SISSA AT 40

Hammerle Editori in Trieste

MA PER SEGUIR VIRTUTE E CANOSCENZA

SISSA

40!

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«SISSA is 40, but doesn't show its years – it remains the young and exploratory institution that its founder, Paolo Budinich, intended»

Stefano Ruffo

«My wish is that by remaining faithful to the spirit which led it to take its first steps, SISSA will remain young, brilliant, creative and able to explore new directions and take on new challenges»

I became director of SISSA in November, 2015. I had no previous experience in management, and was somewhat apprehensive about my new role. In an interview which I gave to *Il Piccolo*, Trieste's local newspaper, I said that I had arrived at SISSA "by chance". I wanted to interpret and execute my new responsibility in an original way, but it was not an easy task, given the prestige and impact of those who had preceded me in this role.

SISSA is so "beautiful" that naturally I didn't dare change too much. As I said in my opening speech at the 2015 "Welcome Day", (SISSA's original way of celebrating the beginning of the Academic Year where we eschew cap and gown so as to produce a more festive atmosphere), I

SISSA Welcome Day 2015. Director Stefano Ruffo meets the SISSA Club Directive Board. On the left-hand page a stone work realized by the artist Milos Ciuk and inspired by SISSA's logo.

wanted SISSA to maintain its high standards in research and education and keep "international" and "small and pretty" side by side.

However, I had in mind doing something more than in the past to encourage what I had called "inter-Area" activities (SISSA is organized into three Areas: Physics, Mathematics and Neuroscience). We gradually begin to see the effects of this in the newly formed Institute of Geometry and Physics, and the Institute for the Fundamental Physics of the Universe, but especially in the initiative to create a new research group in Data Science.

A source of concern is the future of our PhD students. Many of them pursue an academic career and enjoy brilliant success in renowned institutions. Yet an increasing number of them find interesting and satisfying jobs in companies and industries. To support this trend, SISSA has decided to engage in a placement activity and will create SISSA's Alumni Association by the end of 2018.

SISSA is 40, but doesn't show its years – it remains the young and exploratory institution that its founder, Paolo Budinich, intended. Somewhat daringly, I like to think of SISSA as a Peter Pan of science. My wish is that by remaining faithful to the spirit which led it to take its first steps, SISSA will remain young, brilliant, creative, and able to explore new directions and take on new challenges. This is how it was in the past and how it should be in the future.

On the next page: aerial view of the SISSA building at 265, via Bonomea. Credits: Cristiano De Nobili.

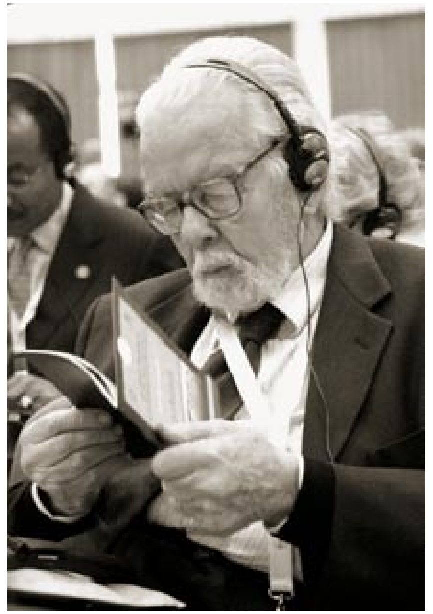
Claudio Magris

«Home is the sailor, home from sea...» Remembering Paolo Budinich

Mourning becomes Electra, but not Paolo Budinich. In his knowing, contented face, in his kindly, inquiring look, there was something that recalled the Protean, equivocal inconstancy of a sea deity, a face that spoke of the great irony of things, of human nature and not only human, in which phrases like “to be born” and “to die” take on a different, unfathomable meaning. Perhaps this impenetrable luminosity also derived from his place of origin, from Lussino in the Quarnero – or better, from Lussingrande, since woe betide whoever should tell him that Lussinpiccolo was the more beautiful. His extraordinary capacity for wonder, for amazement at things, their mystery and simplicity, was inseparable from his scientific calling. In his adventurous quest for the reality and multiplicity of things, of the world, there was the blitheness of the child playing with pebbles and shells on the seashore, that childlike capability of the great Newton whom Paolo loved so much and so often quoted. If I think on him, I see him as an expert sailor steering his boat with calm assurance even in late age, and with his strong hands weighing anchor.

I am certainly in no position to speak of his studies, of the physicist who has enriched our knowledge of the world, including that uncertainty about our knowledge which is the basis for an endless journey towards a knowledge ever more profound. I recall the extraordinary clarity and affectionate indulgence with which he was ready to explain – even, or perhaps especially, to people ignorant of science like myself – both the simplest and the most complicated things, yet never with the arrogance of the scientist confronting the masses, but rather Socratically, the way of the wise man who is such precisely because he knows that he does not know. Paolo felt the need to enrich others, as far as possible, with the knowledge of what research says and discovers about the world, life, the universe, and therefore about us all. Many things distinguished him from the majority of other scientists. In the first place – very rare in science and, as a rule, also on the lofty heights of culture, often the theatre of the worst petty narcissism – he was not afraid, unlike so many of his colleagues, to be surrounded by great scientists, sometimes greater than he. His interest was only in the fascination of research and its advantage to all, and was totally free, in his childlike play, of the fear that their greatness could eclipse him.

It was in this that his safety consisted, the awareness – not proud but simple, humble yet strong – of his intellectual vitality, which no one could upset. He knew that each value attained is never the exclusive property of a single person but always the result of a progress in some way common, of a dialogue in which it is difficult to distinguish what one gives and what one receives. That dialogue is the real protagonist of the intelligence, and I should like to say of the loving intelligence, of life and the world. All this was bound up with his vitality, with the fascination he irradiated, with the spontaneity with which he acted in life and which was not hampered by that enchanting shyness that was also so strong in him.



He had preserved all the creative qualities of the child that ventures out into the world, qualities that so many lose on the way. His research was inseparable from an instinctive impulse to make others share in it, the community in which he lived, his city and his country, the world. He certainly did not jealously bury the talent of his intelligence and of his scientific results in a place inaccessible to the profane, like that character in the Gospel parable who is punished for doing so, but generously scattered about him the gifts of his intelligence, making of them seeds which have borne an abundance of fruit, social, cultural, civil and therefore indirectly political, in the sense of making a contribution towards rendering the polis, the City of which we all form part, more human.

In actual fact this city was his and our Trieste, but was enlarged to include the country, the entire world, in the awareness that each one of us, precisely to the extent that he is lovingly rooted in a specific reality – and few like him were so enamoured of Trieste and its sea – is at the same time rooted in the whole world; so Dante observed, remembering how he had learnt to love Florence by dint of drinking the water of the Arno, but adding that the world is our country, as the sea is for the fish. Totally free of the jealous egoism that marks many scholars, even the great ones, he was not satisfied just with studying and with what scientific discoveries might later mean for the progress of mankind. He felt the need for the results of intellectual conquests to have an immediate effect on the lives of people, starting with the community close to him, then spreading to Africa, to research in the Countries of the Third World for which he did so much, sacrificing his own scientific research but without any regret or concern, always with that elusive

Exhibition *L'arcipelago delle meraviglie. Omaggio a Paolo Budinich*, Trieste, Palazzo Costanzi, August 2016.

and generous gaiety of his which rendered him so charming. He was a singular blend of feline allure, vitality, shyness, generosity and unconventionality. Living alongside him cannot have been an easy experience.

Today we remember him in this place, but we could remember him in so many situations, solidly tangible as well, which he created, beginning with the International Centre for Theoretical Physics of Miramare, where many scientists from all over the world have studied, especially from the developing countries. We could remember him in the head office of SISSA, the International School for Advanced Studies, which he both created and directed and where many great scientists work and have worked. We could remember him in the International Centre for Genetic Engineering and Biotechnology, founded by him together with another great man, Arturo Falaschi, or in the AREA Science Park, to whose creation he contributed much.

A distinguished physicist, in love with science and nature, Paolo Budinich had a very strong sense of the need for dialogue between the hard sciences and humanistic knowledge, in particular between physics and literature, two very different ways of presenting an image of the world and of working together in a symbiosis of attentive precision and bold imagination. For this reason, too, he wanted the establishment in SISSA of that Laboratory of which I also was part, and I will never be sufficiently grateful for the enrichment and the opening given me by those years in which, thanks to him, I was able to work in the Laboratory at Miramare. That laboratory confronted a central problem, namely the possibility or perhaps impossibility of dialogue between the difficult discoveries of physics – and increasingly difficult for the common

The Main Lecture Hall dedicated to Paolo Budinich.

man to comprehend – and their influence on the vision of the world which is the basis of every artistic creation or, better, visions of the world.

There is a problem that intrigued both of us. Up until a particular point in history there was a certain correspondence between the discoveries that the natural sciences made and their capacity to influence – albeit approximately – the vision of the world of people who lack scientific knowledge and therefore, in the case of writers and artists, their way of representing and inventing the world. Epicurean physics turned into the great poem of Lucretius; when Copernicus and Galileo split open the heavens the influence on poetry was profound – suffice it to consider the quantity of English lyric poetry in that century; Newton's vision of time and space entered – obviously approximately but with fundamental importance – into the sensibility, the intelligence of even those with no scientific training, and so influenced their way of seeing and perceiving the world and, if one speaks of artists, of representing it.

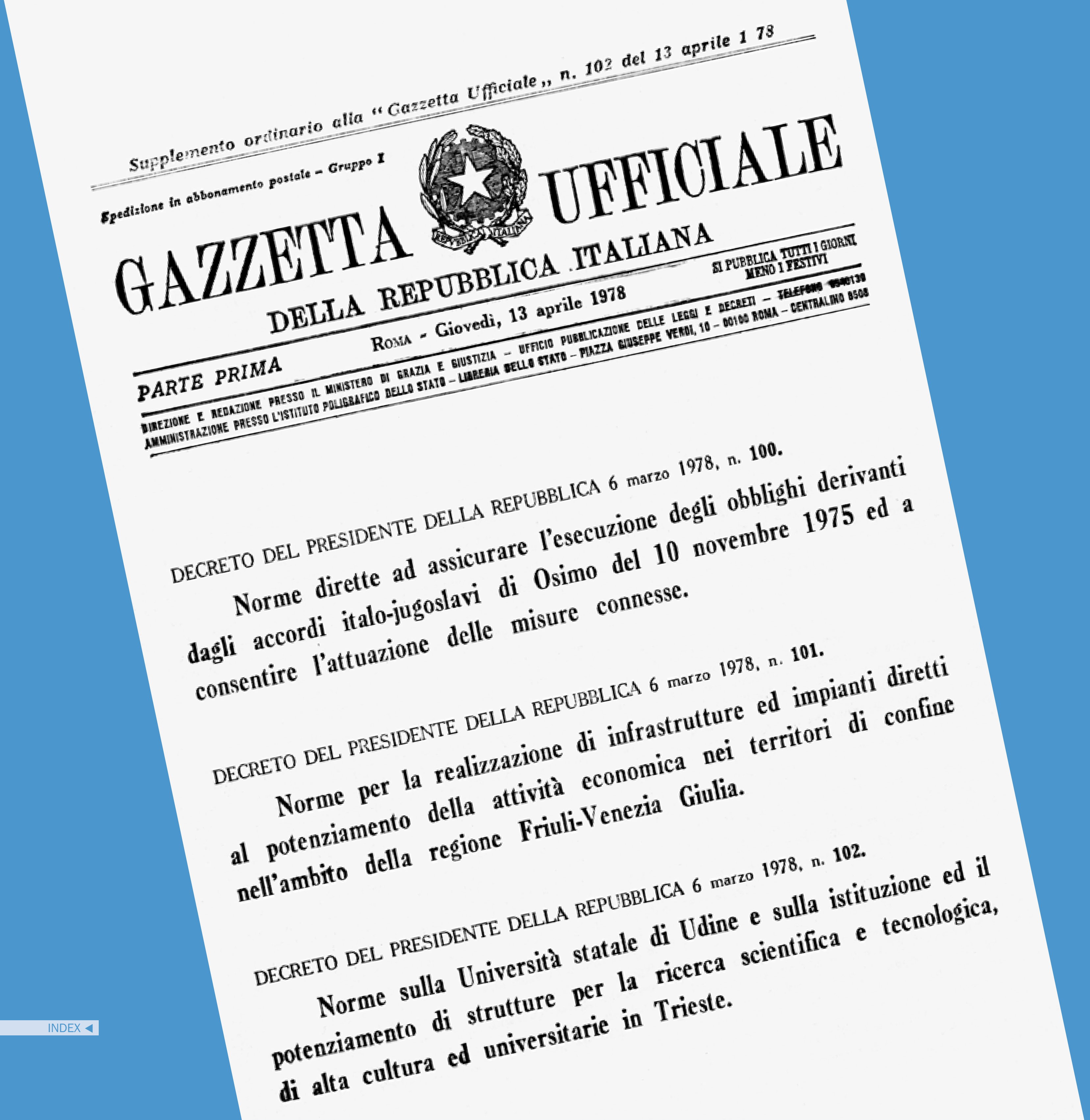
This correspondence, albeit imperfect, lasted more or less until Einstein, and seems to have been interrupted by the arrival of quantum mechanics. The great question that we asked ourselves was whether this incommunicability – which renders today's most solid and important knowledge, namely that of the physical sciences, incapable of influencing the perception of the world and therefore of really permeating culture – is the result of a lack of knowledge, even if superficial, or of the character of the new scientific discoveries, so abstract, so remote from sensory perception (to which Paolo Budinich attached great importance) as never to be capable of really becoming an element that shapes our culture, namely our vision of the world in general.

We held various seminars on this subject, with the participation of physicists, mathematicians, historians and philosophers of science, writers interested in these problems such as Daniele Del Giudice. It is, as I remember, one of the most fruitful periods in my life, and this too is due to the spontaneous and festive creativity which marked Paolo Budinich's every project. Paolo had none of that haughtiness that at times is typical of many of his physicist colleagues, in their conviction of being custodians of a knowledge greater than others', and in the arrogance with which they think they can explain to us and assure us, depending on the case, that God exists or that God does not exist.

Paolo was a brother more than a father; a classmate rather than a teacher, and precisely for this reason he was a genuine teacher, not in the least pompous. There was in him something of the unfathomable, disquieting innocence of the sea he loved so much, a unique blend of shrewdness, diplomatic ability, candour and irony, the ever fascinating and demonic irony of nature. Something of a wizard, very playful and, when it was necessary to obtain from the authorities the means for his ingenious projects, also enchanter and showman. I think that, like me, he had never, really never, read a ministerial circular or bureaucratic or institutional document, and in this too we were akin. I, for example, in the period when the Ministero dell'Università e della Ricerca Scientifica e Tecnologica was called MURST, believed that this was the name of the Director General, because to me it sounded like the name of some official of Austro-Bohemian origin, so much so that once, when summoned for a commission by MURST, I replied with an obsequious telegram addressed to Dr. MURST. Although, like me, understanding nothing of the rules, the mechanisms and the practices of bureaucracy – something that made us both feel somewhat guilty and irresponsible – Paolo, unlike me, was immersed in all the aspects of university study and research, and when he went to Rome to obtain some funding for his projects – which led to the creation of many essential institutes – he returned to Trieste with the result in his pocket after having spoken with who knows what officials and having persuaded them with his snake-charmer's art.

His love for the world of his origins and his life, starting out from his island, Lussino, was perfectly integrated with his love for the world beyond all frontiers. I recall – and it is only one of many examples – the time when, during the editorial meeting of an international magazine, largely Central European in character, which he had founded, he energetically intervened with a fierce attack on nationalist positions that were being taken up amongst the very different multinational components of that executive committee. Budinich become Budini, and then again become Budinich, was a true man of the border, the border that unites and not, as so often happens, the border that divides and separates. Among his last ideas, at least among those he spoke to me about, was that of founding in Trieste a centre to promote scientific research in Africa. Yet this concrete, not vainglorious, undertaking, which he felt as something natural, did not stop him from enjoying himself, living, creating, seducing and playing. All of us, I think, are here not simply for a ceremonial occasion, however right and proper, but because we miss him, truly and deeply, and it seems strange to us that, in the words of Stevenson's poem "Requiem" – *Home is the sailor, home from sea...*

The text, written on the occasion of the inauguration of the exhibition *L'arcipelago delle meraviglie. Omaggio a Paolo Budinich*, is by courtesy of Claudio Magris.



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GAZZETTA UFFICIALE

DELLA REPUBBLICA ITALIANA

SI PUBBLICA TUTTI I GIORNI MENO I FESTIVI

PARTE PRIMA

ROMA - Giovedì, 13 aprile 1978

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DECRETO DEL PRESIDENTE DELLA REPUBBLICA 6 marzo 1978, n. 100.

Norme dirette ad assicurare l'esecuzione degli obblighi derivanti dagli accordi italo-jugoslavi di Osimo del 10 novembre 1975 ed a consentire l'attuazione delle misure connesse.

DECRETO DEL PRESIDENTE DELLA REPUBBLICA 6 marzo 1978, n. 101.

Norme per la realizzazione di infrastrutture ed impianti diretti al potenziamento della attività economica nei territori di confine nell'ambito della regione Friuli-Venezia Giulia.

DECRETO DEL PRESIDENTE DELLA REPUBBLICA 6 marzo 1978, n. 102.

Norme sulla Università statale di Udine e sulla istituzione ed il potenziamento di strutture per la ricerca scientifica e tecnologica, di alta cultura ed universitarie in Trieste.

March 6^th^ 1978
Presidential Decree (D.P.R.) no. 102

Art. 19

With effect from the date this decree comes into force, the International School for Advanced Studies is established at the University of Trieste as a special scientific institute, endowed with legal personality, and administrative, teaching, disciplinary autonomy.

Art. 20

The school aims to promote the development of culture and scientific research, preparing graduates, especially those coming from developing countries, for advanced research, both pure and applied, and for teaching physics and mathematics at university level.

A forty-year-long journey

«Ma per seguir virtute e canoscenza»

SISSA 40th Anniversary

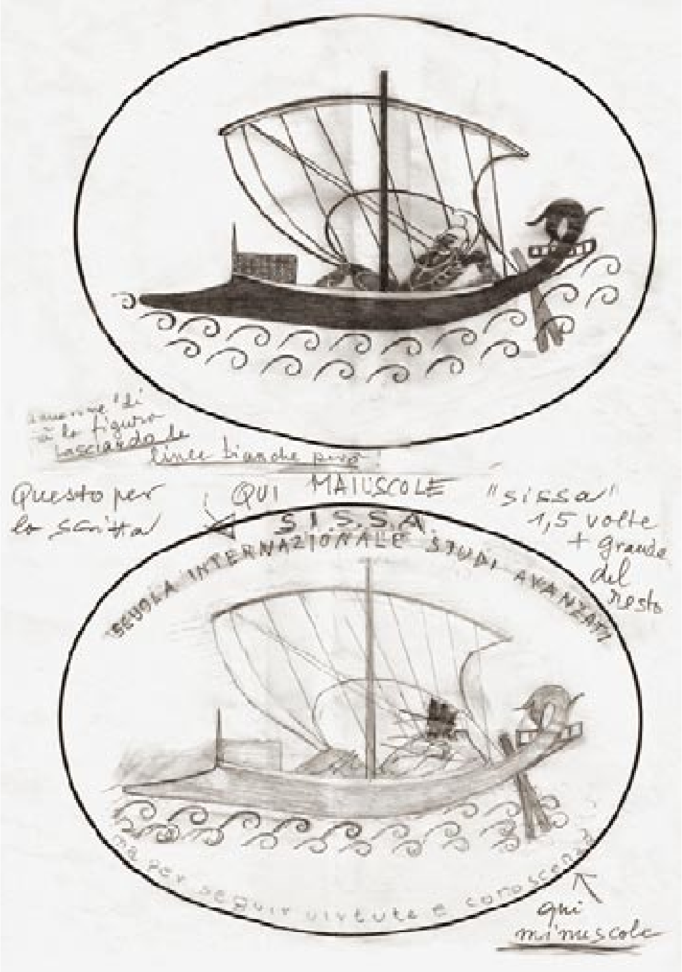
The International School for Advanced Studies (in Italian: Scuola Internazionale Superiore di Studi Avanzati), more broadly known as SISSA, is a scientific centre of excellence, an Institute of Higher Education for Doctoral Studies, located in Trieste. It is a model for post-degree studies and, as a result of its history and its specific nature, is a unique institution in the Italian and international academic panorama. Its symbol is Ulysses' vessel, accompanied by the words from *Canto XXVI* of the *Inferno* in Dante Alighieri's *Divine Comedy:* "Ma per seguir virtute e canoscenza" (To follow virtue and knowledge). These words best express the values that inspire the School's existence: the hunger for knowledge, the urge to go beyond the boundaries of what has so far been discovered, the yearning to push oneself past the Pillars of Hercules, to venture towards the unknown. And if Dante's Ulysses had the Journey as his life's purpose, aiming for the *sapientia mundi*, the same could apply to Paolo Budinich, founder of SISSA, a great man of science but also a great mariner, always ready to leave port in search of new lands and new horizons.

And how could the search for knowledge possibly stop at the nation's borders? The School had to be international, inevitably.

SISSA was officially established on March 6th 1978, the day on which, by Presidential Decree (D.P.R.) no. 102, it became part of the Italian Academic System.

The fact that it was located in Trieste – a border city *par excellence*, a bridge between Eastern and Western Europe, a meeting point of languages and cultures, a clever combination of both the Mediterranean and the Central European – quickly established the School as an international reality, sharing this tendency (as part of its initial development) with the nearby International Centre for Theoretical Physics (ICTP), this too founded by Budinich, together with the Pakistani physicist Abdus Salam, who obtained the Nobel Prize for Physics in 1979.

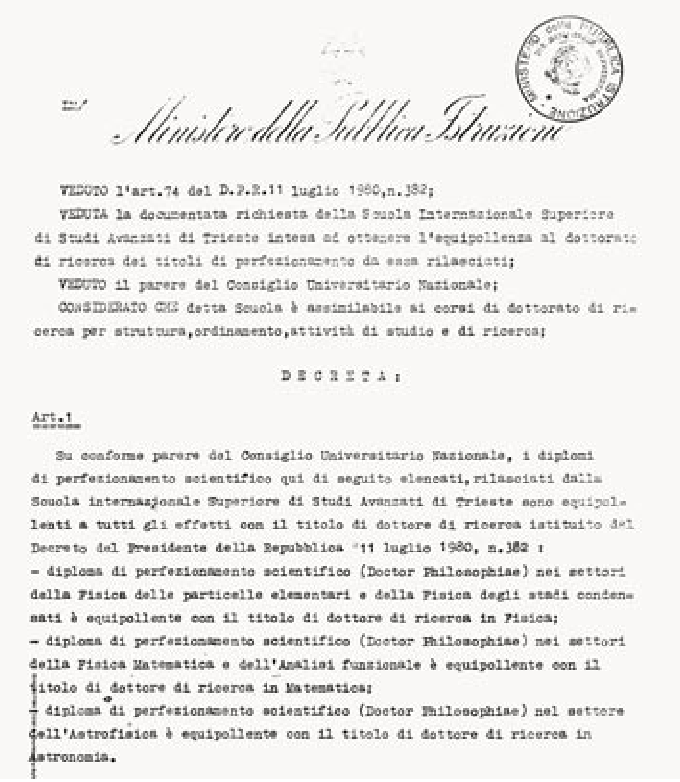
In Budinich's words, SISSA was to be conceived as an "institute of advanced research, with a distinct international character, which was also to be – as an institute of excellent research should be – innovative and bureaucratically more agile than the cumbersomely structured Italian universities". The Institute for Advanced Studies of Princeton was taken as a model, and so was the Scuola Normale Superiore in Pisa. The idea motivating its creation was to found a research centre with the highest



Draft project of the SISSA logo.

level of training, restricted to post-graduates, and therefore to be accessed through a very strict selection after the conclusion of a cycle of studies equivalent to the Italian *Laurea*. In this regard, it is important to remember that SISSA was the first Italian Institution to award the title of Master's Degree and of *Philosophiae Doctor* (PhD), which in 1987 became equivalent to the title *of dottorato di ricerca*, awarded after a post-degree course, which in the meantime had started to be activated in other Italian universities.

