

bois-marie

INSTITUT DES HAUTES ÉTUDES SCIENTIFIQUES

editorial

There was more change at the Institute as Philippe LAGAYETTE, who had been chairing the IHÉS Board of Directors for 20 years, chose to leave in May 2014. The Board wished to pay tribute to the former Director General of the Caisse des Dépôts by making him Honorary Chairman, so the Institute will continue to benefit from his kind support. Marwan LAHOUD, Chief Strategy and Marketing Officer of Airbus Group, is taking over from him. IHÉS is delighted that a senior executive from one of Europe's leading industrial groups has been elected Chairman – a clear statement of the need for a strong link between highly theoretical research and cutting edge technology.

“IHÉS Lectures”, which aim to present recent important scientific results in a range of fields in mathematics and theoretical physics, started in the autumn of 2013. The speakers are IHÉS permanent professors and postdoctoral researchers or external researchers, by invitation. Certain lectures form part of the graduate schools in the Paris area. This initiative is a reminder that IHÉS is an active member of partnerships within the local scientific community.

IHÉS now also makes systematically available on line video recordings of all its scientific events. Freely accessible by all, these videos demonstrate IHÉS's wish to be an integral part of the collective development of scientific knowledge at its most complex level.

This vision of an outward looking institute serving scientific excellence is that of its founder Léon MOTCHANE; it is an ambition shared by the four directors who have come after him. The generous support of the community itself, be it from research institutes or from scientists, is a very welcome sign for the Institute. MOTCHANE's dream lives on thanks to the commitment shown by all the Institute's donors – their contribution is gratefully acknowledged.

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conference in honour of Vadim KNIZHNIK

On 30 and 31 October 2013 A. BELAVIN, N. NEKRASOV and S. SHATASHVILI organised a conference in honour of Vadim KNIZHNIK, who passed away 25 years ago and would have been 50 in 2012.

Twelve speakers who had worked with V. KNIZHNIK or known him personally each in turn recalled his great contribution to theoretical physics and modern mathematics.



Samson SHATASHVILI

IHÉS wished to pay tribute to Jean-Pierre BOURGUIGNON and organised two events to mark the 19 years he spent as the Institute's Director.

On 12 September 2013, a ceremony to mark the handover between the Institute's two directors took place at the headquarters of one of IHÉS's partners, AXA. Many scientific anecdotes were told and tokens of friendship expressed. The talks ended with a speech by Geneviève FIORASO, Minister of Higher Education and Research.



Jean-Pierre BOURGUIGNON, Emmanuel ULLMO

events in honour of Jean-Pierre BOURGUIGNON



Jean-Pierre Bourguignon, Sir Michael Atiyah

On 13 September, an international conference was organised by Mikhail GROMOV, Oussama HIJAZI and Emmanuel ULLMO, at IHÉS this time.

Six scientists from China, the United States, Germany and the United Kingdom and two IHÉS permanent professors made presentations.

There were several highlights, one of which being the opening presentation by Sir Michael ATIYAH, 1966 Fields medallist and 2004 Abel Prize winner, who was a member of the IHÉS Scientific Council from 1973 to 1980.

Watch videos of this event:



conference in honour of Yvonne CHOQUET-BRUHAT

To celebrate Yvonne CHOQUET-BRUHAT's 90th birthday, Jean-Pierre BOURGUIGNON and Thibault DAMOUR organised a conference on 9 and 10 January 2014 at the Institute. Its theme was *Recent Advances in Mathematical Relativity*. Leading experts presented recent developments in mathematical relativity over the two days.

Yvonne CHOQUET's work has made many lasting major contributions to the mathematical aspects of physics and to general relativity, starting with her foundational work in 1952 in which she showed that Cauchy's problem was correctly set for Einstein's equations. Her work has recently led to spectacular progress, especially in astronomy. She was the first woman to be admitted to the Académie des Sciences in Paris in 1970 for this groundbreaking work.



IHÉS lectures

IHÉS lectures were set up to encourage IHÉS professors (both permanent and invited) to present key recent scientific results in mathematics and theoretical physics. The lectures can also form part of graduate school programmes in the Paris area.

Since the autumn of 2013, Mikhail GROMOV, Thibault DAMOUR, Jean-François QUINT and Frank MERLE have taken part in these lectures. Vasily PESTUN, newly appointed permanent professor at IHÉS gave lectures throughout the month of October.

