite unique gem. Also in view of the motility studies at Mathlab, it was a smart

move to acquire expertise in fluid-structure interactions and reduced-order modelling, two very active areas in numerical analysis with a strong basis in northern Italy. Moreover Professor Rozza's masters program in high performance computing fits into this endeavor and is a valuable service to the (local and global) scientific and business communities. The same holds true for his many activities to build up a more industry-oriented PhD program.
The computational track of SISSA's PhD program gives it an advantage over SNS's.

Here is some more detailed feedback from the conversations with the postdocs and PhD students in mathematics:

- The postdocs praised the possibility to give PhD courses; in view of their careers it might be advisable to encourage them to participate in undergraduate education at the local university, and to facilitate such teaching exchanges.

- Some postdocs wished for better career coaching, and support in exposure and networking. They suggested installing a more institutional career advisory system, for instance a 4 hour course on how to write a research statement, and a conversation discussing career prospects just after the third year qualifying exam.

- In comparison to the anecdotal experience in other European countries, the non-EU postdocs complained about the slowness of the local authorities in granting a European travel visa.

- The PhD students felt that information was spreading too slowly. In this context, they strongly voiced a wish for mathematics-wide casual opportunities to get together scientifically. Possibly tea with blackboards around, perhaps in connection with the colloquium, a regular get-together made attractive by offering food and drinks.

- The good experience of some PhD students in organizing a seminar where they explain their dissertation work to each other could be a model for all groups.

- Among both students and postdocs there were consistent complaints about the IT support: the scattered Wi-Fi availability, the datedness of the software blamed on an old operating system.

- There were complaints about the navigability of the SISSA webpage.

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