Since its early days, therefore, SISSA has occupied a distinctive position as a unique school in the orbit of Italian Higher Education. The first Statute, for example, contained several innova-



Ministero della Pubblica Istruzione

VEDUTO l'art.74 del D.P.R.11 luglio 1980,n.382;

VEDUTA la documentata richiesta della Scuola Internazionale Superiore di Studi Avanzati di Trieste intesa ad ottenere l'equipollenza al dottorato di ricerca dei titoli di perfezionamento da essa rilasciati;

VEDUTO il parere del Consiglio Universitario Nazionale;

CONSIDERATO CHE detta Scuola è assimilabile ai corsi di dottorato di ricerca per struttura,ordinamento,attività di studio e di ricerca;

D E C R E T A :

Art.1

Su conforme parere del Consiglio Universitario Nazionale, i diplomi di perfezionamento scientifico qui di seguito elencati,rilasciati dalla Scuola internazionale Superiore di Studi Avanzati di Trieste sono equipollenti a tutti gli effetti con il titolo di dottore di ricerca istituito del Decreto del Presidente della Repubblica 11 luglio 1980, n.382 :

- diploma di perfezionamento scientifico (Doctor Philosophiae) nei settori della Fisica delle particelle elementari e della Fisica degli stadi condensati è equipollente con il titolo di dottore di ricerca in Fisica;
- diploma di perfezionamento scientifico (Doctor Philosophiae) nei settori della Fisica Matematica e dell'Analisi funzionale è equipollente con il titolo di dottore di ricerca in Matematica;
- diploma di perfezionamento scientifico (Doctor Philosophiae) nel settore dell'Astrofisica è equipollente con il titolo di dottore di ricerca in Astronomia.

The Decree of equipollence in 1987.

The Director of the School, Professor Paolo Budinich, signing the founding paper.

tive elements, such as the possibility of having for three years visiting professors coming from abroad and staying for up to three months per year: a perfect instrument to foster long-lasting scientific collaborations with outstanding foreign scientists. With Paolo Budinich, who was the first Director of the School, SISSA also concentrated all its scientific efforts in the fields of physics and mathematics, calling as first members of the academic staff Nicolò Dallaporta in the area of astrophysics, Antonio Ambrosetti and Arrigo Cellina for mathematical analysis, Erio Tosatti in the field of solid-state physics, and Nino Borsellino in the area of biophysics.

A few years later, the faculty expanded further, enhancing the fields of: cosmology with the entrance of Dennis Sciama, the pre-eminent scientist from Oxford; Elementary Particles Physics with Roberto Iengo; Geometry and Mathematical Physics with Boris Dubrovin; and many others. The arrival of all these notable scholars, together with the small community blossoming around them of PhD students and of postdocs coming from all over the world, led SISSA to become very soon "the jewel in the crown of the Ministry of Education", as the Minister of Education Franca Falcucci stated in her report to the Italian government in 1985.

SISSA was first quartered in the Bellavista building, previously a three-storey hotel on the hill of Miramare, right in front of the historical railway station ordered by Maximilian of Austria.

On the ground floor were located some administrative offices together with the Reception desk and a tiny library; on the first floor, there was the Elementary Particles group; the Condensed Mat-

The Bellavista building.

The Main Building and the stairs between SISSA and ICTP.

ter group was located on the second floor and the Astrophysics group had the third floor. The mathematicians, however, together with other administrative staff, were located in another building, close by the sea, at the Bivio di Miramare. In addition, a number of professors and students were accommodated in some offices of the nearby ICTP, and had lecture rooms in common. Being close to ICTP was an additional advantage for SISSA because it could benefit from the presence of international scientists visiting the Centre for conferences, schools or other collaborations.

Since Paolo Budinich had a physical-mathematical background and was familiar with the German academic environment (years earlier he had been a visiting scientist at Wolfgang Pauli's lab at the ETH in Zürich and Werner Heisenberg's in Göttingen), the natural development during his direction was the strong relationship between SISSA and the Vienna group of Mathematics and Physics, directed by the famous physicist Walter Thirring, and other collaborations with Central European groups.

The middle of the Eighties was for SISSA a period of important logistical changes: Bellavista, the three-storey house at the top of the hill which had witnessed the very first steps of SISSA, had become too small and unable to house either all those new scientists already settling in as part of the faculty, or all the new postdocs and PhD students who at the same time, and in ever increasing numbers, were coming to study and to work at

SISSA. New headquarters were necessary, so on February 26th 1985, in the presence of the Minister of Economy, Pierluigi Romita, the first stone was laid to create a new building at the bottom of the Miramare hill so as to host the new scientific community which was gravitating towards SISSA. The construction ended a few years later and this new building, in via Beirut 2-4, became SISSA headquarters until 2010, when the School moved to its present location, the Santorio building near Opicina.

Another significant change was brought about by the arrival of a new Director: in 1986 Daniele Amati, Elementary Particles physicist coming from CERN in Geneva (a global focal point for physics studies) took over from Paolo Budinich. Under the passionate drive of Daniele Amati SISSA, during the Nineties, saw a huge expansion of its activities, strengthening those already present when he arrived but also opening others that were radically new. In those years the School was involved in challenges in innovative fields such as the Neurosciences, where laboratories with equipment, trained technical staff and significant funding are required for experimental activities. Internationally renowned scientists such as Tim Shallice and Jacques Mehler contributed to the creation – within the Neuroscience area – of a group dedicated to the superior cognitive functions. The Eighties and the Nineties were also the years of the String Theory, which imposed its relevance as the ideal theory that unifies the fundamental forces

in Nature, and which brought SISSA to the fore. This was done also thanks to the strong internal collaboration between the Elementary Particles Physics section and the Mathematicians, especially in the field of Geometry. Moreover, in the area of Condensed Matter, those were the years in which at SISSA, with Michele Parrinello and Roberto Car, extremely powerful algorithms for molecular dynamics were developed, algorithms that opened many horizons in the field of computational physics. During the same period a group of extremely well-grounded young mathematicians, which had grown around Antonio Ambrosetti, Gianni Dal Maso and Boris Dubrovin, was gradually acquiring national and international visibility. This was confirmed by the invitation that Alberto Bressan received to deliver a presentation in front of the International Congress of Mathematicians held in Beijing in 2002.

In the year 2000, Edoardo Boncinelli became the new Director, taking over from Daniele Amati. Then we had Stefano Fantoni in 2004, Guido Martinelli in 2010 and now Stefano Ruffo, who started his term of office in 2015. In 2010 all SISSA activities – theoretical and experimental – which up to that moment had always been a bit scattered among several laboratories between the centre of Trieste and Miramare, finally moved to one single building, in the present Santorio Complex, located in a big park on the hill of Opicina, facing the gulf of Trieste.

From 2000 till now the numbers of scientists, students, postdocs, technical and administrative staff have quadrupled, multiplying – consequently – also the number of scientific activities and leading to the creation of new research groups: in the Physics Area we have the groups of Statistical Physics, Astroparticle Physics and Physics & Chemistry of Biological Systems, which have joined the original historical groups of Elementary Particles, Condensed Matter and Astrophysics; in the Mathematics Area, to the initial groups of Functional Analysis, Mathematical Physics and Geometry a new group of Applied Mathematics

has been created; and in Neurosciences, we have now a group that studies Genomics, Nanotechnologies applied to Neuroscience, reading, language and the way our brain governs these functions.

In the last twenty years SISSA has promoted an intense editorial activity, linked to scientific journals published entirely online that have achieved international prestige (*JHEP – Journal of High Energy Physics*, was the first one, created in 1997, which was then followed by *JCAP – Journal for Cosmology and Astroparticle Physics*, *JSTAT – Journal of Statistical Physics* and *JINST – Journal of Instrumentation*). The interdisciplinary activities promoted by the SISSA Interdisciplinary Laboratory for Natural and Humanistic Sciences had a great impact through Science Communication. The Laboratory created Italy's first Master's Course in science journalism, a course that in 2018 will celebrate its quarter century and that can boast a record number of job placements for most of its past students.

At the finishing line of its first 40 years, SISSA is enthusiastically launching into new scientific challenges in areas related to genetics, neuroscience, new cosmological data and the nature of dark matter, quantum entanglement, non-equilibrium physics, the topological phases of matter, algebraic geometry, systems dynamics and optimization problems.

In spite of all the radical changes SISSA has undergone in these 40 years, one thing has remained the same: the way research is carried out. "SISSA looks like the workshop of an artist, where the trade is learnt day by day, by doing the work. Here we do not have many lectures, our students are an integral part of the research groups and we all work together: the most senior bring experience, the young ones bring energy and grit" – this is how Daniele Amati described it in 2003, on the occasion of SISSA's 25th Anniversary. And we believe this will also hold true for its future, since it is what makes SISSA such a unique place.

The library in the new SISSA building. Credits: Fabrizio Giraldi.

SUPERLAUREA: A MIRAMARE LA SCUOLA INTERNAZIONALE SUPERIORE DI STUDI AVANZATI

come ti insegno a pensare in grande

la storia e il futuro

apprendisti stregoni

Vediamo in concreto il funzionamento accademico della Scuola Internazionale di Studi avanzati. Istituita a Trieste come istituto scientifico speciale, intende promuovere lo sviluppo della cultura e della ricerca scientifica in collaborazione con l'Unesco e con il Ministero degli affari esteri. In questa prospettiva organizza per l'anno accademico 1981-'82 dei corsi e seminari per il perfezionamento universitario nei seguenti settori:

FISICA

Astrofisica
Fisica delle particelle elementari
Fisica degli stati condensati

MATEMATICA

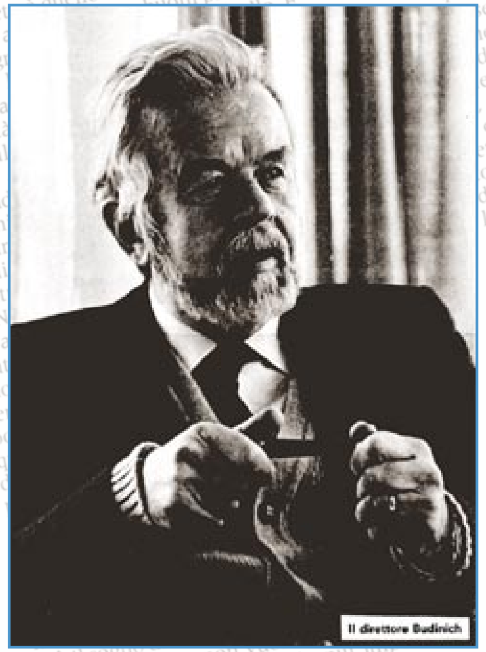
Analisi funzionale e applicazioni

I corsi e seminari sono tenuti da docenti della scuola e altri istituti scientifici italiani e stranieri con i quali la Scuola collabora da tempo.

Ai corsi possono essere ammessi i laureati in Fisica, Matematica e materie affini, ma i posti disponibili sono solo 16 e quindi si tratta di un numero chiuso particolarmente severo, anche perché l'ammissione avviene per titoli ed eventualmente per colloquio con relativo «giudizio inappellabile del Consiglio della Scuola».

I diplomi che la Scuola rilascia seguono il modello statunitense. Si diventa «Doctor Philosophiae» (il nome non deve ingannare, si tratta sempre di Fisica o Matematica) dopo tre anni di studio e «di ricerca originale secondo le norme prescritte dallo statuto» della scuola. Ma la scalata all'Olimpo della Scienza (quella con la S maiuscola evidentemente) non finisce qui. Dopo altri due anni si diventa «Magister Philosophiae», e a questo punto si hanno tutte le carte in regola per scoperchiare il terribile e irresistibile «vaso di Pandora».


Un ricercatore brasiliano


Il direttore Budinich

Il Meridiano di Trieste, November 1981.

Those who mapped out the course

Daniele Amati

«The critical motivation for excellency should not be provided by the extention of the areas covered, but by the interdisciplinary connections of the fields that grow at the frontiers of knowledge»

I clearly remember when, in the early 1980s, Paolo Budinich came to see me at CERN to share with me the enthusiasm he had for his latest scientific enterprise in Trieste: he wanted to launch SISSA, the first Ph.D. school in Italy. His idea was to have SISSA located alongside the International Centre of Theoretical Physics (ICTP) – directed by Abdus Salam – in order to use the excellence and internationality already established there to attract notable scientists from the outset. He asked me to collaborate with him and proposed that I should follow the operation after its launching. Paolo was an enthusiastic person and his optimism was contagious. He was able to obtain approval and support to accomplish the original ventures he would plan. So he seduced me. I decided to ask for a three-year leave from CERN to substitute for him as Director, trying to consolidate SISSA in its innovative role within the Italian scientific and academic scene. My original intention was to go back to CERN after helping to put SISSA into its orbit, but I was so captured by the challenge offered by that novel scientific endeavour that I decided to leave CERN and stay at SISSA.

I started at SISSA in November 1986. The initial staff consisted of a small group of professors and

students active in Mathematics (Functional Analysis) and Theoretical Physics (Elementary Particles, Structure of Matter and Astrophysics), scientific fields essentially linked to the research carried out at ICTP. In addition to lecturing, mentoring graduate students and managing the activities that a professor and director has to follow, I immediately tried to understand how to financially support and promote the development of a project that would enhance the specific identity of SISSA at a national and international academic level. In fact, the School, just like any newly born organism, was destined to grow, but in a moderate way, and very focused on the meaning of its basic identity.

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Considering that SISSA did not have the responsibility for forming professionals in any discipline – thus providing a broad training – its development could cover a limited choice of novel scientific fields. The critical motivation for excellency should not be provided by the extention of the areas covered, but by the interdisciplinary connections of the fields that grow at the frontiers of knowledge.

To attract to SISSA first-rate scientists open to this challenge was not going to be easy and I was convinced it had to involve experts from disciplines not yet present in our School. The Director's role was to be sensitive to new scientific developments, including in this operation personalities with vision, figures capable of giving the right stimulus and suggestions in tune with what we were already doing at SISSA. So we created an International Advisory Board composed of excellent scientists, that helped us efficiently in all important choices. They periodically performed a comprehensive evaluation of the activities carried out, giving their opinions and advice on how to improve and extend our efforts towards new lines. Besides this activity of evaluation, I regularly consulted Board members for every relevant decision we had to make.

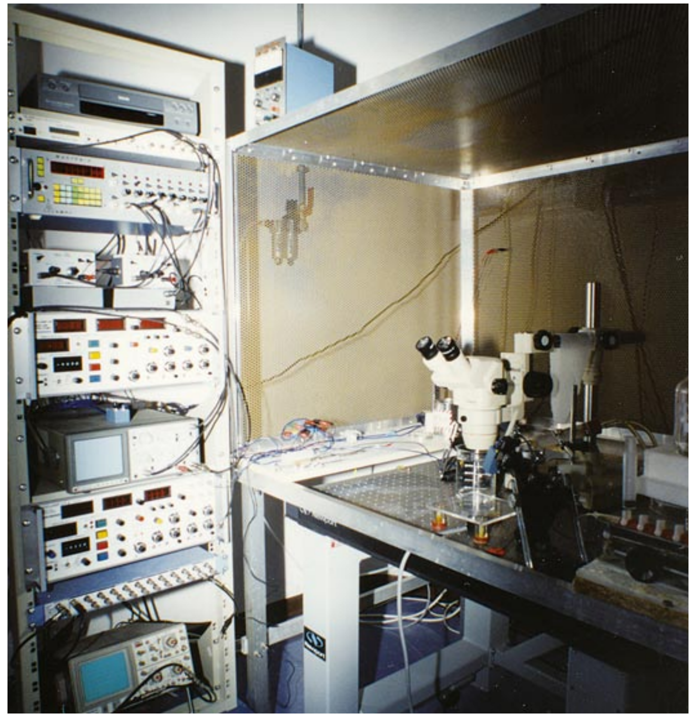
I was coming from CERN, the world fs most famous laboratory for the study of elementary particles. The results expected or obtained from the detectors exposed to the accelerators, were the subject of discussions with theoretical physicists all over the world. This community was fully represented in the CERN Theoretical Division. I have always believed that the natural sciences – such as Physics – cannot exclude the observation of nature and that it would have been wrong to have a new scientific institution like SISSA totally disconnected from any experimental activity. It is true that elementary particles physics requires such complex experimental technologies that a small body like SISSA could not afford them. But experimental activity is not mere comparison of data: it involves a methodology of analysis and an approach that illustrates and complements the theoretical studies. Introducing into the School a more complex scientific activity that would not ignore the experimental approach represented to my point of view an essential methodological goal.

At that time, the neurosciences were rapidly establishing their role, studying the neural basis of animal and human behaviour. As an example of this new approach, I learned that MIT had established, besides the specific Departments (Neurophysiology, Linguistics, and so on), a Department for Brain Research and Cognitive Sciences implementing an integrated neural approach. It happened that this Department was constituted and directed by Emilio Bizzi, who was an old friend of mine from the period I spent in Rome as a young physicist. He was then a medical student, then a neuroscientist with Moruzzi, in Pisa, and later made a brilliant career in the United States. So, encouraged by several members of the Ad-

visory Board, I contacted him and restored our interrupted friendship. I asked if he would help us to establish a similar innovative line on the many aspects of the nervous system, from the molecular to the cellular levels, to the study of integrated systems (such as movement or vision) and including the human cognitive systems (such as language). I presented this project to the Ministry of Education and Research with the initial name of "Intelligent Systems", asking for funding and new positions (professors, researchers and technicians), which at the time could be assigned by the Government for Original Projects. The proposal was successful, so – always under the scrutiny of the Advisory Board and Emilio Bizzi – we decided to start from the two ends of that research line.

We advertised internationally for two full professorships, one in neurobiology and one in neurophysiology, as well as one post for associate professor and two for researchers. Also the funds necessary to implement all the laboratories for these new scientists were allocated. The selected professors came from INSERM in Paris, from London and from Rome: within a few months they all moved to Trieste and started to set up their laboratories.

The other end of the line, which was represented by the area that studies the higher animal and human functions, was initiated by bringing to Trieste, for a couple of months per year, a group of scientists specialized in various cognitive functions,



First labs of the Neuroscience Area.

A picture of Trieste Encounters on Cognitive Science. Standing from the left: Willem Levelt, Mark Jeannerod, Jacques Mehler, Luigi Rizzi, Alfonso Caramazza, Paolo Legrenti, John Morton, Stefano Fantoni. Sitting from the left: Walter Gerbino, Daniele Amati, Paolo Viviani, Massimo Piattelli Palmarini, Tim Shallice.

who gathered together at SISSA during the so-called "Trieste Encounters on Cognitive Science". To identify the right scientists, I asked for the enthusiastic and friendly support of active experts in the best European centres, such as Tim Shallice (neuropsychologist), Jacques Mehler and Pim Levelt (psycho-linguists), Marc Jeannerod (motor system) and many others. Then, gradually, some of them decided to remain in SISSA as distinguished foreign professors. In this way the Cognitive Neuroscience labs began, and they then extended the research to include the animal's somato-sensory system and neural networks applications for modelling of brain functions, which required a call for younger scientists to work on these topics. This is how – not always smoothly – the Neuroscience Area of SISSA started and developed.

Apart from this totally new experience at SISSA, several other initiatives were launched; and for the established activities there were also modifications and changes. This was always done while trying to safeguard the different interests and needs of the staff and of the School, and to guarantee that new scientists maintained their autonomy and originality in research topics in order to avoid some sort of reproduction of the "school" scheme present in the Italian academic world.

New branches were created. In Physics, in particular, we made an effort to implement an Astro-Particles activity which, besides being part of an area of great theoretical and experimental development, could represent a sort of natural bridge between the elementary particles scientists and the astrophysicists of the School: a field that vigorously flourished, especially in the hands of young recruits.

The Astrophysics group joined the consortium that received and analysed data from the Planck satellite and is now participating in other collaborations that so successfully explore the structure of our universe.

SISSA also pioneered computational physics: a new field where the rapid development of scientific computing allowed the application of computational methods to implement and study theories and models. The capacity of computation had increased so fast that it was not sufficient to use traditional

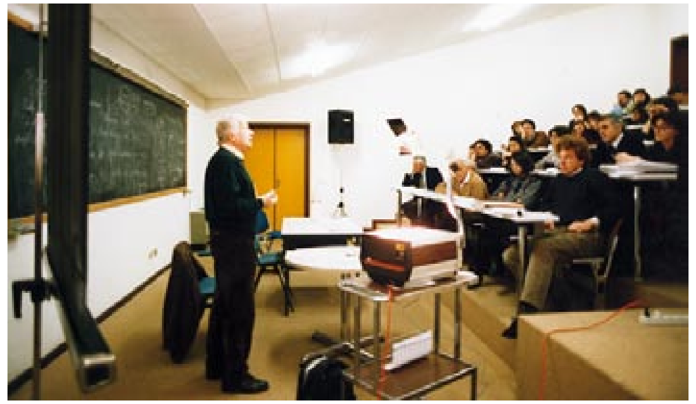
computers at home any more. We therefore had to negotiate the use of external computational centres and we managed to become the privileged users of CINECA, the Italian academic computational centre. At the same time we could not ignore the developments in parallel computing, which later allowed us to adopt new calculation systems. In this way we regained the essential capacity to satisfy the need for larger computational processes required in almost all the scientific areas. I must admit that the unquestionable success of Computational Physics at SISSA, with the acknowledgement and universal application of the Car-Parrinello method, did have its costs. In fact, we lost two brilliant young professors who moved to prestigious institutes where they pursued their excellent careers. This is indeed the inevitable price of great choices! And this happened at SISSA more than once, but luckily with less damage.

Roberto Car and Michele Parrinello during the Dirac Medal ceremony. Credits: Massimo Silvano, ICTP Photo Archives.

Nevertheless, not all attempts were successful. To build a beneficial bridge between statistical physicists and molecular biologists, we were advised by the members of our Advisory Board to construct a Chemistry pillar that would connect the two sides. So we hired a joung clever chemist who, in the wake of his success, was carried away to Germany to direct a biophysics centre. Nevertheless the frame of the bridge survived and managed to become a lively group of young physicists sensitive to biological complexity.

The mathematics area extended its interest to applied sectors that included computational implications. An active geometry group was also constituted and enjoyed a fortunate development. In all these initiatives we always took into account the possible affinities among the different areas, trying to attract, for each activity, some promising and enthusiastic young figures.