2014 summer school

The theme of the third IHÉS Summer School, which took place from 9 to 23 July 2014, was *Analytic Number Theory*.



Terence TAO

Organisers Emmanuel KOWALSKI and Philippe MICHEL are two of the specialists in this field.

Summer schools enable young mathematicians from around the world to attend a programme of lectures given by very high-level speakers. They are partly funded by the Société Générale Fund at IHÉS.



conference on Pierre DELIGNE's work

Friends of IHÉS and the Simons Foundation organised an event in New York on 5 October 2013, *Celebrating the Mathematics of Pierre DELIGNE*.

Pierre DELIGNE, professor at IAS, was a permanent professor at IHÉS from 1970 to 1984. To celebrate his being awarded the Abel Prize in 2013, his colleagues and students were invited to make presentations on his work and its impact and also to share their memories of IHÉS and elsewhere.

The speakers at this wonderful event were Ravi VAKIL (Stanford University), Brian CONRAD (Stanford University), Luc ILLUSIE (Université Paris-Sud), Dennis SULLIVAN (SUNY Stony Brook) and Bernard SAINT-DONAT (Harvard University).



Emmanuel ULLMO, Michael R. DOUGLAS

physics and mathematics bi-seminars

This seminar, organised by F.BROWN and P.VANHOVE since November 2013, focuses on recent developments in theoretical physics and mathematics in field theory and string theory.

Schlumberger workshop

Topics on Applied Probability was the theme of the most recent Schlumberger workshop, which took place on 28 March 2014.

The two organisers were Josselin GARNIER and George PAPANICOLAOU, both holders of the Schlumberger Chair for mathematical sciences at IHÉS.



the mathematical physics of Hurwitz numbers for beginners

This conference was organised by M. KONTSEVICH, A. ZORICH and D. ZVONKINE from 13 to 15 February 2014. Six speakers took part in this new type of conference, the objective of which was to introduce the concept of topological recursion.

arithmetic and algebraic geometry lectures

This lecture series, held in partnership with the Fondation mathématique Jacques Hadamard, aims to present recent or current work in arithmetic geometry. Speakers are chosen from among the key contributors to this area of research.

Vincent LAFFORGUE gave a series of lectures on *Paramètres de Langlands et cohomologie des champs de G-ctoucas*.

The next lectures will start in February 2015.

Watch videos of all IHÉS scientific events on IHÉS video channel:



Maxim KONTSEVICH, 2014 Breakthrough Prize in Mathematics winner

On 23rd June 2014, Maxim Kontsevich was awarded the inaugural Breakthrough Prize for his work *“making a deep impact in a vast variety of mathematical disciplines, including algebraic geometry, deformation theory, symplectic topology, homological algebra and dynamical systems”*.

The Breakthrough Prize in Mathematics was launched by Mark Zuckerberg and Yuri Milner with the aim to recognize major advances in the field, honor the world's best mathematicians, support their future endeavors and communicate the excitement of mathematics to the general public.



Maxim KONTSEVITCH

The four others recipients were Simon DONALDSON (Stony Brook University and Imperial College London), Jacob LURIE

(Harvard University), Terence TAO (University of California, Los Angeles) and Richard TAYLOR (Institute for Advanced Study).

Maxim Kontsevich Doctor Honoris Causa

In early September 2014, Aarhus University (Denmark) also conferred the title of Doctor Honoris Causa to Maxim KONTSEVICH.



Pierre VANHOVE, Sylvia SERFATY,
Bernard MEUNIER, Vice President of Académie des sciences

Pierre VANHOVE, Mergier Bourdeix 2013 prize

Pierre VANHOVE, CEA Senior Researcher at IHÉS, received the Mergier Bourdeix “grand prix” jointly with Sylvia SERFATY (UPMC, Paris) in October 2013. The prize is one of the major ones awarded by the Académie des Sciences (Paris) and recognises each year a young French researcher working on fundamental research with no commercial purpose or immediate application and whose results show exceptional talent.

Pierre VANHOVE has made fundamental contributions in theoretical particle physics and in string theory. He has brought to light a remarkable simplicity in the structure of gluon and graviton scattering amplitudes. His work on the scattering amplitude of two gravitons in string theory has determined the non-perturbative structure (from virtual supersymmetric black holes) providing new results to the description of quantum gravity. This has led to a new interpretation of some fascinating examples of automorphic forms, leading to new results in number theory.