A successful experience was also attempted in the field of science dissemination to a wider public. We created a Master in Science Communication, which did not have to train researchers as stated in the SISSA mission, but was aimed at preparing young graduates in scientific disciplines to use journalistic language and skills to communicate science. From the beginning the Master's was piloted by SISSA scientists and journalists with specific expertise and preparation, like Franco Prattico. The Master's had great success and many scientific journalists and science communicators passed through this experience and then found a bright future in this field.



Finally, another initiative, which was not included in the school's mandate but had a strong link with the world of research, was prompted by riding the discomfort of the international community of Particle Physicists. In those years, scientific journals were produced, edited and sold mainly by private publishers and they were very expensive. SISSA proposed the creation of an international editorial committee that would evaluate the work produced in the Elementary Particles field, submitted to an online-only journal made with an original in-house-invented software. The idea was that the whole editorial process was going to be managed by physicists for physicists who, the world over, responded positively to the initiative. We called it *JHEP* (*Journal of High Energy Physics*) and it has now become the foremost journal in the field. This scientific and editorial activity was then replicated by the School in three other Physics journals. One last but not least activity that I had to attend to as School Director was the design and establishment of a proper "governance" that would maintain cohesion among the various decision-making levels in our small academic body, including the administration which often, over the years, had to adapt to the various changes that were made in the university system. I must admit that keeping a robust and at the same time bureaucratically agile bond among the various components of the School was a complex task.

The positive outcome of this effort was largely due to the common participation in a novel challenge as felt by our scientists and students, as well as by the technical and administrative staff led by Giuliana Zotta, an extremely intelligent administrative director.

I have been elected SISSA Director for five consecutive triennial mandates; altogether, these fifteen years represent a very rewarding and privileged part of my life.

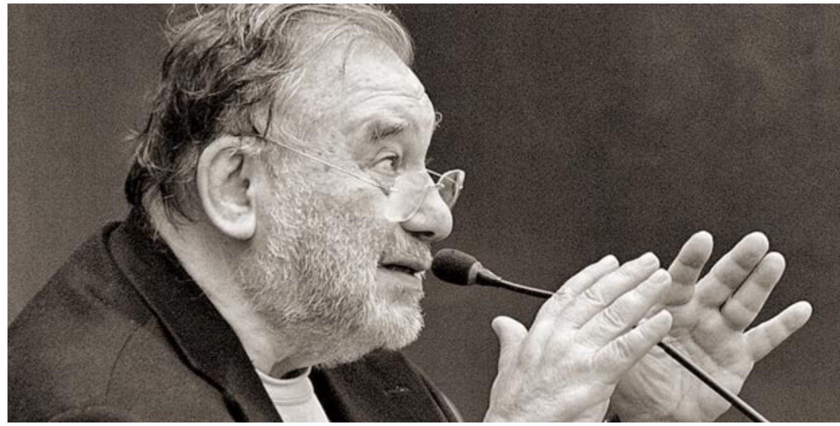
Snapshots of a Master in Science Communication.

Edoardo Boncinelli

«What I remember most about SISSA is the enthusiasm of everyone, from the administrative staff to the more technical, from the students to the teachers…»

Each time frame is a transition period both for the community and for the individuals. There is no doubt that the time when I headed the school was really one of transition. Daniele Amati, the historical director of the School's growth, left, and the only question was whether and how one could change, even slightly, the direction he had till then taken. The successor had to do exceptional, and exceptionally positive, things to distinguish his direction from Daniele's.

Construction of New Building.



The motivation to build something lasting, therefore, was somewhat feeble. Yet there were two things that marked a kind of discontinuity: the possibility of moving the school to a new venue, and the continuation of the process of expanding its scientific themes in the direction of new biology and neurobiology, fields already well present even to those who had always been interested only in physics or maths. Within this frame of reference is to be found the period when I was Director, and the results did not fall short on either front, thanks to favourable political and academic circumstances.


Oggi pomeriggio a Miramare la cerimonia per il quarto di secolo di attività. Un appuntamento con relazioni, testimonianze e un intermezzo musicale

La Sissa festeggia 25 anni all'avanguardia

Durante la manifestazione coordinata da Cecchi Pane interventi di Budinich, Amati, Regge e Magris

L'INTERVISTA

Il direttore Edoardo Boncinelli legge nel futuro della Scuola

Un cruccio: il poco spazio Il sogno è il Porto Vecchio

IL LINGUAGGIO SI ATTIVA A DUE GIORNI DI VITA


DOMENICA 9 NOVEMBRE 2003 TRIESTE CITTÀ IL PICCOLO 19

Studiosi, giovani, collaboratori e rappresentanti delle altre istituzioni scientifiche si sono dati appuntamento a Miramare per i 25 anni della Scuola

Sissa, anniversario tra ricordi e nuovi progetti

«Questa è un'oasi felice della scienza in un momento particolarmente difficile per la ricerca in Italia»

Explora sta per riprendere il mare

What I remember most about SISSA is the enthusiasm of everyone, from the administrative staff to the more technical, from the students to the teachers, and their pride in belonging to a large and ever evolving institution. Paradoxically, the thing I missed most was interaction with students, the real protagonists and the vital lymph of the School. I did not have enough time or did not dedicate the right time to that interaction. The university was small, but it took time and attention out of proportion to its size. Or else I was too inexperienced in running an organisation of that kind. Directors are born, not made. I also spent a lot of time trying to resolve a problem that seemed important to me, the substantial non-involvement of SISSA in the Trieste city complex and the lack of commitment of the city towards SISSA itself. But we know that solving material problems is relatively easy, while psychological and social ones require very different times and logic. I remember the sun and the sea of Miramare, though I did not have the good fortune to experience the atmosphere of the new, fabulous home, always overlooking the Adriatic, but from an altogether higher location.

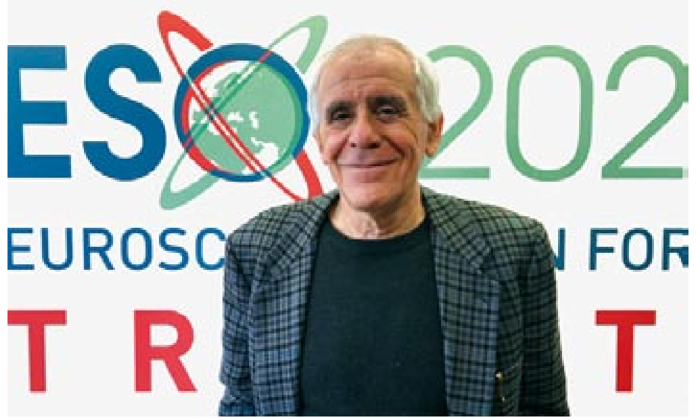
Stefano Fantoni

«The opening up of a new research area needs to be motivated by an increasing capability to attract good students from all over the world…»

SISSA and Trieste appeared on my horizon thanks to Erio Tosatti, who acted as a siren upon me. We knew each other from the time we were both at the University of Pisa. In the late eighties it happened that he was looking with some interest at the theory I had developed for strongly interacting fermions, the Fermi Hyper-Netted Chain theory, and he contacted me, apparently, to learn more about it. In reality, it was me to learn from him. I learned about the extraordinary opportunities that I could have by moving to SISSA.

I obtained a secondment from the University of Lecce, where I was full professor. I came to Trieste to substitute Paolo Budinich in the Direction of the Interdisciplinary Laboratory, a very important experience, which guided my SISSA route. I cannot forget the project of the Master in Science Communication that we developed two to three years later. I inherited from Budinich the activity of the scientific and literary languages sector coordinated by Claudio Magris.

During one of the meetings of that sector the idea of focusing upon science communication as a Laboratory activity came up. I knew Franco Prattico, the *father* of science journalism in Italy, whom



I had the opportunity to meet in Lecce on the occasion of a science festival that I had organized for the Nuclear Physics Institute (INFN). Franco, Paolo and myself, around a table at the ICTP cafeteria, decided to create a Master in Science Communication. With the approval of Da-niele Amati, who was the SISSA director at that time, I started it up in the Interdisciplinary Laboratory. The Master's was very successful and has educated several young students who today constitute a large presence in Italian science journalism. The Master's became well known abroad. For its development I was awarded with the Kalinga Prize by Unesco in 2001.

Franco Prattico and Stefano Fantoni.

Let's now come to my directorate. During my unforgettable six years of SISSA leadership, I followed three main strategies that I would like to share with the friends of the School on the occasion of its 40th celebration.

The first one, maybe the most important, was to revitalize and keep alive the original spirit of Amati fs SISSA, that of a school open to new ideas and new research areas, with solid commitments and a strong sense of realism. Let me explain more clearly what my interpretation of commitment and realism was. The opening up of a new research area needs to be motivated, on the one hand, by an increasing ability to attract good students from all over the world, and on the other, to be able to educate them to the highest level, so as to launch them towards wonderful research careers. That involves being as farsighted as possible, but at the same time avoiding starting new PhD sectors from scratch. The way to accomplish that has always been to try out new ideas within the Interdisciplinary Laboratory, and moreover to make use of the International Advisory committee. That has worked very well for the Neuroscience sector and for the Master in Science communication, and reasonably well for the Astroparticle and the Statistical Physics sectors, as also for the activities developed in Applied mathematics. Such a strategy could not have been pursued without having in the School top-quality scientists, world-famous and very well connected with all the major scientific teams around. In particular the coordinators of the sectors, the Directors of the Interdisciplinary Laboratory and my Deputy Director Luigi Danese, all shared this strategic view and made an important contribution to its realization. All of us paid great attention to the recruitment process of new

Stefano Fantoni and Paolo Budinich.

scientists, based on both scientific merit and the rejuvenation of the School.

The second strategic view was faced with a SISSA becoming more and more self-referential: a beautiful island wrapped in mist. The school continued to be very well known abroad, thanks to the high level of its scientific production, but not so well known in the local and national territory. People in Trieste were hardly aware that SISSA was different from ICTP and had no perception of the jewel they had at home. The same thing happened at the Conference of Italian University Rectors, the CRUI, where SISSA was considered to be only a small entity, and because of that of scant importance, rather than as one of the best PhD schools in the world. Even our relations with the other Italian Universities having a Special Statute, like Scuola Normale Superiore and Scuola Sant'Anna in Pisa, were increasingly weakening.

For this reason I thought it was crucial to establish strong relations with the Ministry of Education and Research (MIUR) and with all the Italian Universities, both the normal, public ones and those with Special Statute. At the local level we strongly improved our dialogues of Science to Citizens and Science to Business.

As far as the Science to Citizens is concerned a fantastic job was done by the team of the Master in Science Communication and the Interdisciplinary Laboratory. We organized two memorable Science Festivals, the "Trieste Fair of Scientific Media" (FEST), which resonated throughout the national

The restoration of the new SISSA Building.

territory and are still remembered by the Trieste citizens. Those events were very effective in bringing SISSA and the city of Trieste closer together.

Regarding the Science to Business interaction important activities were made by the Neuroscience, Condensed Matter and Applied Mathematics sectors. I would like to mention the contribution made by Alfio Quarteroni, who was hired by me to promote and lead the dialogue between Applied Mathematics at SISSA and a number of local companies.

The third and last strategy concerned the need of the School to get a building which could host its research and educational activities for at least the next twenty years. SISSA was still growing in terms of research areas. In particular, the experimental component of the Neuroscience sector was in need of more space and facilities.

The speech of the President of the Republic Giorgio Napolitano at the inauguration of the new SISSA Building in 2010.

The opportunity for a new, larger building arose with the disused hospital, Santorio, put on sale by the regional administration. It was a fantastic opportunity that we could not afford to miss: a huge building with a large and beautiful park in a splendid location up on the hill of Trieste with a tremendous view of the bay. Together with my irreplaceable Administrative Director, Giuliana Zotta, we started the complex procedure of acquiring the building and renovating it from a disused hospital to a new SISSA. The important financial side to the whole operation was made possible thanks to the support received by the regional administration and by MIUR. The strong relations earlier established with these institutions proved to be essential to the success of the enterprise. The whole Santorio operation was performed within the expected time, about three years, and within the expected budget. It was not even necessary to sell the old building located in Via Beirut, close to ICTP, which is still a SISSA property.

It was real teamwork, which saw professors, administrative and technical personnel working together with great passion and enthusiasm.

Let me conclude by saying that leading SISSA has been one of the most exciting times of my life. I remember one by one all the SISSA people, the *sissini*, as we used to say. Most of all, my memory and my gratitude goes to the fantastic administrative and technical team, Giuliana Zotta *in primis*, for their dedication, their hard work, their efficiency and for their sympathy.

Stefano Fantoni and Giorgio Napolitano.

On the next page: aerial view of the new SISSA Building at 265, via Bonomea. Credits: Cristiano De Nobili.

Guido Martinelli

«I am absolutely confident that the qualities that made SISSA unique will remain the same also in the future»

When I arrived at SISSA as its fifth director, the School was already a renowned international institute for research and education, an excellence in the Italian university system and in the world. These important achievements were certainly the result of the activity of the Directors who came before me.

As the new person responsible for the School I then tried to figure out what new initiatives for development and innovation could further advance SISSA, and I found two main directions: to create new research infrastructures, and to set up new collaborations with the other important scientific bodies present in Friuli Venezia Giulia and beyond. In addition, following the previous Directors' tracks, I tried to improve the image of SISSA as a real presence in the territory and as a centre of scientific dissemination.

We invested substantial effort on the part of the personnel in the informatisation of both serv-

The inauguration of the Main Lecture Hall dedicated to Paolo Budinich in 2014. On the previous page: photo from the terrace of the new SISSA Building. Credits: Cristiano De Nobili.

Fernando Quevedo, Director of ICTP, and Guido Martinelli inaugurate the supercomputer Ulysses in 2014.

ices for users and administrative procedures. A major effort was devoted to the necessary reorganization regarding safety in the laboratories, with better defined procedures, new regulations, and the assignment of precise roles and responsibilities. Finally, during my term, SISSA underwent several important transformations induced by the "Riforma Gelmini" that substantially modified the role and scope of the Rector, of the Board of Directors and of the Academic Senate.

Regarding the new infrastructures, besides several new laboratories for our researchers, we made the new computing centre Ulysses at Miramare, in collaboration with ICTP, the "Laboratorio di meccatronica avanzata del Friuli Venezia Giulia (Lama FVG)", and with the Universities of Trieste and Udine and SISSA Mathlab. These are important achievements which attract researchers and students from all around the world.

Regarding the collaborations with other institutions, new PhD courses were activated: a joint PhD for Mathematics and Physics in collaboration with ICTP and the Joint PhD in Molecular Biology with ICGEB and Trieste University. An agreement for the "International Joint Master program – Physics of Complex Systems Methods and Multidisciplinary Applications" was signed by Université Pierre et Marie Curie, Université Paris Diderot, Université Paris-Sud 11, ENS Cachan (Francia), Politecnico di Torino, ICTP and SISSA. Several shared initiatives, including joint meetings of the Boards of Directors and Academic Senates, were also undertaken by the Universities of Trieste and Udine so as to strengthen the spirit of collaboration, optimize resources, and improve research and education.

Presentation of the new SISSA/ICTP supercomputer Ulysses.

As for science dissemination let me recall "SISSA per la Scuola", organized in collaboration with SISSA Medialab, a regular programme of visits by schools started in 2013. School groups, from the small children of primary schools to high school students, were accepted in SISSA in order to make its activities and researchers known to young citizens. We hosted several hundred students from many different institutes, most of them from Trieste or nearby. SISSA students were the protagonists of the visits, since they worked as guides, speakers or explainers. We also organized several editions of "SISSA in Festa", a series of open days with several events for schools and the public: scientific lectures, exhibitions, guided tours through the School's Labs, concerts and games. Moreover, SISSA participated in all the editions of "Trieste Next", a Science education event held yearly in Trieste.

Guido Martinelli meets high school students at SISSA.

Graduation ceremony for first ICTP-SISSA PhD during Martinelli's managment.

Let me finally stress that It is thanks to my colleagues, professors, researchers and postdocs, to their spirit of initiative and innovation, and to the extraordinary technical and administrative staff, that SISSA was able to achieve so many important goals. A special acknowledgement must also be devoted to the students for their passion and enthusiasm for research and their support and skill in all the dissemination activities. I am absolutely confident that the qualities that made SISSA unique will remain the same also in the future.

It was a great privilege for me to lead the School for an extraordinary human experience which lasted five years.

40 years of SISSA Administration

In 1978 SISSA carried out its scientific activity at Strada Costiera 11 with small administrative support. In 1980 the first public technical administrative calls for recruitment of 7 staff members were held for the main activities of the personnel, accounting and purchasing offices.

The scientific and administrative growth led to the search for more space, which in 1981 was found in an ex-ERDISU building at the Bivio di Miramare, where the administrative management, registry, personnel, accounting, and purchasing offices, as well as the activities of the PhD courses in Mathematics, Geometry and Astrophysics, were located. Other activities, including those of the Director's secretariat, were still at Strada Costiera 11.

The need for more space is a constant in the life of SISSA. In 1984 the building of the headquarters at Via Beirut 2-4 began, and was completed in 1991. However, the rooms were already too small for the requirements and the administration moved from the Bivio di Miramare to the Bellavista building at Via Beirut 9.

Office in the building at Bivio di Miramare.

The building at Bivio di Miramare.

During these years, the scientific activities were supported by supercomputers, while the administrative documents were still carefully typed and the documentation was exchanged in paper envelopes. The first PCs and the first management programs appeared. The advent of e-mail automated and facilitated the exchange of communications.

The administrative direction of SISSA was managed for more than 20 years (1987-2010) by a single leader who closely contributed, together with the scientific direction, to boosting the School's activities.

The young administrative personnel (aged circa 40) tried to keep up with the lively development of the School's scientific activities, despite the growing bureaucracy and the policy of reduction of recruitment and of professional training.

Here is the table with the numerical evolution of the administrative technical staff:

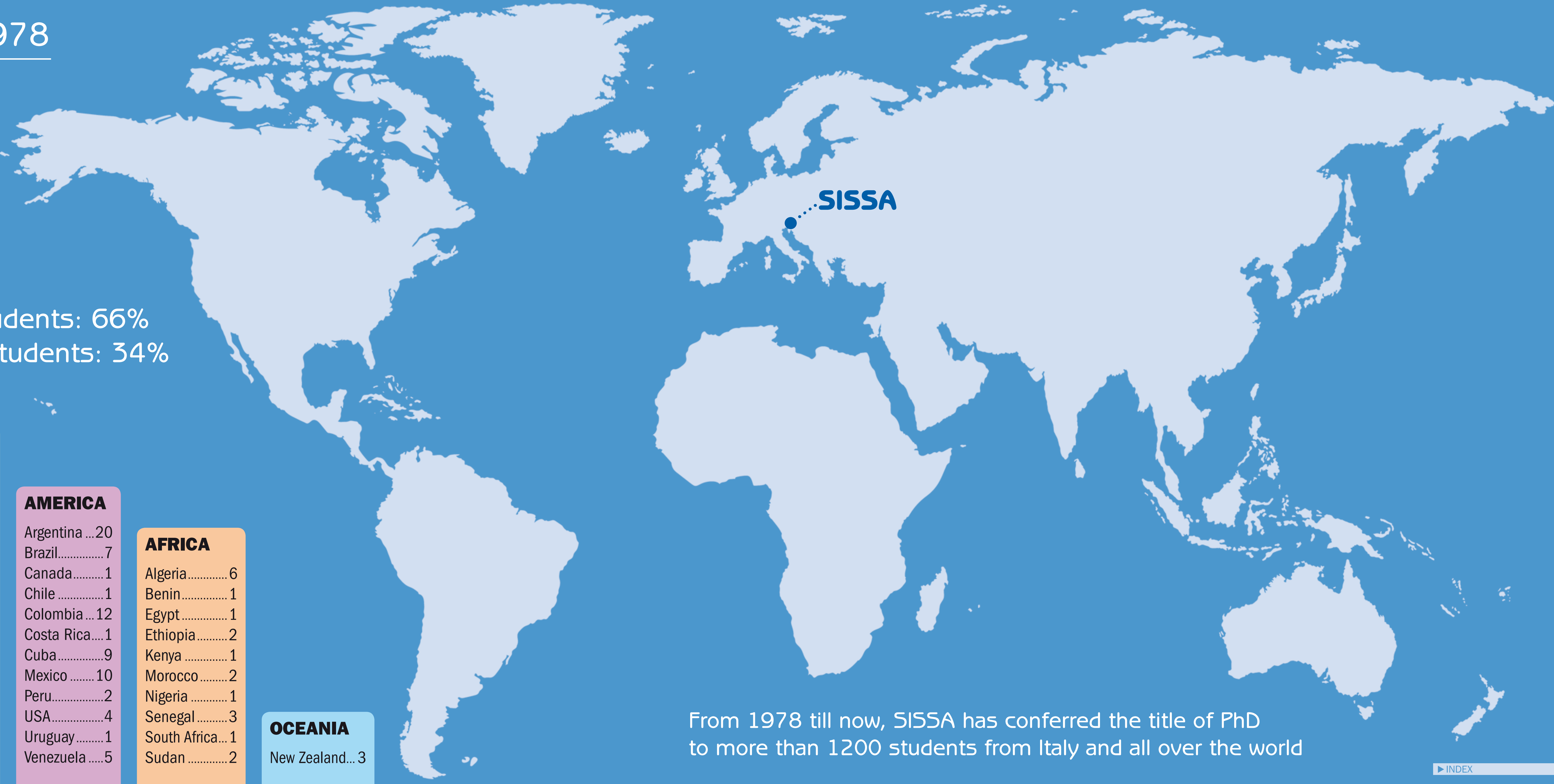
1978/1980	1991	2001	2010	2017
7	42	65	90	117

The year 2010 was fundamental in the history of the School which could see all its activities united in a single district, following the transfer to the new site at the ex-Hospital Santorio, located at Via Bonomea 265, after 4 years of renovation.

That same year, the change of both scientific and administrative directions also involved a radical change in the administration.

Today, SISSA's administration, through a growth and training process, guarantees good quality standards in its support of all the activities of the School.

SISSA PhD since 1978



Italian students: 66%
Foreign students: 34%

EUROPE

Albania	2
Austria	1
Bosnia Herzegovina	2
Bulgaria	4
Croatia	11
Czech Republic	6
Estonia	1
France	7
Germany	6
Greece	3
Hungary	1
Ireland	1
Latvia	1
Lithuania	3
Netherlands	1
Poland	17
Portugal	4
Romania	11
Russia	19
Serbia / Jugoslavia	6
Slovakia	3
Slovenia	3
Spain	3
Sweden	1
Switzerland	5
Ukraine	2
United Kingdom	8

ASIA

Armenia	1
Bangladesh	1
China	55
India	34
Indonesia	1
Iran	30
Iraq	1
Jordan	2
North Korea	2
Pakistan	4
Syria	1
Thailand	2
Turkey	6
Uzbekistan	3
Vietnam	15

AMERICA

Argentina	20
Brazil	7
Canada	1
Chile	1
Colombia	12
Costa Rica	1
Cuba	9
Mexico	10
Peru	2
USA	4
Uruguay	1
Venezuela	5

AFRICA

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From 1978 till now, SISSA has conferred the title of PhD
to more than 1200 students from Italy and all over the world

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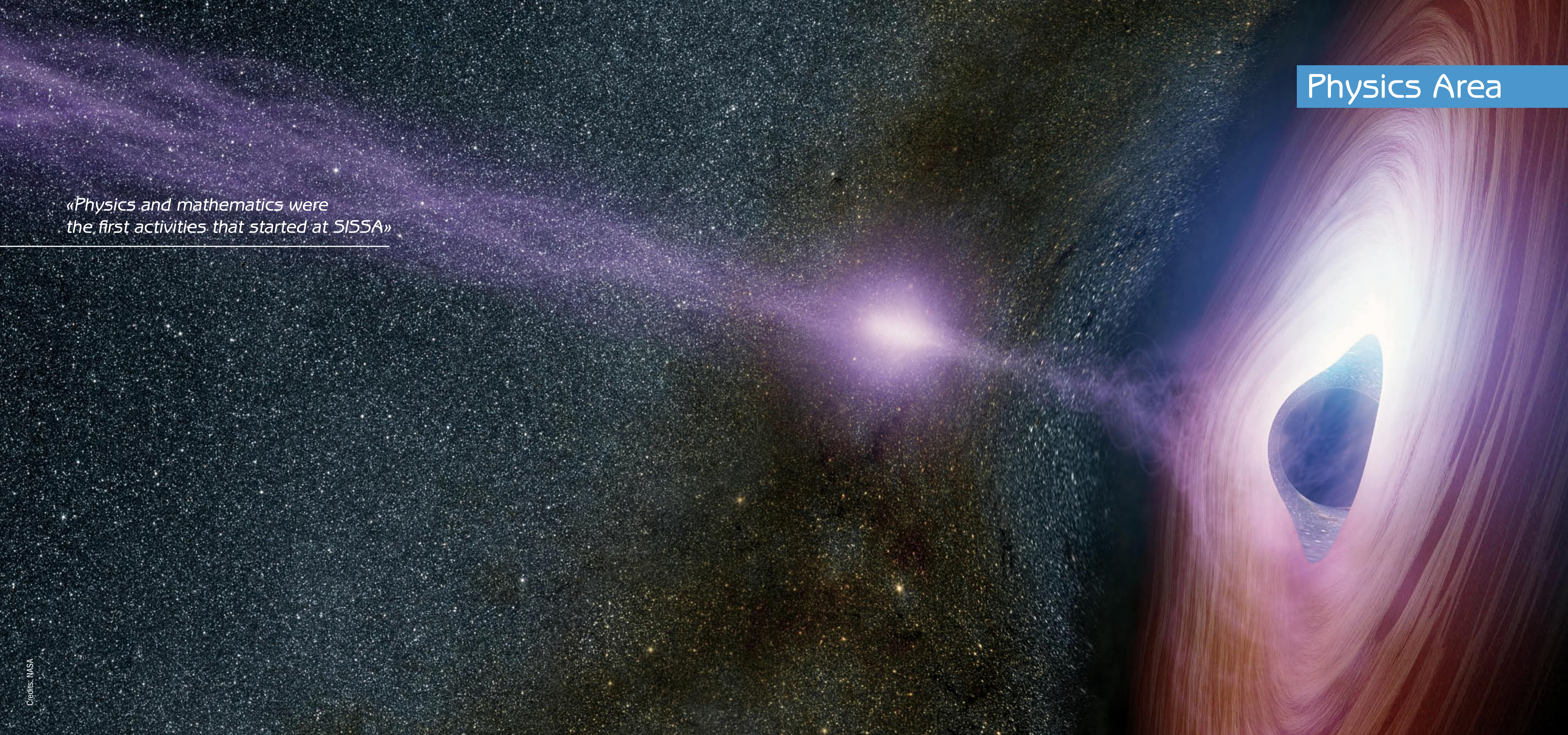
What we do at SISSA everyday

Credits: Fabrizio Giraldi

Physics Area

«Physics and mathematics were the first activities that started at SISSA»



Credits: NASA

PHYSICS AREA

«This is the very nature of fundamental research: the biggest technological revolutions are the result of curiosity-driven scientific quests»

Physics and mathematics were the first activities that started at SISSA. The physics seeds included particle theory and condensed matter, both of which were connected with ongoing activity at ICTP, and astrophysics which was efficiently launched by Dennis Sciama, who left Oxford to join the new-born SISSA faculty. Their growth led to what is now the Physics Area at SISSA, and to spin-offs such as the first electronic journal in the world, the Journal of High Energy Physics.

The Physics Area now covers a broad range of topics in Astrophysics, Astroparticle Physics, Theoretical Particle Physics, Statistical Physics, Condensed Matter Physics, and Molecular and Statistical Biophysics. The research carried out is mostly theoretical. The aim is to understand Nature in its pure beauty and fascinating complexity at all levels, from the tiny size of an elementary particle to the scale of the entire universe, from the ephemeral subatomic processes to the timescales of cosmology, from the feeblest energies of neutrino fluctuations to the most extreme event that ever happened, the birth of the universe; and, midway, the world we experience, in its uttermost complexity and amazing variety. The understanding of the behaviour of the building blocks of life, from proteins to chromosomes; or of inorganic matter, in terms of its dynamics at the molecular level; or of the incredible number of correlated constituents making up macroscopic matter and its variety of surprising behaviours – such researches have an impact on everyday life that in some cases is immediate and concrete and in others might take decades to become apparent. This is the very nature of fundamental research: the biggest technological revolutions are the result of curiosity-driven scientific quests.

Research and teaching go together at SISSA. Most of the teaching effort in Physics is devoted to Ph.D. training, offering the students during their first year of studies a uniquely intense and articulated set of advanced courses, a wide spectrum of research projects to choose from, and constant interactions with their supervisor.

The results of the research activity are published in the most prestigious international journals. The overall publication record in Physics at SISSA has been consistently rated as top level in the periodic national research evaluations. This is also reflected in the number of international competitive grants obtained to financially support research, the highest per capita in Italy.

Astrophysics and Cosmology

Astrophysics was one of the original sectors of SISSA at its foundation in 1978. It was headed first by N. Dallaporta, and then by D. Sciama. The leading idea has been to develop interdisciplinary researches in Astrophysics, Cosmology and Fundamental Physics.

In the field of Cosmology and Galaxy Formation, major contributions have concerned cosmological perturbation theory. Very efficient methodologies to investigate the nature and properties of Dark Matter (DM) have been developed by exploiting the phenomenology of galaxies and galaxy clusters; the results are mainly used by particle physicists to design strategies for direct DM searches.

SISSA is one of the leading Institutes in the theory and observation of the Cosmic Microwave Background (CMB), the key observable for Cosmology. During the early eighties staff, post-doc and PhD students were involved in the precise determination of the CMB spectrum and, at the beginning of the nineties, in proposing the ESA PLANCK mission devoted to precisely characterizing the CMB anisotropies. SISSA set up in Trieste the PLANCK LFI Data Processing Centre in collaboration with INAF. These efforts, coordinated with the most important centres for Cosmology in the world, contributed to the spectacular results concerning cosmological parameters such as the baryon, DM and Dark Energy (DE) content of the Universe, the amplitude of primordial perturbations, weak lensing, and the reionization epoch. SISSA is now involved in next-generation experiments on polarization of the CMB (SIMONS ARRAY and OBSERVATORY, the LiteBird satellite), looking for Primordial Gravitational Waves imprinted during the Inflation Epoch.

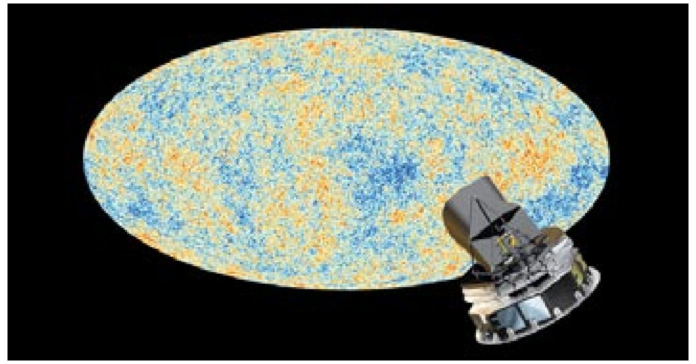
SISSA has been a leading Institute in the development of studies aiming to shed light on the physical relations between the formation of stars in the galaxies, the growth in their centres of Black Holes (BHs) endowed with mass larger than a billion Suns, and the QSOs phenomenon.

The Einstein ring of the gravitationally-lensed galaxy SDP81. The bright orange central region of the ring (ALMA's highest resolution observation ever) reveals the glowing dust in this distant galaxy. The diffuse blue element at the centre of the ring is from the intervening lensing galaxy, as seen with the Hubble Space Telescope. Credit: ALMA (NRAO/ESO/NAOJ); NRAO/AUI/NSF; NASA/ESA Hubble (NRAO).

A key area in SISSA has been the study of accretion of mass onto BHs, both observationally and by means of numerical simulations. The influential slim disc model and the oscillations of accretion discs have been studied in SISSA since the eighties. Most of the advanced tools to extract gravitational waveforms of neutron star and Black Hole coalescence have been produced since 2000. Relevant contributions have been made towards thermodynamic aspects of BH physics in relation to the possibility of BH evaporation via the celebrated Hawking effect.

Since its foundation SISSA has been largely contributing to the development of stellar formation and evolution. The main fields have been those of Evolutionary Tracks, Isochrones (Padova-Trieste database) and the integrated Spectra of Galaxies. The final stages of the stellar evolution have been investigated and the results of the dedicated papers have been used by the LIGO collaboration to determine the metallicity of the progenitors of the merging BHs detected by Gravitational Waves.

In SISSA the results obtained by the most advanced facilities such as CHANDRA X-ray and FERMI gamma-ray space telescopes have been exploited in order to study the physical mechanisms that produce and accelerate particles up to extraordinary high energies > 10^{20} eV. Thermal Comptonization has been shown to produce the peak emission of Gamma Ray Bursts, which are the extraordinary electromagnetic manifestation of the final phase of the implosion of star(s), very recently clearly associated with the detection of gravitational waves. Also the astrophysical jets in Active Nuclei/QSOs have been found to be mainly powered by the extraction of energy from a rotating supermassive Black Hole.



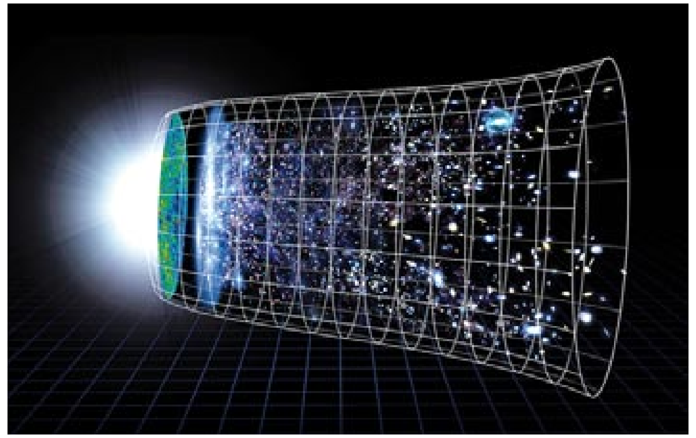
The anisotropies of the Cosmic microwave background (CMB) as observed by Planck. The CMB is a snapshot of the oldest light in our Universe, imprinted on the sky when the Universe was just 380,000 years old. It shows tiny temperature fluctuations that correspond to regions of slightly different densities, representing the seeds of all future structure: the stars and galaxies we see now in the sky. Credit: ESA and the Planck Collaboration.

While in the past century the astrophysical and cosmological observations were used to test gravitation and particle physics, in recent decades they have become a fundamental phenomenology, posing the most crucial problems Physics faces at the present time (e.g. DM and DE). Astrophysics and Cosmology groups in close coordination with the new Institute IFPU, founded by SISSA, ICTP, INAF and INFN, will contribute to the development of new ideas in Physics with renewed enthusiasm.

About 20 staff members and 200 PhD graduates and post-docs have been contributing to the above results over 40 years.

Astroparticle Physics

Astroparticle Physics is a relatively new field of research at the intersection of Particle Physics, Cosmology and Astrophysics. The aim is to study the fundamental laws of Nature as emerging from astrophysical and cosmological observations, in conditions not accessible to the technology of terrestrial experiments. It addresses some of the most pressing open issues in Science today, such as, for example: identifying dark matter and dark energy, the two main components of the Universe, which regulate how galaxies, clusters of galaxies and all the structures seen in the Universe formed, and how the Universe itself is evolving, although their nature remains mysterious; understanding the physics of the primordial Universe and shedding light on the relative enigmas, such as the reason why there is ordinary matter in the Universe but hardly any antimatter; learning from Cosmology and Astrophysics the properties of neutrinos, the most elusive particles detected so far and a window on physics beyond the Standard Model; addressing the origin of the Universe itself and grasping the nature of gravity.



A representation of the evolution of the universe over 13.8 billion years. Credits: NASA's Goddard Space Flight Center.

The field has been rapidly growing under the stimulus of very vigorous and variegated experimental programs. Results have been beyond all expectation, with at least five Nobel prizes in Physics assigned to discoveries related to Astroparticle Physics in the last fifteen years, including the prize in 2017 for the detection of gravitational waves. The goal of the SISSA group has been to bring such exciting observational developments to the forefront of the theoretical research.

SISSA has acquired a position of prominence in the field since its earliest steps, with leading scientists affiliated to the Astrophysics and Theoretical Particle Physics Sectors, including, e.g., Prof. Dennis Sciama, one of the initiators of the field, and Prof. Antonio Masiero, currently Chair of the Astroparticle Physics European Consortium (APPEC). In 2004 Astroparticle Physics was promoted to one of the preeminent interests of SISSA, with the institution of a new independent research group and a dedicated PhD program. About 35 students have graduated since then, with research projects mainly dedicated to various possible approaches to the dark matter problem, tests of fundamental physics in the early Universe and cosmological environments, as well as to a deeper understanding of the theory of gravity and its possible quantum extensions, or to discovering new particles or particle properties via cosmic messengers, such as cosmic-rays, gamma-rays and neutrinos.

Concept illustration of a supermassive black hole with millions to billions times the mass of our sun. Credits: NASA/JPL-Caltech.

The journey through the history of the Universe, represented on the sixth floor of SISSA building, as you learn from Cosmology, Astrophysics and Astroparticle Physics. Credits: Stefano Amadeo.

Theoretical Particle Physics

Phenomenology of fundamental interactions

In the reductionist spirit that has characterized the understanding of Nature since Democritus, theoretical particles physics aims at an ultimate understanding of all known phenomena in terms of a minimum number of laws governing the interactions of a few fundamental constituents. The dream is to understand all phenomena in terms of a unified theory, to understand the evolution of our universe from its birth. An ambitious goal! However, Nature has always shown an inclination for elegance, and such a theory would be its ultimate manifestation. Moreover, a lot of progress has been made in this direction: we can today explain almost all the known phenomena in Nature in terms of 4 fundamental forces and 17 elementary particles, the so called “Standard Model” (SM).

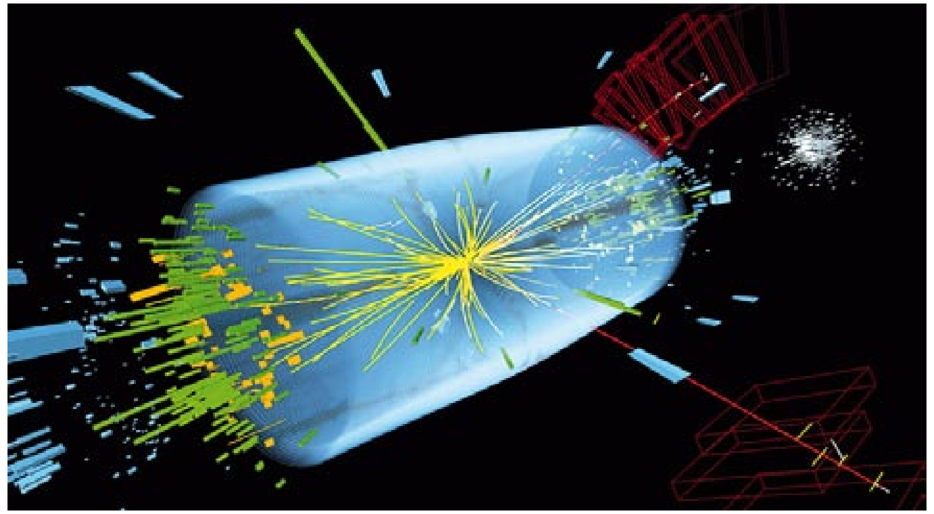
Powerful as it is, the synthesis provided by the SM is still not sufficient. The research on the phenomenology of fundamental interactions at SISSA aims at going beyond it – something not only longed for because of the above-mentioned dream, but also needed for a number of reasons. First, some phenomena are not explained by the SM. For example, we do not know what 95% of our universe is made of, what dark energy and dark matter are, nor the origin of the mass of neutrinos, particles that can cross the whole Earth unnoticed. Moreover, the SM is plagued by theoretical problems. For example, it is not clear how the enormous difference in intensity between the gravitational and the weak force can be reconciled with the quantum structure of the SM.

Testing our theories requires experiments with ever-higher energies (at the microscopic level of elementary particles). Hence the enterprise that led to the construction of an experiment of a complexity never achieved before, the “Large Hadron Collider” at CERN, near Geneva. Several hypotheses have been formulated for what such an experiment would find (besides the Higgs boson, found in 2012) and have been investigated at SISSA, such as “supersymmetry” and composite Higgs models, or more speculative possibilities involving extra space dimensions, or the “multiverse”. To date, though, the LHC has not found hints of new physics, a significant surprise. If such a surprise were confirmed, it would lead to a striking paradox whose explanation would become the central problem in the effort to understand the laws of nature at their most fundamental level, an effort to which SISSA aims at continuing to contribute.

Theory of fundamental interactions

Theoretical particle physics aims at studying the laws of nature at the smallest scales, those of elementary particles. This microcosmos is not governed by the “classical” laws of mechanics we are used to, but by their more exotic “quantum” version. In the last forty years or so a general framework to describe all the elementary particles that we know has emerged: the so called Standard Model of particle interactions. This incredibly successful theory, however, does not describe all the interactions in nature, excluding the one that we are most aware of every day, that keeps you seated in your chair while reading this text: gravity.

We can have a detailed description of particle interactions without gravity for the simple reason that gravity in the microcosmos is completely negligible, being millions of billions times weaker than the weakest of the other interactions (on the other hand in the cosmos it is the dominant force of nature). However, we believe that if we keep going at smaller and smaller distances, directly inaccessible at present, at some point gravity will no longer be negligible. We will be faced with the problem of understanding the quantum nature of this interaction, the so called “quantum gravity”. This is crucial if we want to understand extremal phenomena, such as the first moments of the universe after the Big Bang or the physics of black holes. Unlike the other interactions, gravity does not fit easily into the framework of quantum field theory, the mathematical framework used by theoretical physicists to study the other interactions, which is also at the base of the aforementioned Standard Model. On purely theoretical grounds a theory has emerged as the most promising quantum gravity candidate: string theory. Such a theory in some sense predicts the existence of gravity. Moreover, it admits an approximate description in terms of the framework of quantum field theory which has proved to be highly successful. It seems we are on the right track, but without the help of experiments it is hard to draw firm conclusions. String theory is an amazingly rich laboratory of new ideas and nowadays has several applications beyond the physics of elementary particles. Most of the theoretical research made in the TPP group at SISSA in the last 40 years concerns developments of various aspects of string theory and of its recent related aspects, and of other models of quantum gravity.



What the Higgs boson looks like. The figure shows the remnants of its production and its subsequent decay into a pair of electrons (green lines and green towers) and a pair of muons (red lines), as measured at the LHC experiment at CERN (Photograph: McCauley, T.; Taylor, L.).

Installation of the CMS detector at the LHC experiment at CERN. Credits: CERN.

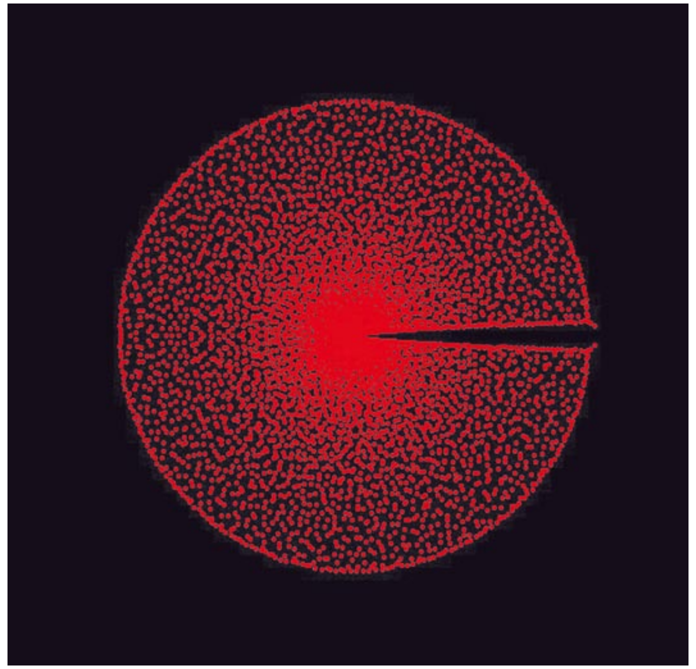
On the next page: a lesson of Theoretical Particle Physics at SISSA. Credits: Stefano Amadeo.

Statistical Physics

Statistical Physics, together with Quantum Mechanics, is the pillar of our understanding of many physical phenomena, from the very simple to the more sophisticated. In short, Statistical Physics deals with the behaviour of classical or quantum systems consisting of an enormous number of degrees of freedom: it foresees the possibility of forging new states of matter, e.g. Bose-Einstein condensation in ultra-cold gases, and also addresses crucial questions about the nature of the phase transitions. What is their ground state in each phase? What are the entanglement properties of the system? How do the quantum systems thermalize?

While it helps us in controlling profound features of our natural world, Statistical Physics also provides a vital source of fresh ideas and inspirations for those working in more theoretical directions, e.g. quantum field theory, exactly solved models, random matrices, complex systems, probability, topological quantum computation, quantum many-body systems and even number theory.