David RUELLE, 2014 Max Planck Medal

David RUELLE, honorary professor at IHÉS and permanent professor from 1964 to 2000, was awarded the 2014 Max Planck Medal by the Deutsche Physikalische Gesellschaft (German Physical Society) *“for his fundamental contributions to relativistic Quantum Field Theory, statistical mechanics and the theory of dynamical systems and applications to the problem of the onset of turbulence.”*

The Max Planck Medal is the most prestigious distinction awarded by the Deutsche Physikalische Gesellschaft. Every year, it recognises outstanding contributions in the field of theoretical physics. The Max Planck Medal was created in 1929 and the joint winners that year were Max PLANCK and Albert EINSTEIN.



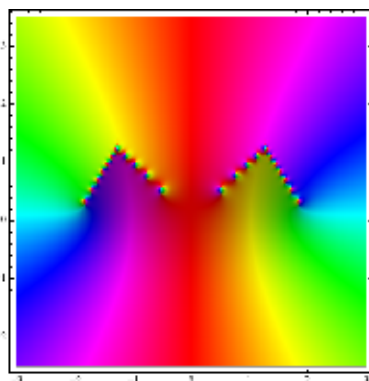
David RUELLE

arrival of Vasily PESTUN

Vasily PESTUN joined IHÉS as a permanent professor in September 2014.

He presents an overview of his research below.

We are surrounded by complex non-linear systems that have infinitely many interacting degrees of freedom. Most of these systems are not deterministic but are stochastic or probabilistic in nature. Developing the fundamental theoretical framework to characterize and predict the evolution and dynamics of such systems is the primary task of modern mathematical physics, which is comparable with the task of developing calculus to describe the interaction of several mechanical particles.



Quantum Riemann surface for one of the simplest non-linear integrable quantum system of the S -class (Toda system): a quantum particle in $\cosh(p)$ potential.

The goal of String Theory, a field which had its origin in the early 1970s, is to resolve the once apparently irreconcilable descriptions given of the physical world by Einstein's General Relativity on the one hand and Quantum Mechanics on the other. General Relativity is inherently highly non-linear and Quantum Mechanics is fundamentally stochastic. On the way to unify General Relativity with Quantum Mechanics, String Theory has developed broadly applicable concepts and techniques to treat complex non-linear stochastic systems, such as a concept of conformal field theory (CFT) explained below.

We meet the above-mentioned systems at all temporal and spatial scales. A short list of examples, arranged in increasing orders of scale, would include subnuclear quark-gluon processes (quantum chromo-dynamics), phase transitions of condensed matter states (criticality), neurocortical dynamics in the human brain, the dynamics of modern financial markets (especially high-frequency and automated trading), and atmospheric dynamics. Common features of all these systems include

- their volatile, stochastic and probabilistic natures,
- the simultaneous presence of a continuous range of interacting spatiotemporal scales and a self-similar or fractal structure, and
- the intrinsic, non-Gaussian nature of their probabilistic distributions that is responsible for the non-negligible probability of rare and big outlying events.

Technically, such events are deviations from the equilibrium that are much stronger than the standard deviation; some well-known examples include hurricanes in the Earth's atmosphere, unprovoked seizure onsets developing in a brain, rogue waves in the oceans or financial market flash crashes. Strongly interacting quantum conformal field theories (CFT) address such systems. These theories interact at all scales with



Cédric VILLANI, Vasily PESTUN

fractal structures, have no simple particle states, have non-Gaussian probabilistic distributions with fat tails of abnormal events, and often cannot be adequately described by a Lagrangian. My research is mainly focused on such conformal field theories and related topics. Non-trivial conformal field theories are known to exist in space-times of dimensions ranging from two to six. Most conformal field theories in lower dimensions can be obtained by taking various special limits of one of the theories in a distinguished class of six-dimensional conformal theories; this class is called S_g and is defined for all simply laced Lie algebras \mathfrak{g} . For example, by reducing S_g theory on a two-torus, one finds the most distinguished four-dimensional conformal gauge theory with maximal supersymmetry, which is famously known as holographic dual of 5d gravity.