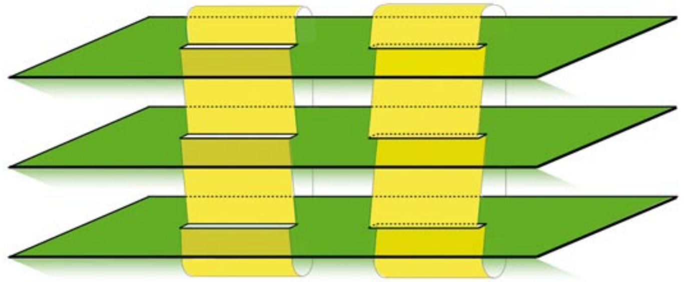
Its attraction lies in its profoundly interdisciplinary nature and its ability to produce an array



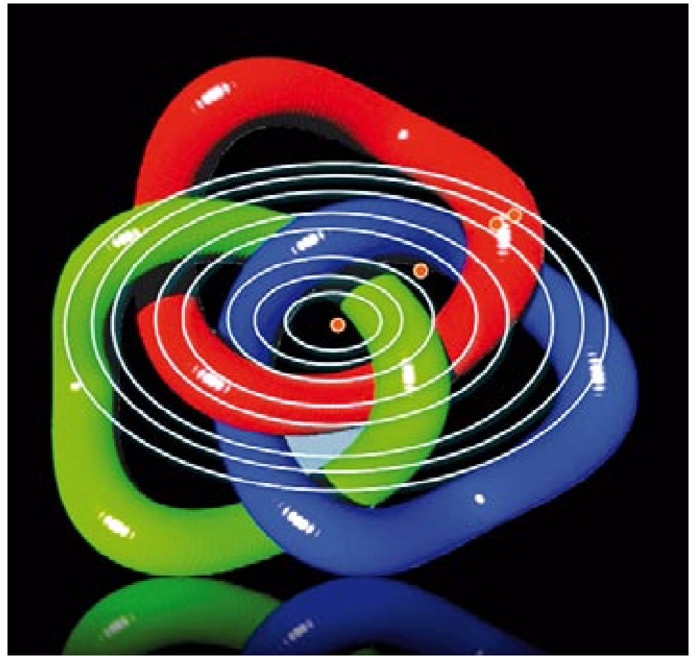
Yang-Lee zeros in the complex plane
for a statistical model based on prime numbers.
Credits: Giuseppe Mussardo.

of sophisticated analytical and conceptual tools with far-reaching applications. It contains some wonderfully general ideas: entropy, entanglement of quantum systems, probability distributions, the idea of renormalization, universality of phenomena in Nature, the irreversibility nature of many physical processes and then the emergence of the arrow of time. This remarkable blend of mathematical and physical ideas is at the root of the outstanding scientific elegance and extraordinary efficiency that characterize this scientific area. The subject has a very rich and profound logical structure and it is connected to the rest of physics by a multitude of experimental studies, theoretical arguments, empirical experience and a deep analysis of the consequences of the basic laws in Nature.

The group of Statistical Physics at SISSA, founded in 2005 by Giuseppe Mussardo and presently consisting of Pasquale Calabrese, Gesualdo Delfino, Andrea Gambassi, Stefano Ruffo and Erik Tonni, together with Andrea Trombettoni from CNR, has gained worldwide scientific recognition for the deep and exact analysis of cutting edge topics such as quantum integrable field theories, Ising model in a magnetic field, breaking integrability, anyon physics and topological quantum computation, optical lattices and cold atoms, Casimir effect, quantum quenches, quantum systems out of equilibrium, number theory and quantum physics, Yang-Lee zeros, holographic methods and entanglement entropy.



Riemann surface for the description of the entanglement
between two disjoint intervals in a conformal field theory.
Credits: Pasquale Calabrese; Erik Tonni.



Braiding of anyon excitations.
Credits: Giuseppe Mussardo.

Condensed Matter

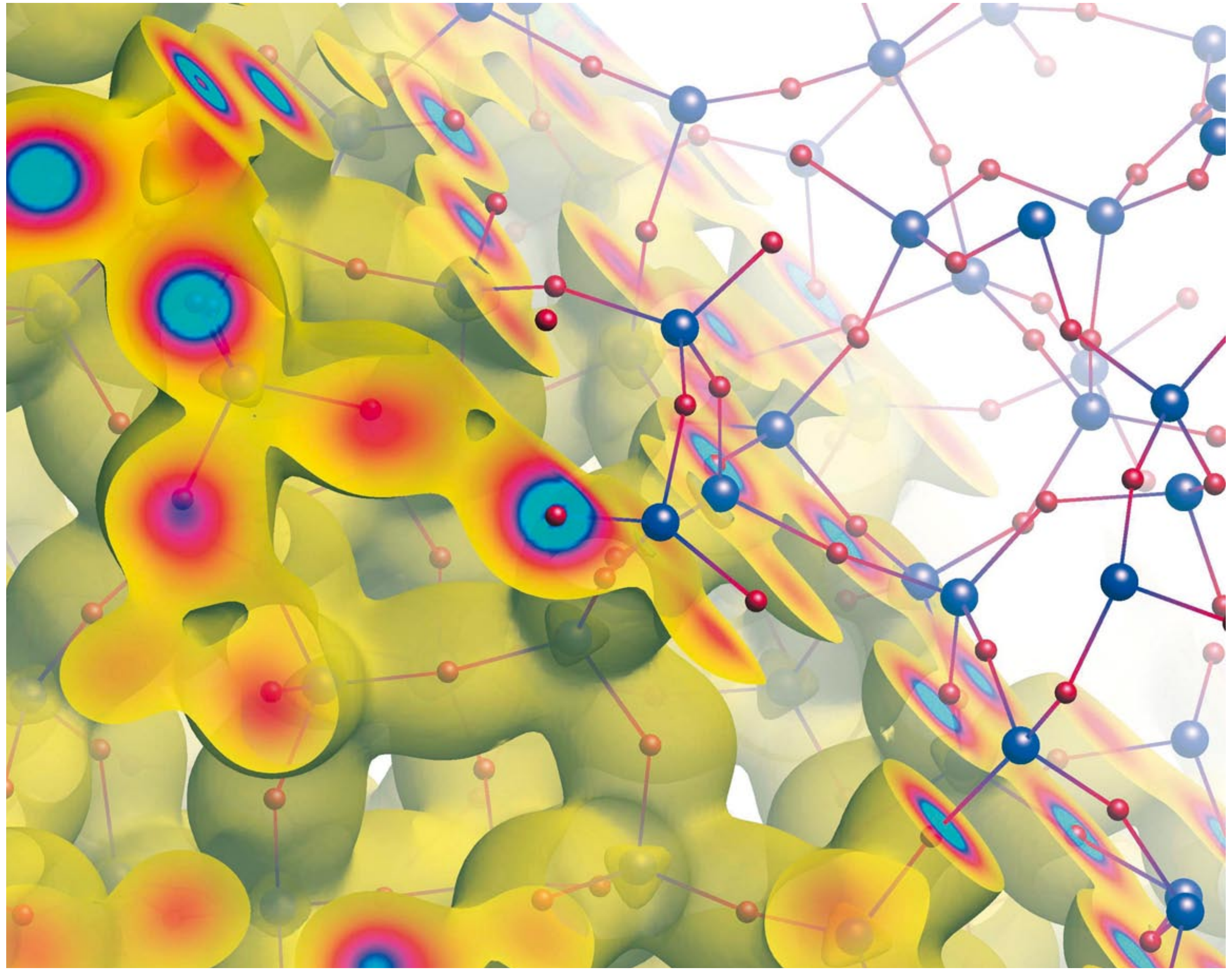
Why theory of condensed matter matters

Everything tangible around us is matter or radiation. The scope of Condensed Matter Theory (CMT) is understanding, through calculations, the reason why matter and radiation behave the way they do. Quantum mechanics describes an atom, a molecule or a photon with great accuracy: yet matter contains monstrous numbers of them, requiring ad hoc approximations for different systems or different properties. Superficially, that might seem unattractive when compared to the elegant formulations of other areas of physics. What turns this perspective completely around is the existence (Anderson 1972, “more is different”) of emergent laws. New laws emerge out of very large numbers of individuals, entirely different from, and arguably of higher universal status than, those that rule the single atom, molecule or photon. Solid or liquid, metal or insulator, topological or trivial, etc., are but examples of this emergent universality, projecting every case study, specific as it might be, well beyond its narrow scope. Members and students of the CMT group of SISSA work in this rich intellectual context, solving theoretically or numerically curiosity-driven problems – science rather than technology (although technology will surely benefit). Since its inception, SISSA’s CMT group has gained world renown for the development of frontier methods for especially difficult problems, such as first-principles simulations of matter, the properties of solids with strong electron correlations, electron and lattice dynamics of crystals and interfaces, magnetic and strongly fluctuating systems, matter under extreme conditions of high pressures or ultra-high excitation, subtle chemical physics processes, complex and disordered systems, and much else. Former researchers, postdocs and students of the group now occupy key positions worldwide in the most diverse countries and institutions. CMT also spawned life in brother institutions such as the International Centre for Theoretical Physics, the University of Trieste, and beyond, while serving as a permanent incubator of future research lines in SISSA. Statistical physics, and its biologically applied variety, both now flourishing in SISSA with great interdisciplinary impact, were started in 1994 within the CMT group. Materials science, or the physics of friction and soft matter, or surface nanochemistry, currently cultivated within the group, hold a similar potential. We continue and grow in this great tradition.

Computer simulation: from the golden age to the challenges ahead

Say “*SISSA”* and many around the world will understand *Ab Initio Molecular Dynamics*, or *Density-Functional Perturbation Theory*, or *Quantum Monte Carlo*, or *Quantum ESPRESSO*, or any of the countless innovations in molecular and materials simulations that have seen the light of day at SISSA since the Winter of ’85, when Roberto Car and Michele Parrinello met in the basement of the ICTP and decided that the time had come to revolutionize the numerical simulation of matter. Scientific computing was then regarded somewhat condescendingly by the Upper Floors of Science: the few available video-terminals were hosted in a library annex in the basement of the ICTP, which had to be vacated when needed for meetings. All changed when Erio Tosatti, on his return from a sabbatical year spent at the IBM laboratories in Zürich, realized that something really big had occurred during his absence and that something really big had to be done to sustain the revolution. He then convinced Paolo Budinich, whose heart was probably closer to the Upper Floors than to the basement of Science, that supporting computer simulation was strategic for the future of SISSA. In less than no time Budinich managed to secure substantial funding that allowed SISSA to sign the first collaboration agreement with the CINECA supercomputing centre, thus providing plenty of resources through the newly acquired CRAY supercomputer and a then trailblazing satellite connection between the two institutions. Meanwhile, the basement (again!) of the Bellavista building was refurbished to host a dynamic group of young researchers who made the history of those early days of quantum materials modelling. The tradition started by Car and Parrinello can be summarized in a beautiful quote by Richard W. Hamming: *The purpose of computing is insight, not numbers*. However, deep insight can only come from meaningful numbers, thus requiring the deployment of many and complementary technical and scientific skills in the spirit of a Renaissance arts workshop. This concept has inspired the many initiatives that SISSA has promoted in this field since 1985, including the creation of the DEMOCRITOS National Simulation Centre, the Quantum ESPRESSO project, the Master in High-Performance computing, and the EU MaX Centre of Excellence for high-performance materials modelling, thus shaping the *SISSA way to scientific computing*, which is internationally recognized and is leading SISSA students in this field to top positions worldwide.

The SISSA/ICTP supercomputer Ulysses. The project was developed by SISSA through an agreement with ICTP, and the machine is housed in the “old” SISSA headquarters in via Beirut 2-4.



Snapshot from a simulation of amorphous silica (SiO_2). The oxygen atoms are in red, and the silicon atoms are in blue. An electron density isosurface is represented in yellow, as well as some cross-sections shown as colour gradients. Credits: Loris Ercole; Sara Laporte.

Molecular and Statistical Biophysics

The roots of our group can be traced back to specific research lines started in SISSA in the late 1990's. It was a time of sweeping changes for molecular biology due to major advancements in experimental techniques such as atomic force microscopy, optical tweezers and nuclear magnetic resonance.

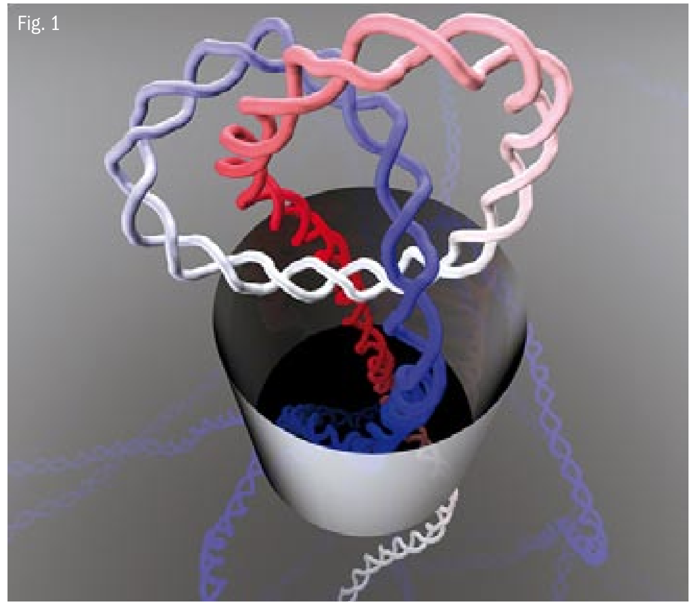
The astounding amount of collected data about the structure, thermodynamics and mechanics of proteins, polysaccharides and DNA called, in turn, for adequate accompanying theories.

In particular, the rapidly growing number of solved protein structures prompted a concerted effort to clarify the physico-chemical forces driving their formation. The activity started by Amos Maritan in SISSA around 1995 was among the first in the world to address this problem, known as protein folding, from the vantage point of statistical mechanics which, for its contiguity with polymer and soft matter physics, was ideally primed to bring innovative concepts and methods to the challenge.

For several years, the activity remained organic to the Condensed Matter Physics sector. Eventually, the increasing number of scientists drawn to it led to a new dedicated Sector and PhD program in 2002, when Daniele Amati was the School director. During the same years the covered topics grew to include chemistry, with Paolo Carloni, and the experimental nano-manipulation of biomolecules, with Giacinto Scoles.

After several changes, the group next acquired and established the research lines that characterize it to this day. These include: methods development for biomolecular simulations by Alessandro Laio; physics and chemistry of RNA by Giovanni Bussi; physical properties of packed chromosomes by Angelo Rosa, and molecular knots and links by Cristian Micheletti. The innately-multidisciplinary collaborative network involves colleagues from across all SISSA areas, Physics, Mathematics and Neuroscience, from local institutes such as CNR and ICTP, and international theoretical and experimental groups.

15 years on since the formal start of the activities, the group has trained about 60 PhD students and hosted as many postdocs, with backgrounds ranging from physics to chemistry, to pharmaceutical sciences, biology and mathematics. These younger researchers, with their commitment, energy and contagious enthusiasm for research, have much shaped and often renewed our scientific identity. Our gratitude goes to them and those that we will be fortunate to have in the future.



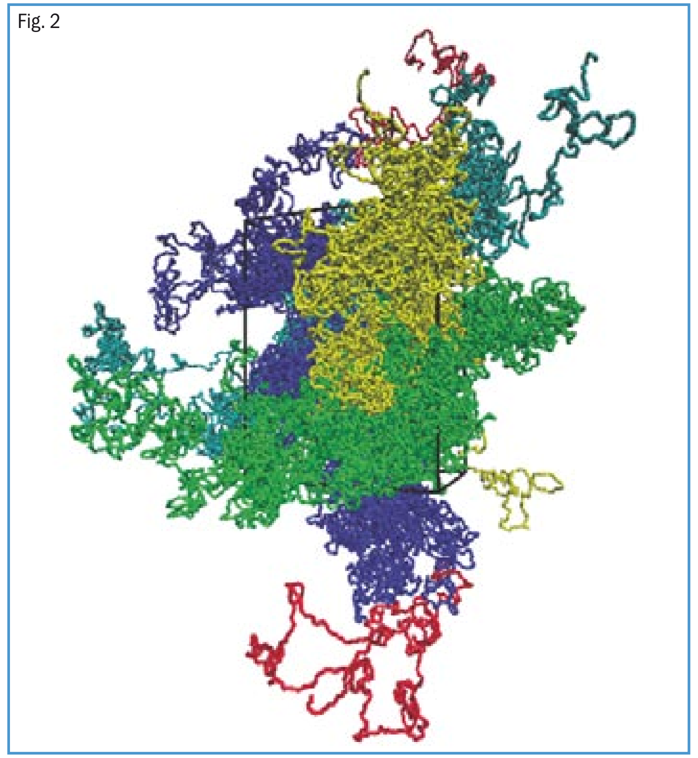


Fig. 1: An intricate problem: model of a knotted DNA filament translocating through a nanopore. The image is the rendering of a specific configuration visited during a molecular dynamics simulation and is related to the study of Suma and Micheletti, PNAS vol. 114, p. E2991-E2997 (2017).

Fig. 2: Model of human chromosomes inside the cellular nucleus. Different colours are used for different chromosomes. The model genome was obtained through numerical simulations, as described in Rosa and Everaers, PLoS Comput Biol. Vol. 4, art no. e1000153 (2008).

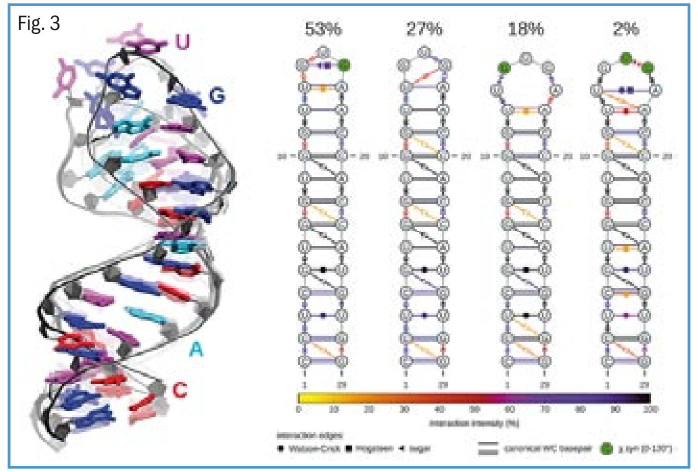
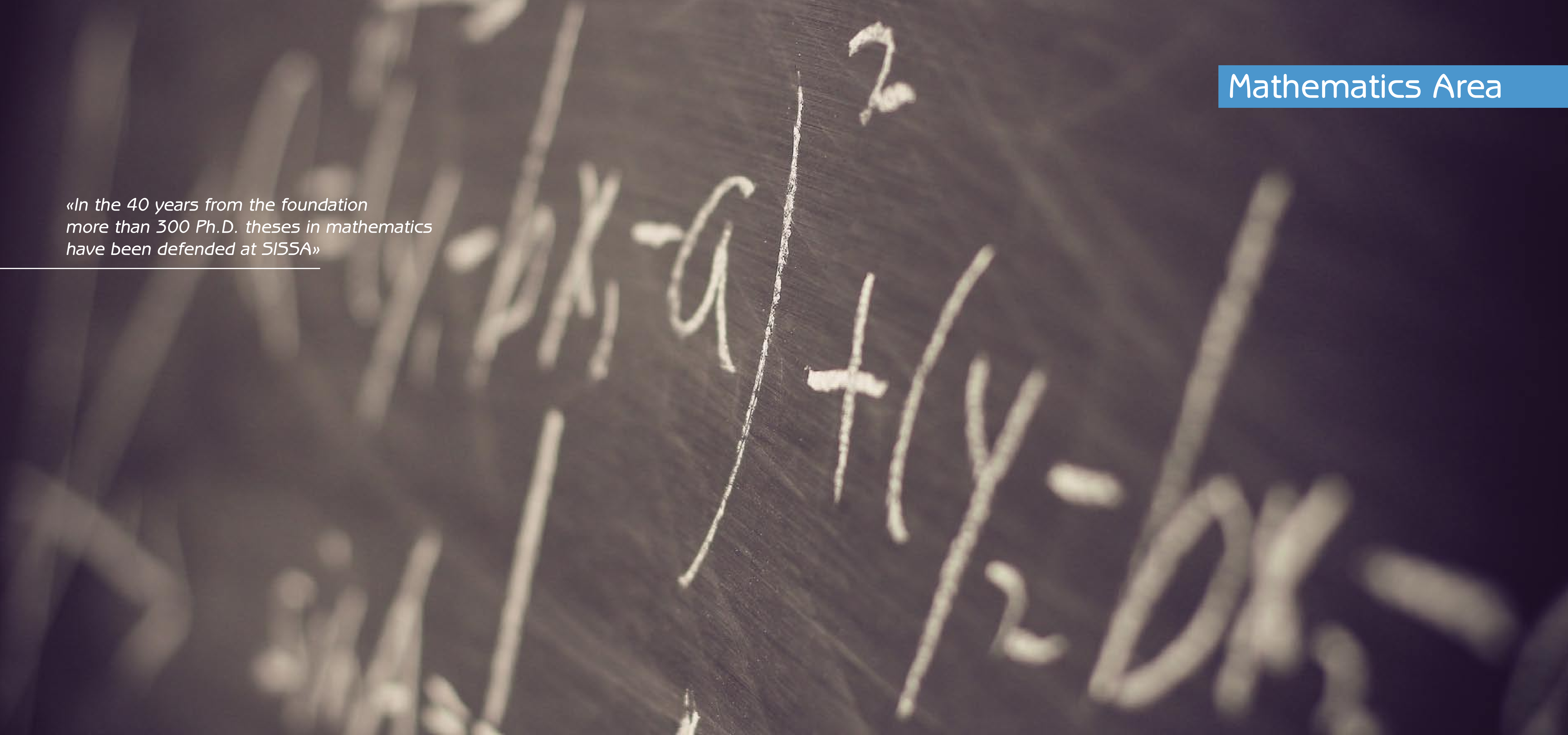


Fig. 3: Dynamics of a hairpin loop from a non-coding RNA. Tertiary structure representation of the most relevant conformations (left panel). Structure opacities are proportional to the predicted populations. Secondary structure representation of the same structures, using the standard Leontis-Westhof classification for base pairs (right panel). Percentage population of each structure is shown. Colours indicate the predicted occupancy of each pairwise interaction. Conformations are obtained using a combination of molecular dynamics simulations [1] and solution-phase experiments [2] based on the maximum entropy principle [3,4]. Credits: Reißer; Bussi.



Mathematics Area

«In the 40 years from the foundation more than 300 Ph.D. theses in mathematics have been defended at SISSA»

MATHEMATICS AREA

«At present the scientific activity of the Mathematics Area covers a wide range of subjects…»

An activity in mathematics has been present at SISSA since the beginning. In the '80s and '90s it was mainly devoted to mathematical analysis and mathematical physics, with a small and time-limited research line in differential geometry. Two new activities were gradually established, starting around 2000. One was applied mathematics which led, in 2010, to the foundation of MathLab, a laboratory for mathematical modelling and scientific computing, devoted to the interactions between mathematics and its applications. The other was algebraic and complex geometry, a natural expansion of the research in mathematical physics reflecting the growing importance of this field and its relevance to the high energy physics community.

At present the scientific activity of the Mathematics Area covers a wide range of subjects including partial differential equations, dynamical systems, calculus of variations, control theory, differential and sub-Riemannian geometry, algebraic geometry, Kähler geometry, integrable systems, noncommutative geometry, geometry of strings and quantum fields, mathematical methods of quantum physics, numerical analysis, computational fluid and solid dynamics, and applications to mechanics of materials and to modelling of biological systems.

In the 40 years since the foundation more than 300 Ph.D. theses in mathematics have been defended at SISSA. Most of the former students now work in the academic system as post docs, researchers, associate or full professors. Among the 150 students that had defended their Ph.D. thesis by 2005, more than 40 are now full professors (29 in Italian universities).

The high scientific reputation of the Mathematics Area is witnessed by two European Mathematical Society Prizes (for mathematicians under 35), won by Stefano Bianchini in 2004 and by Guido De Philippis in 2016; by the honorary degree of the Universidad Autónoma de Madrid conferred on Antonio Ambrosetti in 2005; and by two invitations to deliver a plenary lecture in a top international congress: Boris Dubrovin, European Congress of Mathematics, Budapest, 1996, and Alberto Bressan, International Congress of Mathematicians, Beijing, 2002.

Calculus of Variations

The calculus of variations is the branch of mathematical analysis that studies minimum problems for functionals, which are quantities depending on functions. Examples are the problems of finding the shortest path joining two points on a given surface, or a surface of minimal area spanning a given contour.

The calculus of variations has important applications to natural sciences (mainly physics), technology, and economics. Its methods have strong connections with the theory of ordinary and partial differential equations.

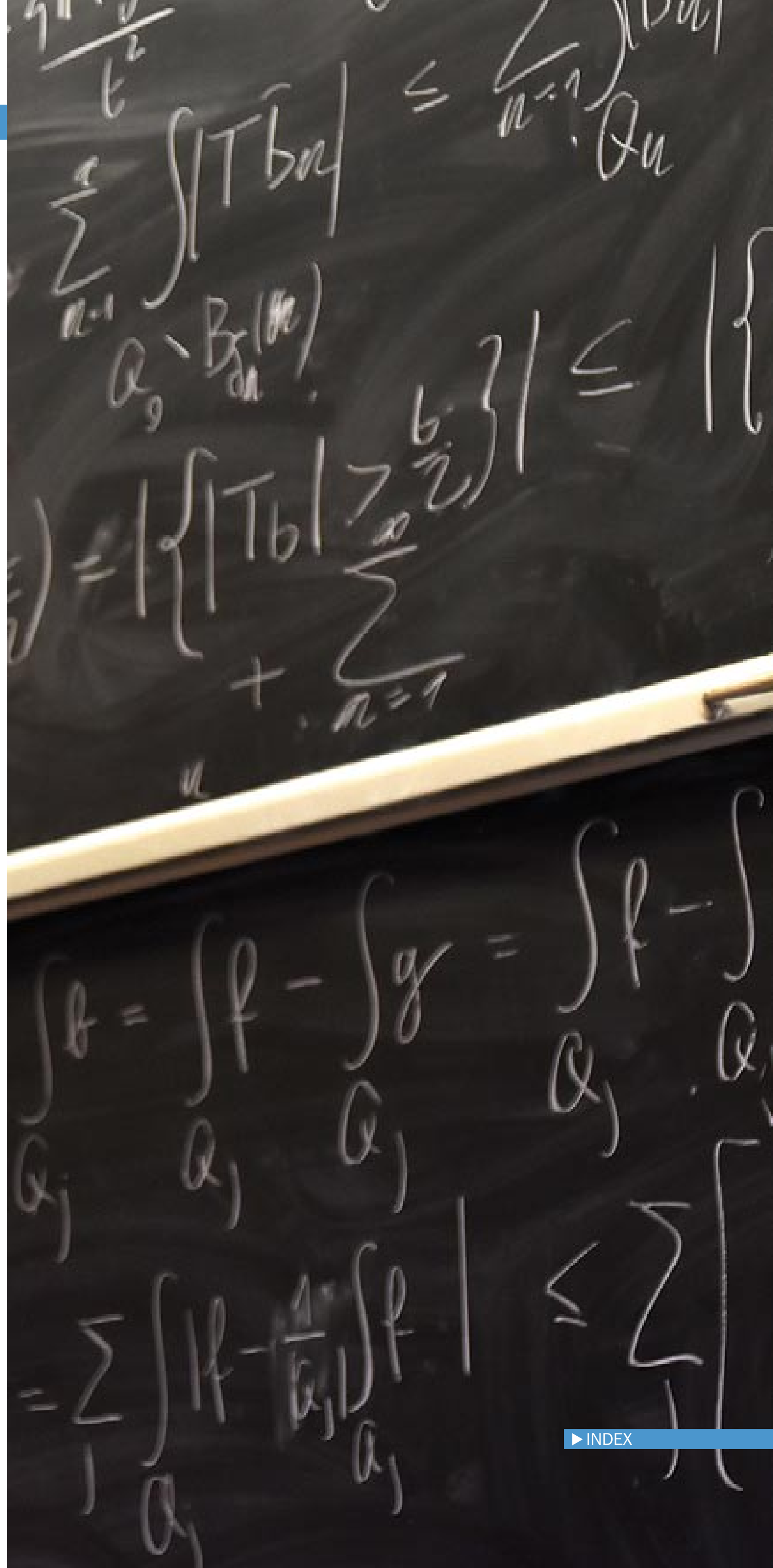
This subject has been studied at SISSA since the beginning. Particular attention has been devoted to proving the existence of a minimiser, often obtained by proving the lower semicontinuity of the corresponding functional. A fruitful research line studies the dependence of the solutions on the functionals, using Gamma-convergence techniques. The methods developed are suitable for problems with strongly oscillating coefficients, which are connected with the study of the macroscopic behaviour of composite materials (homogenisation problems) and with other problems with multiple scales.

Snapshots from a lesson. Credits: Stefano Amadeo.

Starting from the ’90s significant results have been obtained in the new field of free-discontinuity problems, in which the functional depends on the unknown function through the unknown set of its discontinuity points. The prototype is the Mumford-Shah problem, which was introduced as a tool for image segmentation in computer vision. In particular, in 1992 one of the first existence results for this problem was obtained at SISSA. Other results on free-discontinuity problems are related to mathematical models in fracture mechanics, developed at SISSA since 2002.

Another branch of the calculus of variations, studied at SISSA since 2006, deals with quasi-static evolution problems. Recently the study of gradient flows, a different kind of evolution problem, has begun at SISSA. The study of this subject in the setting of general metric spaces relies on tools from the calculus of variations. A related subject is the study of the intrinsic geometry of metric measure spaces.

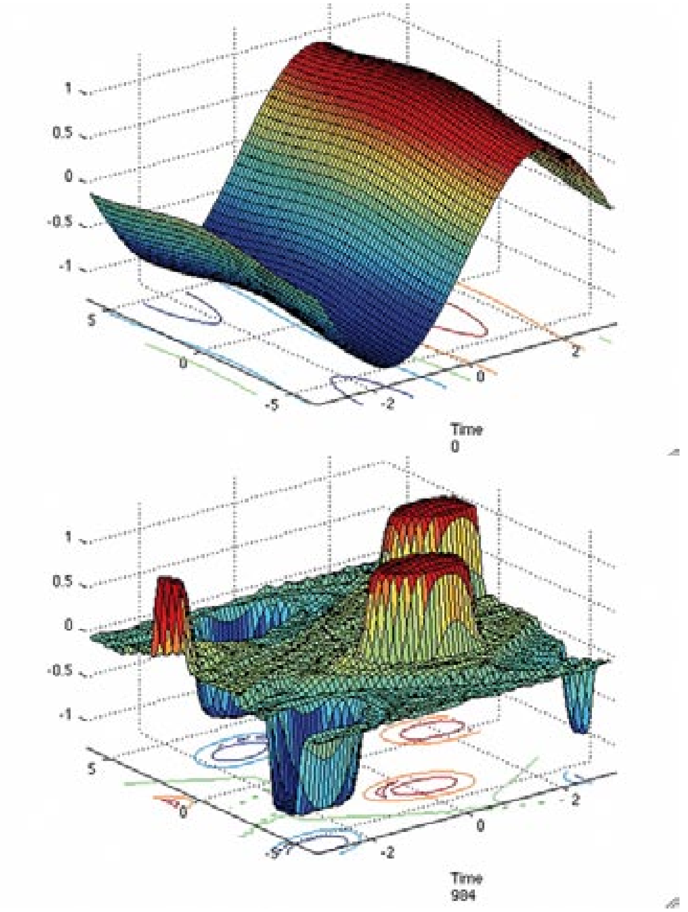
One of the most recent research lines studies regularity and singularity of solutions to minimum problems, in particular those of a geometric nature. In these problems the presence of singularities is often unavoidable and is related either to topological singularities or to the physical behaviour of the system described by the model.



Nonlinear Evolutionary PDEs

Partial differential equations (PDEs) model many phenomena of physics, biology, economics... In SISSA the research in nonlinear PDEs focuses on systems of conservation laws and infinite dimensional Hamiltonian systems.

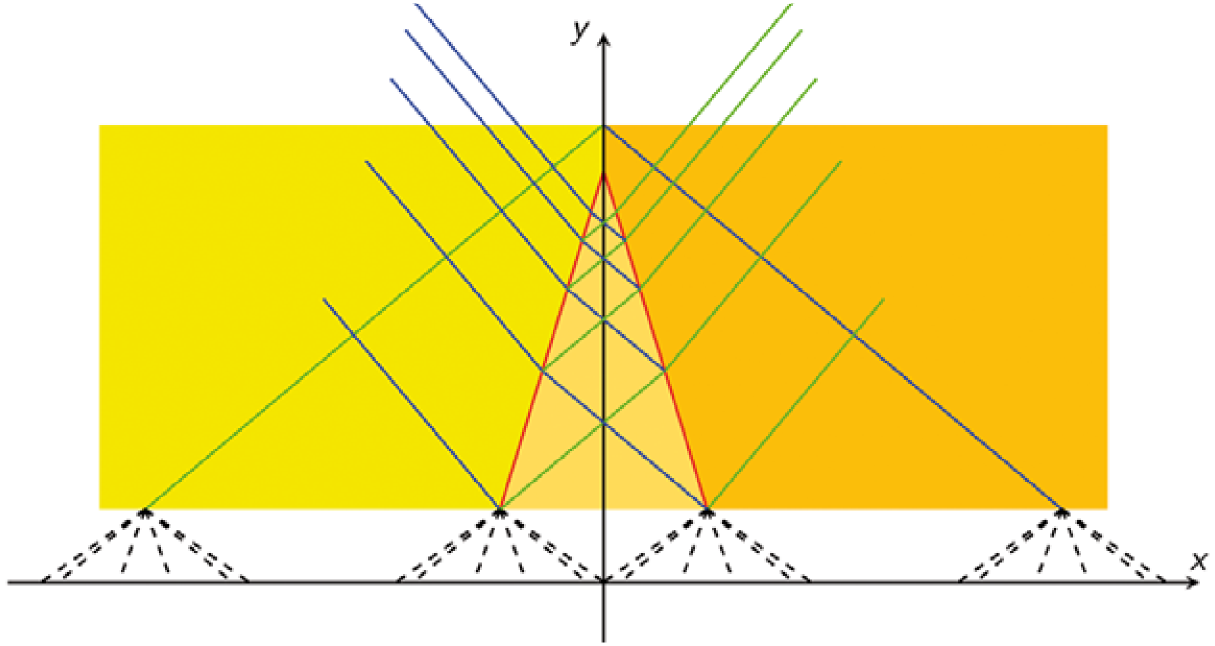
Systems of conservation laws describe the evolution of a conserved quantity. The best known example is given by the Euler equations; however, these kinds of system appear every time there is a quantity which is preserved, for example the number of cars (traffic dynamics) or the number of people (crowd dynamics). The most striking feature of these equations is the formation of discontinuities no matter how regular the initial data are. This is due to the fact that the quantities under analysis travel at different speeds, and indeed everyone has experienced the sudden slowing-down that happens in heavy traffic, due to the presence either of slow trucks or traffic lights. The research done in SISSA has led to fundamental results in the understanding of these equations: the theory of well-posedness and its physical validation. Another point of view regarding these equations is to describe the trajectories of single particles: for example, one can know either the amount of cars in a given section of the road, or the trajectory of every single vehicle. This is an active research field, with several implications in other areas of mathematics, and SISSA is playing a major role.



Inviscid damping towards quasi-periodic solutions of 2-dimensional Euler equations on the torus. Credits: Erwan Faou.

Many PDEs arising in Physics can be seen as infinite dimensional Hamiltonian systems, i.e., roughly speaking, as ordinary mechanical systems of infinitely many interacting particles. Main examples are the nonlinear wave and Schrodinger equations, the Euler equations of hydrodynamics, etc. Usually such evolutionary PDEs are not integrable. In the last few years important mathematical progress has been achieved in the comprehension of their complex dynamics by adopting a "dynamical systems philosophy".

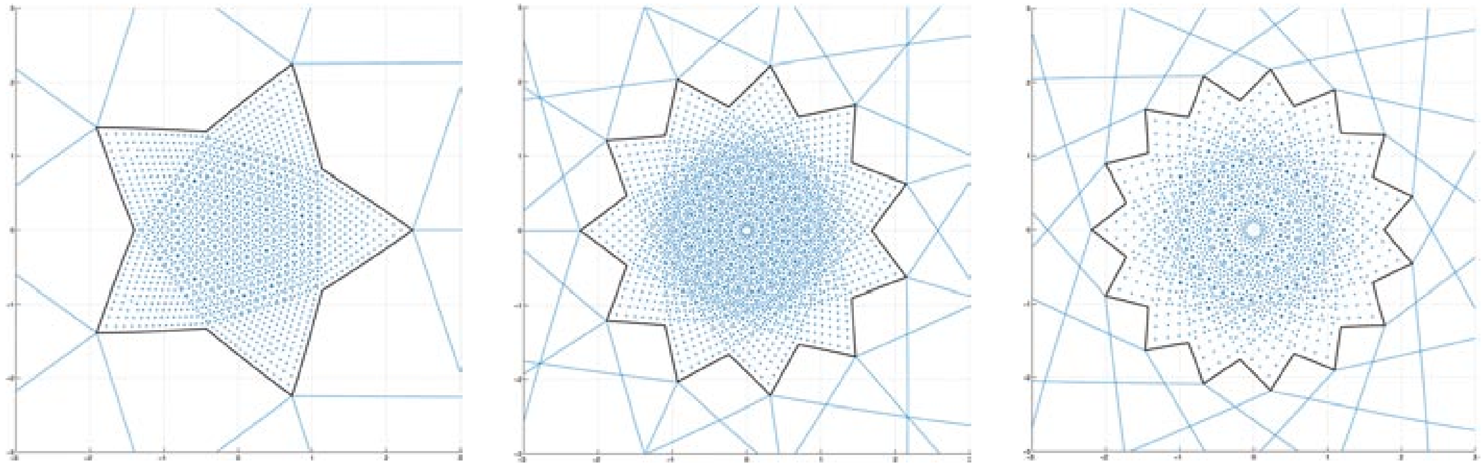
In the '80s and '90s pioneering results about periodic solutions and homoclinic orbits for the n-body problem were obtained at SISSA by looking for critical points of the action functional. For infinite dimensional systems further problems appear due to complex resonance phenomena and long range interactions produced by the nonlinearities. In recent years new bifurcation results of quasi-periodic solutions, and long-time existence of solutions, as well as chaotic dynamics for PDEs, have been obtained at SISSA, opening new perspectives in this fascinating field.



Example of solution in a system of conservation laws in which the discontinuities (or shocks) become infinite in a finite time interval. Credits: L. Caravenna; L. Spinolo.

Integrable Systems

The theory of integrable systems is a rapidly growing branch of mathematics having numerous applications in physics. Integrable systems already arise in classical mechanics as Hamiltonian dynamical systems with a rich family of Poisson-commuting first integrals. The modern theory of integrable systems was born in the ’60s of the last century with the discovery of integrability of the celebrated Korteweg-de Vries partial differential equation (PDE) playing a fundamental role in the theory of nonlinear dispersive waves. The mathematical theory of integrable PDEs and their solutions involves deep connections with many branches of mathematics such as the spectral theory of differential operators, Kac-Moody Lie algebras and W-algebras, Riemann surfaces and theta-functions, Riemann-Hilbert boundary value problems, linear differential equations in complex



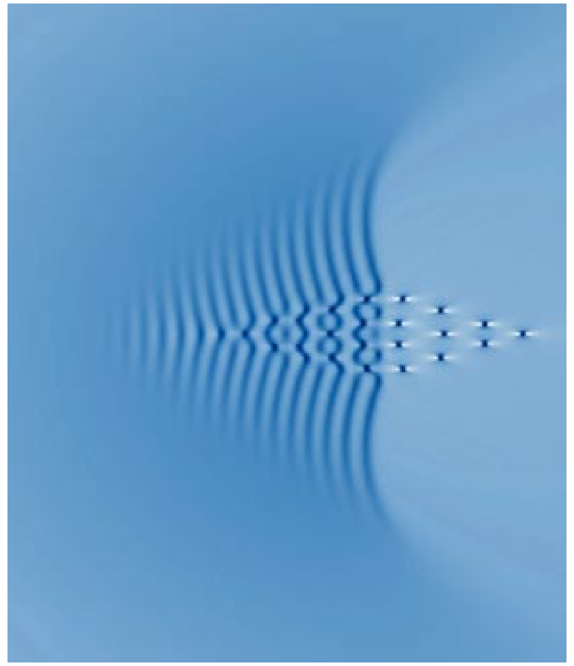
The dots indicate the positions of poles of certain rational solutions of the *Painlevé II hierarchy*. In the limit where the number of poles tends to infinity, they densely fill the region bounded by the black arcs (they appear as straight segments but they are actually analytic arcs). The evident change of patterns within the region can also be explained analytically. Credits: Ferenc Balogh; Marco Bertola; Thomas Bothner: *Hankel determinant approach to generalized Vorob’ev-Yablonski polynomials and their roots*. Constr. Approx., n. 44, 2016, pp. 417-453.

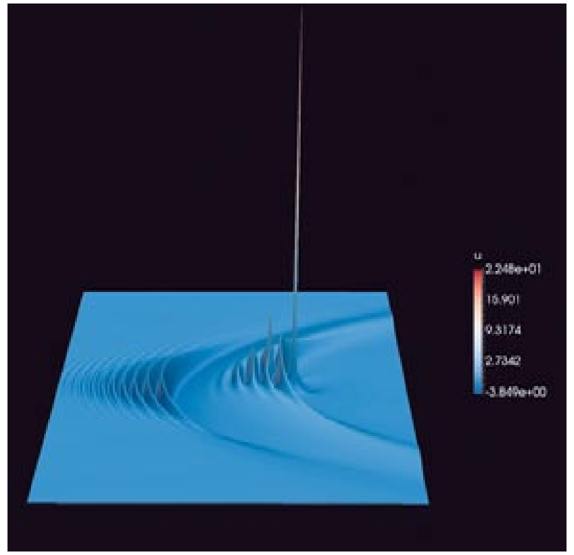
domain and their monodromy-preserving deformations. The theory has many important applications including fluid dynamics, nonlinear optics, the theory of random matrices and orthogonal polynomials.

Various subjects of the theory of integrable systems have been studied intensively at SISSA since the beginning of the ’90s. Geometry of finite-dimensional invariant submanifolds of systems of integrable PDEs was the starting point for creating the theory of Frobenius manifolds that proved to be instrumental in understanding the deep relationship between the theory of Gromov-Witten invariants, topology of the Deligne-Mumford moduli spaces of algebraic curves and singularity theory on the one hand, and the theory of integrable systems on the other. On this basis the theory of integrable systems of topological type has been built.

There are important families of exact solutions of integrable PDEs expressed in terms of Painlevé transcendents and their generalisations. These special functions play a fundamental role in the analytic description of dispersive shocks that have been actively studied at SISSA since 2005. The universality phenomenon was discovered that stated that the critical behaviour of solutions to nonlinear Hamiltonian PDEs near the point of dispersive shock essentially does not depend on the initial data or on the PDE itself.

Substantial progress was recently obtained in the analytic study of properties of solutions to the isomonodromy deformation equations with applications to the analysis of correlation functions in matrix models and random processes and to quantum cohomology theory.





Peak formation (lumps) in the solution of the Kadomtsev Petviashvili equation in the small dispersion limit. The Kadomtsev Petviashvili equation is a model for describing waves on water. Surprisingly the position of the peaks has a lattice structure. Credits: T. Grava, C. Klein and G. Pitton, to appear in Proceedings of the Royal Society, 2018.

Geometry and Physics

The unification of the fundamental laws of nature requires a profound reshaping of our ideas of space and time. In order to get a consistent description of the universe, from galaxies down to atoms and particles, many physicists and mathematicians have been making a great collective effort since the second half of the 20th century. Since its birth, SISSA has played a pioneering role in Italy and Europe in this research by promoting the study of geometrical aspects of gauge theories, which describe the forces among elementary particles, and string theory, which encompasses them into a bigger picture including the gravitational forces.

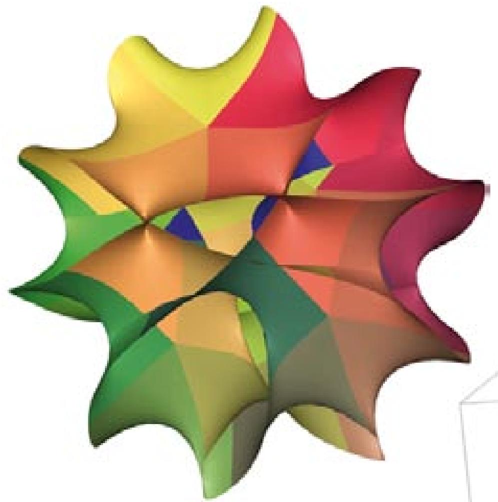
String theory predicts the existence of extra dimensions beyond the three plus one of the presently known space-time. The shape of this extra dimensional space affects the properties of the observed universe and has to be studied by means of algebraic and differential geometry methods. The use of rigorous mathematical methods puts the physics predictions on firmer ground. On the other hand, physics intuition suggests unexpected relations between seemingly different areas of mathematics, and challenges the proof of new important theorems.

One of the most successful ideas in this context is mirror symmetry, which revealed itself to be a powerful tool to describe and classify these extra spaces and has profound consequences in pure mathematics.

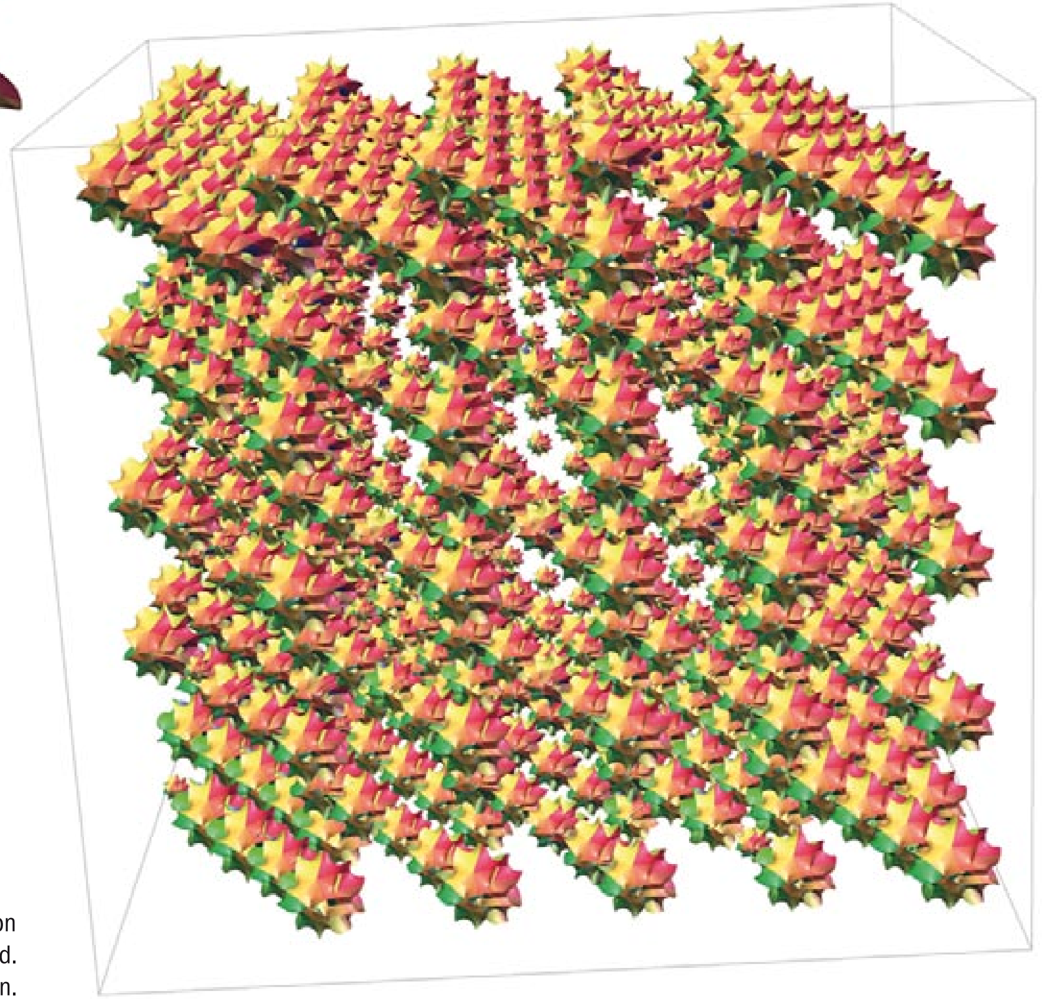
Another is the emergence in some cases of the so-called non-commutative spaces, suggesting a quantum nature of space-time itself. Such spaces have been studied at SISSA in the framework of non-commutative geometry.