The study of conformal field theories of the S -class is critical for the systematic understanding of generic conformal field theories. Several of my current research projects are aimed from different angles at the S -class theory trying to uncover the deeper structures underlying its dynamics. Mathematically, this is a very rich subject linking together several rapidly developing branches, such as geometric representation theory, integrable systems, quantum groups, analytical number theory, non-linear partial differential equations and new insights from the physics of quantum field theories.

Vasily PESTUN

A young graduate from Princeton, Vasily PESTUN has undertaken research visits at the Institute for Advanced Study and at Harvard and is taking up his first professor post at the Institute. His recruitment means that IHÉS continues its tradition of research in string theory, a branch of theoretical physics that lies at the interface with mathematics. This very active field aims to achieve Einstein's dream of unifying quantum mechanics and general relativity and has paved the way for such essential questions as the dimensionality of space-time, grand unification and how the Universe has evolved.

Vasily's work is on the non-perturbative dynamics of nonabelian gauge theories of strong interactions, and in particular on the exact results of supersymmetric gauge theory linked to integrability, of gauge-string correspondence and topological field theory. He has published *Quantum Geometry and Quiver Gauge Theories* in 2013 with N. NEKRASOV, IHÉS permanent professor from 2000 to 2013, and S. SHATASHVILI, holder of the Gelfand Chair at the Institute.

Focus on ...



Frank MERLE, mathematics professor at Université de Cergy-Pontoise and holder of the Université de Cergy-Pontoise - IHÉS Analysis Chair since 2009, gave a plenary conference: *Asymptotics for Critical Nonlinear Dispersive Equations*.



Samson SHATASHVILI, professor at Trinity College in Dublin, Hamilton Mathematical Institute Director, holder of the Louis Michel Chair at IHÉS from 2003 to 2013, gave a mathematical physics conference: *Gauge Theory Angle at Quantum Integrability*.



Francis BROWN, CNRS Senior Researcher at IHÉS, gave a conference on *Number Theory Motivic Periods and $\mathbb{P}^1\{0; 1; \infty\}$* .



Jean-Pierre BOURGUIGNON, former IHÉS Director and President of the European Research Council, presented the *Why STEM?* and *R&D Policy* discussion panels.

The 27th International Congress of Mathematicians (ICM) 2014 was held in Seoul from 13 to 21 August 2014 with the theme being *Hopes and Dreams for Late Starters*. Over 5 000 people from 120 countries came to the Congress over the seven days, during which there were 200 conferences including 21 plenaries and 51 satellite sessions on 19 mathematical topics. 1000 mathematicians from developing countries were invited to take part in ICM 2014, in order to pass on the positive impact of the Congress to future generations in their respective countries.



“As is the case every four years, the Congress enjoyed both a very rich programme and contributions from mathematicians from all over the world. A point particularly worthy of note this year were the efforts deployed by the Organising Committee to enable mathematicians from developing countries to attend, thanks to a bursary programme.

Of course, the key event in 2014 was that for the first time a woman, Maryam MIRZAKHANI from Iran, professor at Stanford (United States) was awarded the Fields Medal, one of the most prized scientific awards. Women who pursue careers in mathematics are all too rare, yet Maryam shows them that it is quite possible, including at the highest level of excellence. With this award, and all the media coverage about her, she becomes a point of reference in a discipline that was missing a role model - we all hope the result will be to inspire a new generation.

The awardee list, which also includes an Austrian, Martin HAIRER, a Canadian, Manjul

BHARGAVA and a French-Brazilian, Artur AVILA confirms that mathematical research is an international endeavour. I’m particularly pleased to see Brazil rewarded for the first time. Mathematical links with France have historically been strong and Artur AVILA is a good example of this cooperation. I spent a year and a half at the National Institute of Pure and Applied Mathematics (IMPA in Brazilian) in Rio de Janeiro; the Institute is currently setting up a cooperation project with IMPA that will make exchanges between the two centres easier.

The diversity and high calibre of the medallists is also manifest in their specialisation: dynamical systems, number theory, stochastic partial differential equations and geometry of Riemann surfaces and their moduli spaces.

Once again, congratulations to the medallists!”

Emmanuel ULLMO

The 2014 Fields Medal awardees:

Artur AVILA: dynamical systems and chaos. He has obtained several fundamental results in dynamics, in particular a proof of the dichotomy between regular and stochastic behaviour for a very large class of dynamical systems (unimodal applications).