Analogues of vector and principal bundles, with gauge fields of instanton or soliton types, have been developed. A major success was the construction of the first examples of spectral triples on the so-called quantum spheres and quantum groups. In recent years the work focused on the non-commutative notion of curvature, the generalization of various topological invariants, and the applications to signal analysis and geometry of the Standard Model.

The quantum aspects of a physical system are deeply connected with topology, which encompasses their non-local and discrete features and accounts in a very elegant way for the stability of quantum systems. The new technologies allow experiments where the behaviour of a small number of atoms can be studied, providing severe tests. The studies performed at SISSA contribute to providing a mathematically rigorous framework for the predictions of quantum mechanics.



This image shows a local 2D cross-section of the real 6D manifold known in string theory as the Calabi-Yau quintic.
Credits: Andrew J. Hanson.



This image shows a 6D representation of the Calabi-Yau quintic manifold.
Credits: Andrew J. Hanson.

Algebraic Geometry

Algebraic geometry investigates objects that can be described by polynomial equations, such as lines and conics.

Its origins can be traced to the introduction of Cartesian coordinates and to projective geometry, a mathematical axiomatization of the notion of perspective in painting. Its initial development was characterized by successive reformulations of its foundations, first in 19th century Germany, and then in Italy between the two world wars.

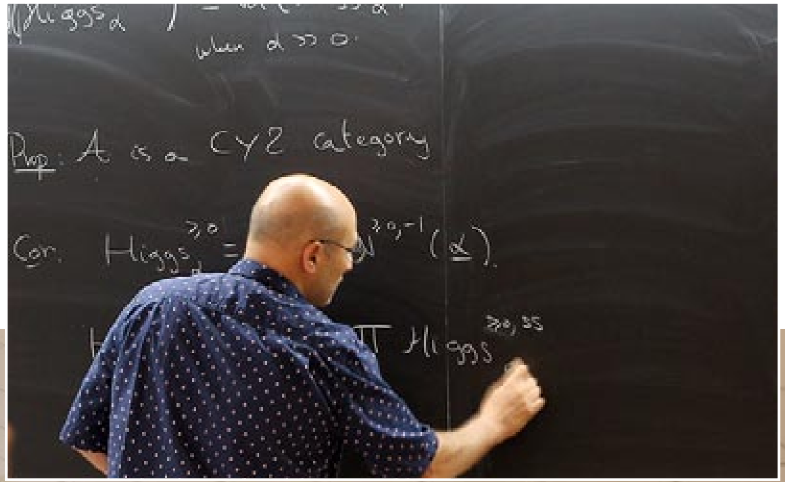
The language which is now used worldwide originated in France in the ’60s; on the one hand it fostered the solution to classical problems, such as the proof of Fermat’s conjecture, while on the other hand it gave rise to applications to computer science (the standard internet security protocols are based on the algebraic geometry of elliptic curves).

At the beginning SISSA did not have an algebraic geometry group, but only a small activity in differential geometry within the Functional Analysis Sector, although some students did earn their PhDs writing theses in algebraic geometry. This interest in algebraic geometry was also catalysed by interactions with the University of Trieste, and its growing importance in theoretical physics.

The first development of algebraic geometry at SISSA was due to the activity of the Mathematical Physics Sector, and was soon reinforced by the inception of a robust programme in integrable systems (1993). The group also enjoyed a collaboration with M.S. Narasimhan, a researcher of international renown, who had previously been the director of ICTP’s Mathematics group. In 2002 the group reached a minimum critical mass.

One of the main research lines of the group is the theory of moduli spaces, a classical topic in algebraic geometry that in the ’90s received a new impetus from the interaction with string theory. The group has made several contributions, at the foundational level, in connection with enumerative problems and with the investigation of many examples, with ample interactions with physics. The group has also collaborated with foreign researchers, sometimes giving rise to PhD theses in “co-tutelle” with other European countries (France and Germany). Other topics of study are deformation theory, stacks, tropical geometry, and quivers. Another line of research is complex geometry, which has been recently reinforced; in particular, the group now is a strongly active in the study of canonical Kähler metrics and algebro-geometric stability.

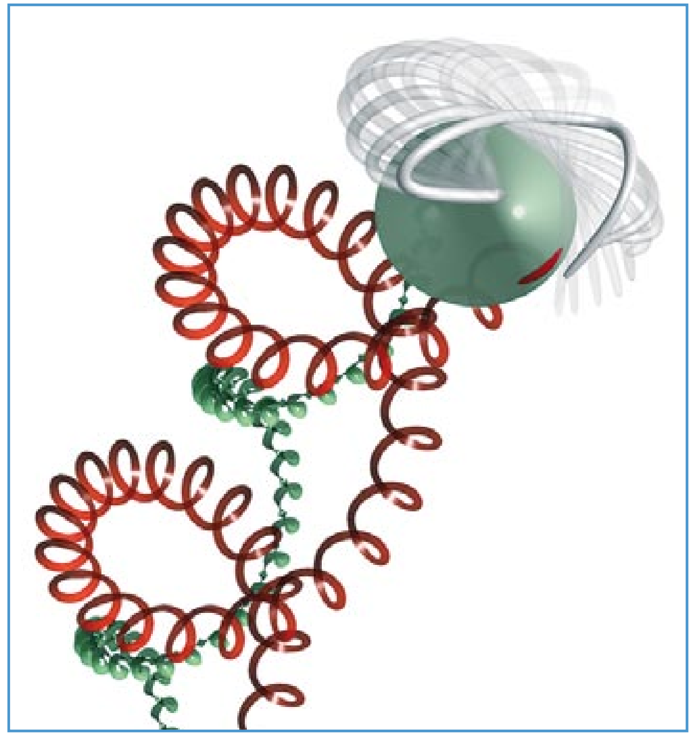
School and Workshop on
Algebraic Geometry and Physics 2017.
Credits: Giulia Annovi.



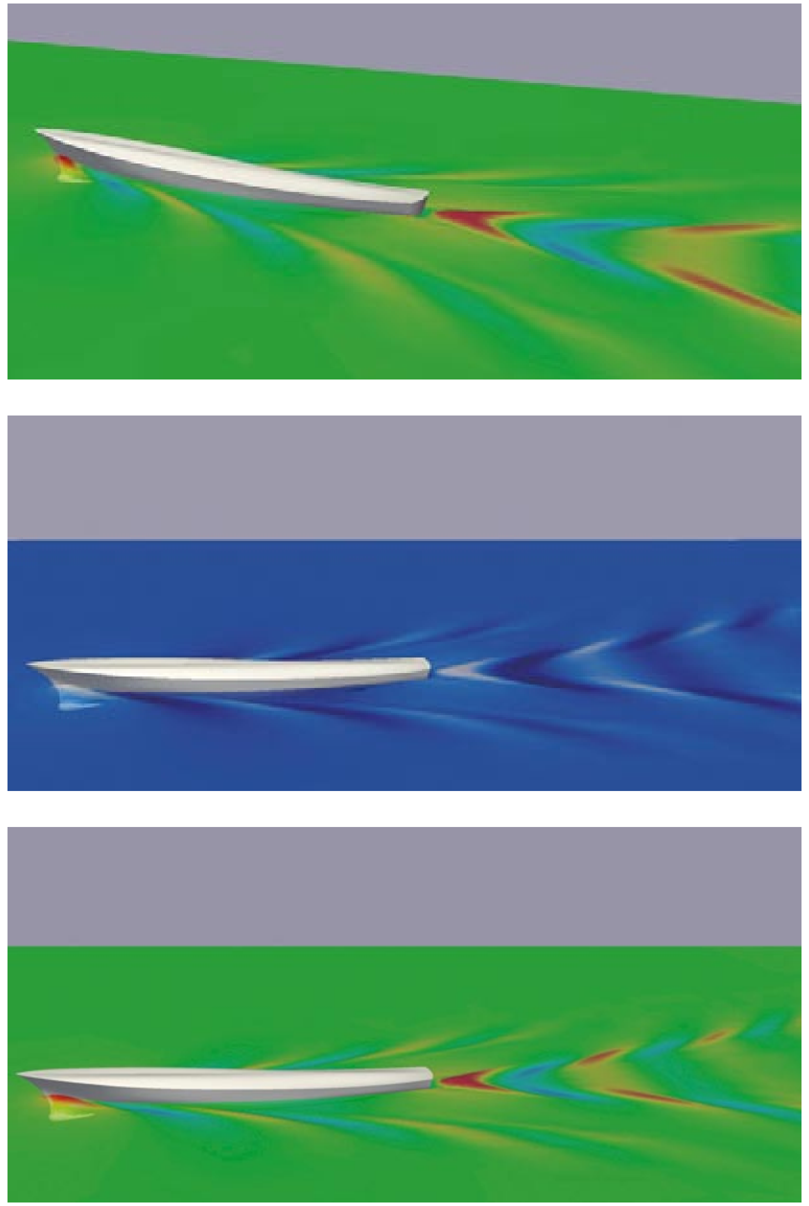
Applied Mathematics

The activity in applied mathematics started at SISSA around 2000. At the beginning the main focus was on mathematical control theory. This allows one to deal with very complex systems, depending on several parameters which have to be chosen with the aim of reaching certain desired goals, taking also some constraints into account. There are several important and challenging applications of control theory in technology. This research activity is carried out with important collaborations in Europe, especially in France (Paris). SISSA has become a reference centre for control theory. Several thematic conferences and events on this subject were organised at SISSA.

A new activity in applied mathematics started in 2010 with the foundation of SISSA MathLab (mathlab.sissa.it) consisting of: a laboratory for mathematical modelling and scientific computing devoted to the interactions between mathematics and its applications; an interdisciplinary research centre powered by the interest in problems from the real world, from industrial applications, and from complex systems; a team of scientists pursuing frontier research, while expanding the dialogue across academic and disciplinary boundaries; a partner for companies interested in mathematics as a tool for innovation; a research team on new trends in computational mechanics and numerical analysis; an integrated group in SISSA Mathematics Area, within the PhD program in Mathematical Analysis, Modelling, and Application, and the Master in High Performance Computing, as well as the master degree programs in Mathematics and Data Science and Scientific Computing, both offered by SISSA with the University of Trieste, and Udine for the latter.



The image illustrates the swimming motion of Euglena gracilis and the complex shapes of the beating flagellum that powers it. The helical ribbons represent the orbits traced by the eyespot and the posterior end of the cell. In a paper published in 2017 on PNAS (doi:10.1073/pnas.1708064114), a mathematical model is used to reconstruct three-dimensional swimming trajectories and flagellar shapes from high-speed two-dimensional microscopy image recordings. Credits: M. Rossi et al., SAMBA/MathLab@SISSA.



Numerical simulation of a ship hull in the sea. Credits: Andrea Mola, SISSA MathLab.

Research activities in applied mathematics deal with continuum mechanics and comprise the biological motility at the microscale, the modelling of soft active materials (e.g., polymer gels, liquid crystal elastomers, biological tissues), and the application of Gamma-convergence techniques to the derivation of limiting, structural theories. Towards a holistic vision of mechanics, theoretical and computational approaches are combined with experimental activities carried out at the SAMBA laboratory established in 2012.

Numerical analysis research activities are mostly oriented to computational fluid dynamics, fluid-structure interaction, reduced order methods, optimization and control, and the development of open source software for scientific and high performance computing applications.

Neuroscience Area

«The activity in neuroscience has been present at SISSA since the early '90s and has developed, based on the core idea of bridging physics to biology»

Credits: Fabrizio Giraldi

NEUROSCIENCE AREA

«The present scientific activity of the Neuroscience Area covers a wide range of subjects emerging from all these diverse lines of inquiry, trying to analyse all the brain's levels»

The activity in neuroscience has been present at SISSA since the early '90s and has developed, based on the core idea of bridging physics to biology. During almost three decades, this approach has involved research taking advantage of the developments of novel instrumental tools, based on physics technology, of theoretical tools, using mathematical modelling of biological processes, and has involved the use of nano science tools to understand the organization and function of neurons.

In the mid-'90s a new activity began, devoted to the study of cognitive neuroscience whose target was to analyse the brain at a different level of investigation, from neuronal bases of perception to social cognition, with more recent activities addressing neural computation in language, time and space perception, or learning and action. From the late '90s a new activity towards the study of various neurodegenerative diseases developed, and included molecular biological, high-throughput screening and bioinformatics analysis, genomics of the nervous system, as well as the study of regulatory mechanisms in brain development.

The present scientific activity of the Neuroscience Area covers a wide range of subjects emerging from all these diverse lines of inquiry, trying to analyse all the brain's levels. The Neuroscience Area is characterized by a broad set of methodologies and various tools for their implementation, ranging from small-scale focused research to big data projects, but ultimately it shares the efforts to progress in answering questions in the neuroscience field by the use of innovative tools, unconventional approaches and innovation.

From the foundation more than 200 Ph.D. theses in neuroscience have been defended at SISSA. The majority of our former students now work in top universities in the US, Switzerland, UK, Australia and elsewhere.

The Neuroscience Area is characterized by the international outlook, a strong focus on research, an interdisciplinary approach and a high scientific reputation, as witnessed by the impact of research extramural grants funding our individual PIs.

Neurobiology

Neurobiology studies how nerve cells and neuronal networks operate during development, normal life and pathological conditions. Within this framework, Neurobiology at SISSA investigates the basic mechanisms of generation (and regeneration) of brain networks, processing sensory and motor information, and the onset and progression of neurological diseases in distinct models of neurodegenerative disorders. To pursue these objectives SISSA Neurobiology uses a multidisciplinary approach that brings together methods of molecular biology, biochemistry, histology, and physiology to study the organization and function of the brain and spinal cord. Nanotechnologies and advanced techniques of microscopy and imaging have also been extensively developed and implemented to continuously improve the molecular resolution of processes under study.

Research and doctoral training in Neurobiology (then termed Biophysics) at SISSA was started in the early 90s with three group leaders, Antonino Cattaneo, Enrico Cherubini and Andrea Nistri, who introduced a range of advanced technologies to explore new avenues of Molecular Neuroscience that laid the foundations of a novel PhD program with strong international collaboration and participation. This endeavour was followed up by the gradual expansion of the academic faculty and the establishment of new doctoral programs, all of them currently included in the latest restructuring of SISSA to create a large Neuroscience department.

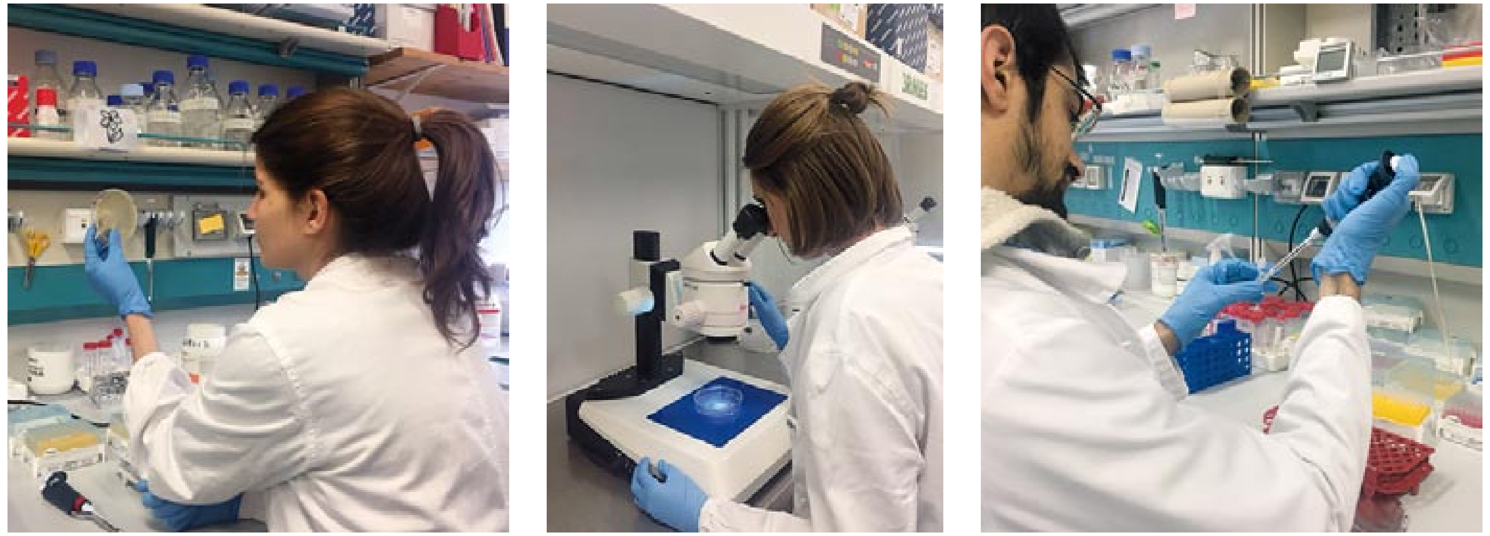
SISSA Neurobiology is, therefore, a scientific bridge between neurogenomics and cognitive neurosciences because it contributes to understanding how genes and gene products are translated into neuronal and glial function (and dysfunction) and, ultimately, to clarifying the processes that integrate external signals into behaviour in health and disease.

Snapshots from the Neurobiology labs activities.
Credits: Stefano Amadeo.

Molecular Biology

Molecular Biology is the study of information-rich macromolecules of biological interest, with special emphasis on their metabolism and impact on biological processes. Three Teams within the Neuroscience Area of SISSA, the Neurogenomics Team (NG), led by Prof. Stefano Gustincich, the Prion Biology Team (PB), led by Prof. Giuseppe Legname, and the Cerebral Cortex Development Team (CCD), led by Prof. Antonello Mallamaci, have strong interests in the molecular biology of central nervous system (CNS) development, homeostasis and degeneration.

It has been recently discovered that, in addition to our immune cells, a number of other cells of our organism are characterized by subtle differences in their DNA. The NG Team specifically studies the role of this structural genome plasticity in CNS ontogenesis and degeneration. Moreover, it

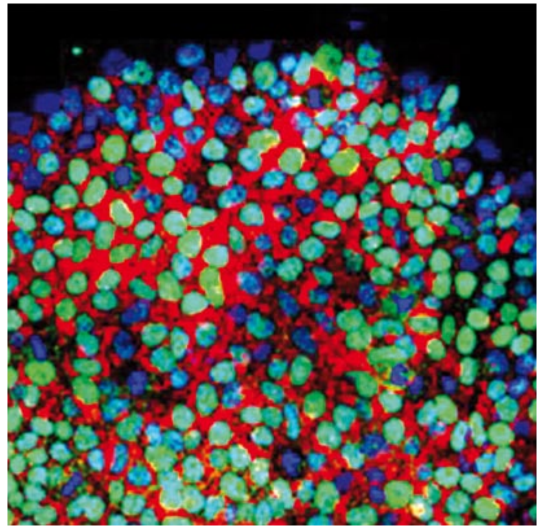


Snapshots from the Molecular Biology labs activities. Credits: Simone Chiola.

has been shown that multiple sets of RNAs not encoding for proteins (ncRNAs) are involved in the fine regulation of our genes. The NG Team has discovered a novel class of these ncRNAs, stimulating the translation of specific target mRNAs. It is investigating the “grammar” ruling their action and it is domesticating them for therapeutic purposes.

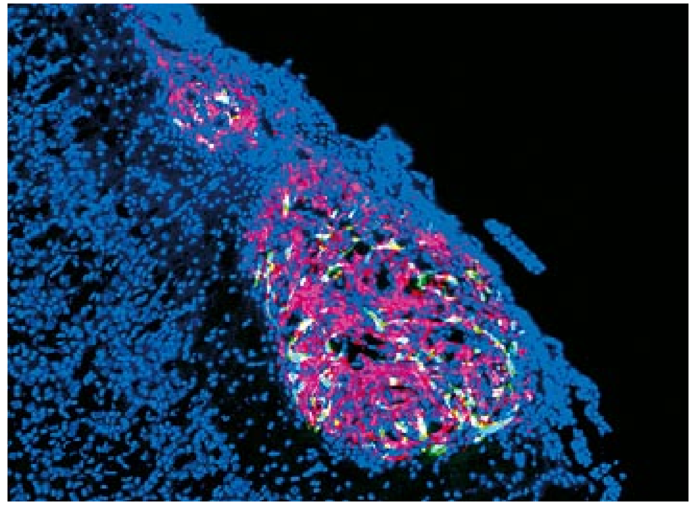
Cellular prion proteins (PrP^{C}) are normal polypeptide components of our nerve cells, susceptible to adopting an aberrant and pathogenic, self-propagating tridimensional conformation (PrP^{Sc}). They are responsible for a class of rare and progressive neurodegenerative disorders, known as transmissible spongiform encephalopathies (TSE). The PB Team studies the role of PrP^{C} in the normal development and differentiation of the nervous system. Moreover, it investigates mechanisms of PrP^{C} misfolding and PrP^{Sc} formation, and it works at experimental prion generation in vivo, triggered by synthetic amyloid preparations.

Cerebral cortex development is mastered by a few transcription factors, imparting specific positional identities to precursor cells located in the anterior embryonic CNS and triggering the activation of complex neurodevelopmental programs.



Induced pluripotent stem cells obtained by OSKM reprogramming of human fibroblasts.
Credits: Clara Grudina, Cerebral Cortex Lab.

The CCD Team investigates the role of a subset of these factors in fine spatio-temporal control of neocortical astroglia generation and neuron differentiation. Inspired by normal control of these processes, it is domesticating one of these factors for therapy of glioblastoma. Moreover, the CCD Team is developing novel ncRNA-based tools for precise therapy of neuropathogenic gene expression deficits, refractory to CRISPR-based treatments.



Xenograft of human glioblastoma cells into mouse neonatal brain.
Credits: Carmen Falcone, Cerebral Cortex Lab.

Genomics

Genomics is the branch of the biological sciences that studies the structure and function of the genome within an organism. The genome is defined as the genetic material that comprises the DNA, which contains the information for making all the necessary molecular structures of an organism.

Usually, molecular biological, high-throughput screening and bioinformatics analysis are the leading techniques employed in understanding the complexity of functions carried out by the different cells that build up the brain.

Here at SISSA we study the genomics of the nervous system.

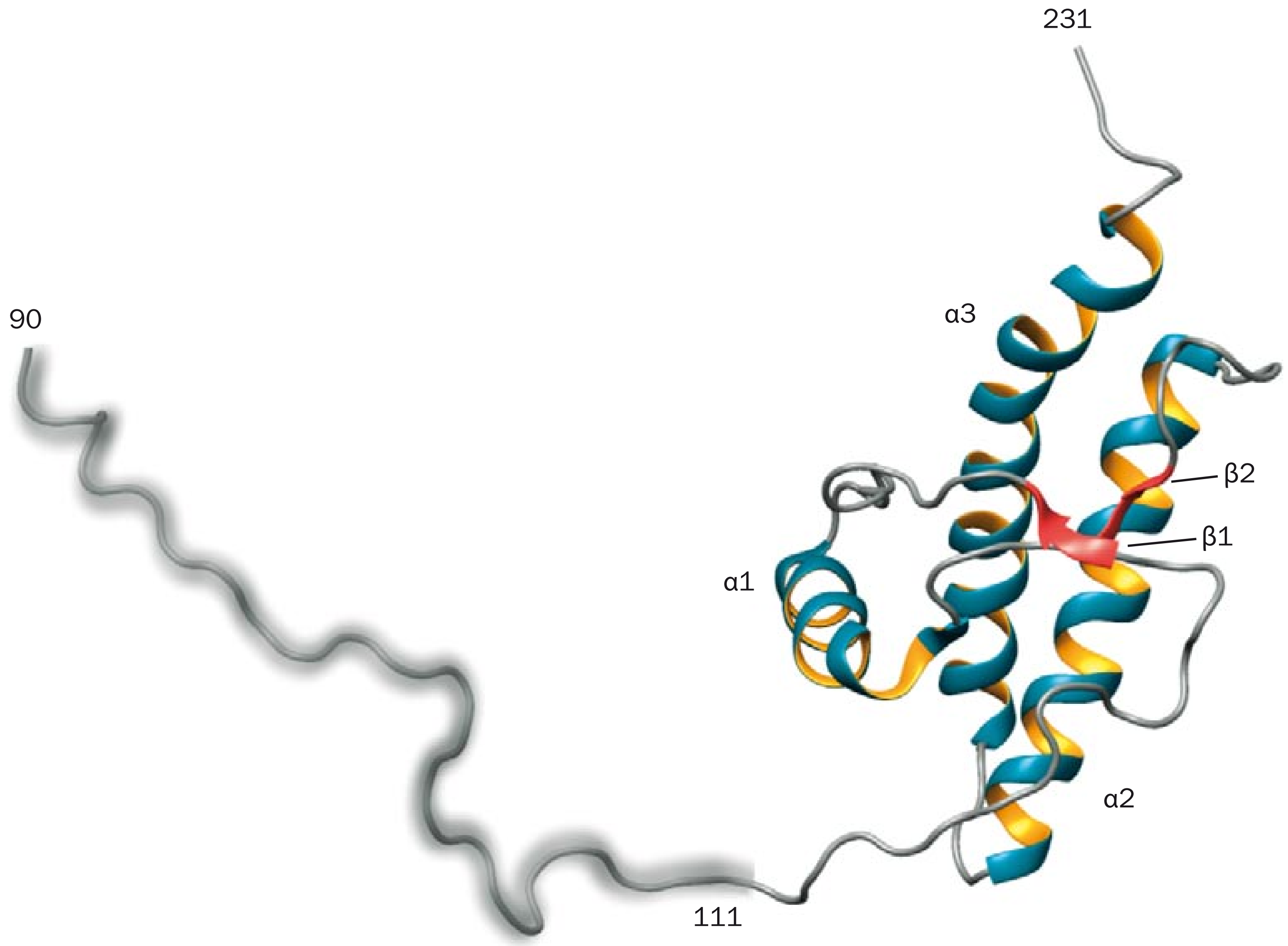
Since the field of study is very broad, we focus on the organization, function and structure of the genome in neurons and other cells in the brain.

Since the discovery of DNA as the molecule containing all the information for a given organism, a major advancement in our understanding has come from the complete sequencing of the genome of given species. The information stored in the DNA only partially covers the classical gene structures that code for transcription and translation into proteins. Indeed, the vast majority of the DNA within a genome apparently does not only code for messenger RNA (mRNA) and therefore proteins but also gives rise to functional non-coding RNA molecules (e.g. transfer, ribosomal, and regulatory RNAs). In particular, Professor Stefano Gustincich is studying a class of non-coding RNA molecules defined as long non-coding RNA (lncRNA). These molecules neither code for proteins, as the name defines them, nor for other functional RNA. In his research Professor Gustincich has identified new classes of these lncRNA able to regulate protein expression through a mechanism that only now has started to be unravelled.

Other research is focusing on the regulation of cell programming during the development of an organism. Professor Antonello Mallamaci has centered his studies on these fine regulatory mechanisms, which allow a not-yet-specialized cell to become a neuron or other cells found in the central nervous system.

Another group lead by professor Giuseppe Legname is employing high-throughput screening techniques to identify genes coding for mRNA, differentially expressed in health and disease. Professor Legname focuses his studies on neurodegenerative diseases, and in particular prion diseases, in an attempt to discover pathways differentially regulated in these disorders.

Some of these studies are carried out in collaboration with the Molecular and Statistical Biophysics Group.



Cartoon representation of the cellular prion protein (PrPC). The overall structure of the C-terminus is composed of 2 short antiparallel beta sheet strands, namely β1 and β2 (in red) and 3 alpha helices, indicated as α1, α2, and α3. The N-terminal domain of PrPC is unstructured and features different domains identified as octapeptide repeats (in grey), able to bind metal ions. Credts: Giulia Salzano.

Cognitive Neuroscience

Cognitive Neuroscience at SISSA examines how human and animal brains generate percepts and organize them into thoughts and actions, with the ultimate goal of understanding how the human mind emerges from the operations of the brain.

The brain is one of nature's most complex systems. Its functions range in quality (neurons versus mental representations), time span (spikes last milliseconds, learning can take years), and spatial resolution (some perceptual features are encoded in single neurons whereas language networks span nearly the whole brain). Addressing all the brain's levels in a single line of research would be a hopeless endeavour. Yet to focus on one level and ignore the others would be a hopelessly incomplete approach to cognition. SISSA Cognitive Neuroscience is an attempt to weave together these many different levels into a colourful fabric.

The group was initiated in the mid-late 1990s by two renowned scientists, Tim Shallice and Jacques Mehler. The current faculty includes seven principal investigators (PIs) whose diverse set of backgrounds, interests, and methodologies reflects the "arm's length principle" – PIs are closely enough spaced to collaborate, but widely enough spaced to ensure independence and a broad coverage of the discipline as a whole. Three PIs

(Treves, Diamond, Rumiati) were part of the original 1990s core, while four were recruited between 2010 and 2017 – Davide Zoccolan from MIT, Davide Crepaldi from Milano-Bicocca, Domenica Bueti from Lausanne, and Chris Mathys from London. In addition to enthusiasm and fresh research lines, the junior PIs bring in prestigious funding.

Targets of investigation include the neuronal bases of tactile perception (Diamond) and of visual perception (Zoccolan); social cognition (Rumiati); neuronal computation in the hippocampus and in language (Treves); time and space perception (Bueti); inference, learning and action (Mathys); language and abstract cognition (Crepaldi). The contributions of independent postdoctoral researchers further colour our fabric.

An active and vibrant environment is nourished through journal clubs and research talks, offered by both the internal personnel and visitors. Cognitive Neuroscience also organizes TEX (Trieste Encounters on Cognitive Science), an annual summer school built round a different topic each year.

Typically, over half of the PhD roster is from outside Italy. Their destinations after concluding the degree include top universities in Europe, the US, and elsewhere.

Snapshots from the Cognitive Neuroscience labs activities.
Credits: Stefano Amadeo; Andrea Tomicich.

ILAS The Interdisciplinary Laboratory for Natural and Human Sciences

«Founded in 1986, is the distinctive Unit inside the School that aims to experience new links between science and the humanities...»

Credits: Luigi Alberto Gozzi

ILAS

«…to promote and extend scientific culture to a large audience, and to examine further the multiple aspects of the complex relationship between science and society»

The Interdisciplinary Laboratory for Natural and Human Sciences of SISSA, founded in 1986, is the distinctive Unit inside the School that aims to experience new links between science and the humanities, to promote and extend scientific culture to a large audience, and to examine further the multiple aspects of the complex relationship between science and society.

For these reasons, the Interdisciplinary Laboratory is thus engaged in an intense activity of scientific dissemination which, among many other things, also covers literature, history, philosophy and the visual arts, such as photography and scientific movies. Hence throughout the years the Interdisciplinary Laboratory has organized a series of public events, held in SISSA but also in public auditoriums or in the historical cafes of downtown Trieste, focusing on literature and science, philosophy of science, history of science and neuroethics, also involving other Trieste institutions. For instance, the public reading of Lucretius' *De Rerum Natura,* held in the SISSA auditorium, was performed by SISSA students and professors and by young actors from the Trieste University Theatre Centre, together with original pieces composed by students from the School of Electronic Music of the Conservatorio Tartini.

In this context, it is worth mentioning a series of events organized, together with famous writers or scholars, on Robert Musil, Dante Alighieri, Giacomo Leopardi, Primo Levi or James Joyce, as well as another series of events devoted to scientific languages, history of photography, Game Theory and the art of chess, famous figures in the history of science such as James Maxwell, Johannes Kepler, Isaac Newton, Enrico Fermi and Bruno Pontecorvo, or a series of events and schools devoted to brain, emotions and neuroscience. Since among the various arts photography marvellously blends together art, science and technology, the Interdisciplinary Laboratory promoted last year the photographic contest *De Rerum Natura – Science in a Click*, devoted to the beauty of Nature and its laws.

The Interdisciplinary Laboratory is also the Unit responsible for the organization and running of several Master courses, such as the renowned *Franco Prattico Master in Scientific Journalism* and the most recent *Master in High Performance Computing*. Since 2017, the Interdisciplinary Laboratory also hosts the Media Relations and Communications Unit of SISSA, responsible for all press releases and social networks of SISSA.

ILAS Events


SISSA EVENTS
"Se sapessi come si fa una buona fotografia, la farei sempre"
Un ciclo di seminari tra immagini, scienza, arte e tecnica
IL PROGRAMMA IN BREVE:
MAGGIO - GIUGNO 2017
ore 18.00
CINEMA E SCIENZA
LABORATORIO INTERDISCIPLINARE
AI LIMITI DELL'IMPOSSIBILE
IL CINEMA DELLA FANTASCIENZA
"Lampi di luce. I primi grandi fotografi"
Primo appuntamento del ciclo "Se sapessi come si fa una buona fotografia, la farei sempre"
Tutte le conferenze sono gratuite e aperte al pubblico
QUANDO
Giovedì 18 MAGGIO
ore 18.00
Giornate triestine
Personaggi interessanti che hanno cose interessanti da dire
Una notte di luna per l'ispettore Laurenti
Tutte le conferenze sono gratuite e aperte al pubblico.
QUANDO
10 DICEMBRE 2015
ore 18.00
DOVE
Sala del Museo Sartorio
INFO e PRENOTAZIONI
Laboratorio Interdisciplinare
eventi.ilas@sissa.it
Tel: (+39) 040 3787401
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Andrea Tomicich
13 dicembre 2012 alla SISSA
EASTMAN KODAK


SISSA EVENTS
La scienza pensata
Dalla filosofia alla scienza e ritorno
Cervelli, persone e valori.
Filosofia per le scienze delle dipendenze
INCONTRI SISSA
GIOCO, CINEMA E SCIENZA
GIOCO E SOCIETÀ
LABORATORIO INTERDISCIPLINARE
GIOCO E SCIENZA
SISSA EVENTS
COMUNICARE LA SCIENZA, PENSARE ALLA SUA STORIA
Tavola rotonda
Venerdì 25 gennaio 2013
ore 15.00
SISSA - Aula 128-129
Via Bonomea, 265
Trieste
SISSA EVENTS
BRUNO PONTECORVO IN ITALIA
Venerdì 08 marzo 2013
MORE INFO

William Demasi, *Streaked Supercell*
(Nature Section, 2014, 1st place)

Luigi Alberto Gozzi, *Upside down*
(Science Section, 2015, 1st place)

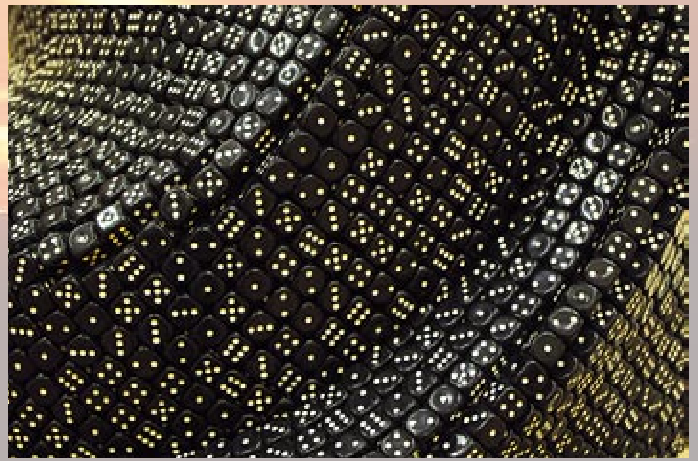
Andrea Candolini, *Oh*
(Nature Section, 2015, 2nd place)

Giovanni Tessicini, *The TNG and the Milky Way*
(Science Section, 2014, 2nd place)

Serafini, *The Man and the Time*
(Science Section, 2014, 3rd place)

Lorenzo Ragazzi, *Nortern Light*
(Nature Section, 2015, 1st place)

John Gubertini, *Signs of the Apocalypse*
(Science Section, 2014, 1st place)



Caterina Manfredi, *Uncertainty*
(Science Section, 2015, 2nd place)

Valentina Sartor, *The Flight*
(Nature Section, 2015, Special Mention)

MCS - Master's Course in Science Communication

Snapshots from the first Master's Course in Science Communication. Credits: Roberto Percacci.

The history of the oldest and longest-running italian training school for science communication begins about 25 years ago. The SISSA Master's Course in Science Communication (MCS) was indeed founded in 1993 as part of the Interdisciplinary Laboratory. Its origin was mainly due to the determination of the physicist Paolo Budinich, who played a key role in the revival of science in Trieste after the Second World War.

In his view, science communication was crucial to establish a real democratic society of knowledge. He also made it clear that training activity was needed in this field and he expressed his view on the issue when he was interviewed by a prominent Italian science writer, Franco Prattico, member of the editorial staff at the Italian newspaper *La Repubblica*.

Prattico and Budinich were both convinced that any separation between science and culture is unnatural and dangerous. In their view, a way to rebuild the bridge between those two dimensions was to set up a training school for science journalists. This idea was then embraced by the physicist Stefano Fantoni, who was at the time director of the Interdisciplinary Laboratory.

Brain Awareness Week 2016, Round table "The brain of things", Lovat Bookshop. Credits: Chiara Saviane.

Hence, in 1993 Trieste saw the establishment of the first Italian school in science communication.

With the help of many journalists and communicators, including first of all the already mentioned Prattico, then Pietro Greco, Daniela Minerva, Fabio Pagan (to name but a few), Stefano Fantoni

Brain Awareness Week 2016, Round table with theatrical reading "Neuroscience fiction", Museo Revoltella. Credits: Chiara Saviane.

Students during a lecture, MCS 2015-16. Credits: Divulgando srl.

Snapshots from the Writing Lab, MCS 2017-18. Credits: Stefano Amadeo.

built a school with at least two distinctive features with respect to similar schools in Europe.

The first original aspect was a joint management of scientists and journalists. The second aspect that identified the Triestine school from the start was its genuine interdisciplinary nature.

Pietro Greco, who was co-director of MCS for a long time, emphasized a didactic approach aimed at training intellectuals able to explore the intricacies of the relationship between science and society. Another crucial role was played by Professor Roberto Iengo, a Sissa theoretical physicist who was director of the Master's course for six years. Iengo made a fundamental contribution both to the administrative and organizational consolidation of MCS, and to the strengthening of networks between journalists and scientists.

The current director is Prof. Anna Menini, while Dr. Nico Pitrelli is the co-director. In the past Prof.

MHPC - Master in High Performance Computing

MHPC lessons. Credits: Lisa Zillio.

SISSA/ICTP supercomputer Ulysses. Credits: Lisa Zillio.

In September 2014 the high-performing supercomputer Ulysses was inaugurated in Trieste, thanks to an agreement between SISSA and ICTP. This event provided an occasion to present the new Master in High Performance Computing (MHPC), founded as a part of the Interdisciplinary Laboratory and set in the stimulating research environment of its co-organizing institutions: SISSA and ICTP.

Now in its 4th edition, the Master in High Performance Computing is an innovative specialization program that prepares students for exciting careers in the fast-growing field of high performance computing (HPC), both in academia and industry. The official Master's headquarters is the SISSA Miramare campus, where Ulysses is also housed.

Advanced research in many different fields, such as applied mathematics, theoretical physics but also biotechnology and molecular biology, requires access to large scientific computing resources, as well as specialists trained in the field of HPC. Given the severe shortage of skilled personnel able to bridge the existing gap between the dynamic environments in IT and research, the

Master in HPC aims to create a group of experts who have the training and the skills needed to fill this gap. Students follow courses by lecturers from academia and from the industrial world, who teach them the latest applications of HPC technologies and innovations. A variety of topics are covered during the 12-month course: scientific computing approaches, algorithms, modelling, data management, numerical analysis, computer architectures and optimizations. MHPC provides access to instant career opportunities on an international scale and is supported by various bodies: Regione Friuli Venezia Giulia, partner institutions, and others.

In the future, MHPC hopes to acquire strategic territorial relevance, also through the involvement of interregional institutions, companies and organizations.

MHPC first day (4th ed. - 2017/2018). Credits: Rachele Mazzaracca.

MHPC lessons. Credits: Lisa Zillio.

A look inside the HPC world. Credits: Lisa Zillio.

Electronic Publishing Journals and SISSA Medialab

*«After the great success of JHEP,
SISSA started to publish JCAP, JSTAT, JINST, JCOM and PoS.
These are all among the leading journals in their fields»*

Credits: Caterina Manfredi

Electronic publishing is an extracurricular activity that has been developed in SISSA since the early ’90s onwards. The first form was the preprint electronic archives. In the Elementary Particle community, the use of electronic media soon became common, not only for experimental data analysis but also for remote communication and for the production of texts (tex, latex). In the ’80s, the exchange of work files between authors via e-mail was more and more frequent, but made on an individual basis. The World Wide Web (www) invention in 1989 created the conditions for this exchange in an organized way: making the preprint electronic archives available to the whole community of scientists became feasible. The idea of creating electronic archives in SISSA was born of the cooperation between the Centre of Calculus and the Elementary Particle of Physics sector. Although this initiative was anticipated by a few months at the Los Alamos Laboratories (September ’91) with its own archives, in March ’92 SISSA issued three archives (Functional Analysis, Astrophysics, Condensed Matter), which coexisted for some years with those of Los Alamos and then merged with them.

When the archives experience was exhausted, the idea arose of using the same technologies for an entirely electronic journal: a magazine in which the various pasages (submission of the articles by the authors, selection and submission to referees, referee responses, possible exchanges with authors for revisions and publication) are entirely automated by an electronic robot. The

project started in 1996 and the journal *JHEP* (*Journal of High Energy Physics*) was launched in July 1997. It was immediately a success. When it was founded, the aim was to create a journal which would allow physicists to write, submit, referee and edit papers in an electronic format – a journal made by scientists for scientists – a concept that was very new at the time. As a result of this foresight, *JHEP* soon became one of the most prestigious journals, if not the most prestigious, in its field. Since 2014, the costs of publishing open access in the journal (the article processing charges, APCs) have been completely covered by the Sponsoring Consortium for Open Access Publishing in Particle Physics (SCOAP3).

Parallel to *JHEP*, another idea was realized, that of using internet to bridge the gap between the scientific community and society. This gave rise to the Ulisse portal. This portal contained several sections, including one for the public's questions and for expert feedback: the initiative was also very successful and obtained the enthusiastic participation of more than 600 scientists in Italy and abroad. It was the first successful science dissemination portal in Italy, and received several awards.

After the great success of *JHEP*, SISSA started to publish *JCAP* (the *Journal of Cosmology and Astroparticle Physics*), *JSTAT* (the *Journal of Statistical Mechanics*), *JINST* (the *Journal of Instrumentation*), *JCOM* (the *Journal of Science Communication*) and *PoS* (*Proceedings of Science*). These are all among the leading journals in their fields.

In order to manage these electronic publishing activities, at the end of the '90s an internal structure was set up in SISSA, SISSA Telematica. In the early 2000s SISSA Telematica engaged about fifteen people. In 2005, it became SISSA Medialab, the in-house company of SISSA, which continued and expanded the electronic publishing activities.

In July 2017, the open access *Journal of High Energy Physics* (*JHEP*) celebrated its 20-year anniversary. *JHEP* covers world-leading research in high-energy physics, as well as related topics including general relativity, gravitation, and mathematical aspects of quantum field theories.

The publishing system is still based on the algorithm created by SISSA back in 1996 and continuously developed and maintained by the Medialab IT Office. Even the typesetting activity is performed by the scientific community: a pool of young physicists and mathematicians, most of

them PhD candidates, are automatically assigned the papers by the system. All the researchers involved in the peer review process receive a payment according to their workload: SISSA journals are the only ones in the STEM (Science, Technology, Engineering and Mathematics) publishing industry providing a financial compensation to the referees, probably the most important actors of the peer review.

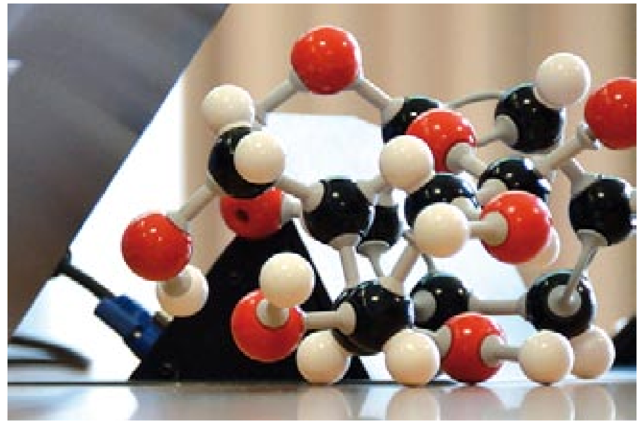
Sissa Medialab organizes events and educational programmes, produces innovative media to communicate science to different audiences, offers consultancy for the development of permanent and temporary exhibitions. It has collaborated with several universities and research centres, institutions and networks.

Sissa Medialab has designed and implemented several exhibitions and provided scientific consultancy for the creation of science museums and science centres.

Since 2005 Sissa Medialab has organized training courses for the explainers of science museums, and many courses in science communication dedicated to scientists and researchers. Organized in several European countries, but also in Brazil and Mexico for Latin-American professionals, these courses have involved a total of thousands of participants.

SISSA and Trieste

Credits: Andrea Tomicich



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SISSA is 40, but doesn’t show its years.

It remains the young and exploratory institution
that its founder, Paolo Budinich, intended.

By daring a little, I like to think of SISSA
as a Peter Pan of science.

(From the *Introduction* by Stefano Ruffo)

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