Manjul BHARGAVA: number theory. He is trying to find out whether Diophantine equations have solutions or not. He gave some very precise upper and lower bounds for the average rank of an elliptic curve over a number field. He obtained his first results by playing with a Rubik’s Cube.

Martin HAIRER: differential partial equations to which random terms have been added. He is proposing a new theory, which will enable a new mathematical meaning to be given to operations that didn’t apparently have any.

Maryam MIRZAKHANI: geometry and surface dynamics, such as saddle-shaped hyperbolic surfaces. With Alex ESKIN, she has obtained deep results on the dynamics on the moduli spaces of curves, with a description close to Ratner’s results for the dynamics of unipotent flows on homogeneous spaces in a situation with far fewer symmetries.



the Israel Gelfand chair

The four permanent professors represent the Institute's identity over the years, but the 200 or so researchers invited each year ensure that different sources of inspiration abound, thus contributing to the scientific dynamism at IHÉS.

Diversity in the culture and in the areas of competence of the visiting researchers and the different projects they work on play a key role in the meaningful exchanges of views. Year in, year out, the stage is set at IHÉS for collaborative work that is remarkable both for its duration and originality.

The Gelfand Visitor Chair enables world class scientists to be invited for several months each year for three consecutive years. Chair holders take part in the high-level programme of lectures at IHÉS.

Samson SHATASHVILI



Samson SHATASHVILI, physicist, Director of the Hamilton Mathematical Institute at Trinity College in Dublin, was holder of the Louis Michel Chair at IHÉS from 2003 to 2013. He has been a Gelfand Chair holder since 2014.

He obtained his thesis on gauge theory in 1985 at the Steklov Institute under the direction of Ludwig FADDEEV (and Vladimir KOREPIN). He was associate professor at Yale University then professor at Trinity College in Dublin.

His area of research is mathematical physics, especially gauge theory, string theory and supersymmetry. In particular, he has developed with N. NEKRASOV a theory of integrability in gauge theories and their link to the Bethe–Correspondance.

In 2010, he was awarded the Gold Medal by the Royal Irish Academy, of which he has been a member since 2007.

Samson SHATASHVILI continued his research on the relation between supersymmetric gauge theories and quantum integrable systems. Most recent results, obtained in collaboration with N. NEKRASOV and V. PESTUN, concern the correspondence between the gauge theories, quantization of the moduli spaces of instantons (and singular monopoles) and the Yangian $Y_{\epsilon}(\mathfrak{g}_r)$, quantum affine algebra $U_q^{\text{aff}}(\mathfrak{g}_r)$, or the quantum elliptic algebra $U_{q,p}^{\text{ell}}(\mathfrak{g}_r)$ associated to Kac–Moody algebra \mathfrak{g}_r for quiver Γ .

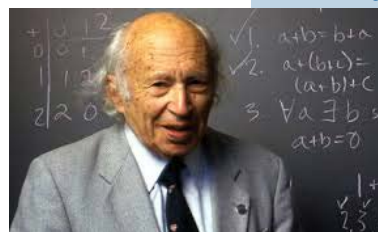
Spencer BLOCH



Spencer J. BLOCH is a mathematician, R.M. Hutchins Distinguished Service Professor Emeritus in the Mathematics Department of the University of Chicago.

He is a member of the U.S. National Academy of Sciences, the American Academy of Arts and Sciences and the American Mathematical Society. He was an invited speaker at ICM Helsinki in 1978 and at ICM Kyoto in 1990. He received the Humboldt Prize in 1996.

The main focus of his work has been algebraic geometry, and most particularly the study of motives, periods of motives, and motivic cohomology. In recent years, he has been studying motives arising from Feynman amplitudes in quantum field theory; working with people like Francis BROWN, Pierre CARTIER, Dirk KREIMER, and Pierre VANHOVE at IHÉS. Amplitudes are periods of motives, and modern algebraic geometry provides tools like Hodge structures which can yield interesting information for physicists.



Israel GELFAND (1913 - 2009) was a great mathematician whose impact on 20th century mathematics was remarkable for the depth and breadth of his areas of research. He would organise particularly lively seminars, covering a very wide range of topics, which left a lasting impression on participants, including Maxim KONTSEVICH, IHÉS permanent professor. Israel GELFAND himself undertook over ten research visits at the Institute.

In naming this Chair after him, IHÉS pays tribute to a great mathematician, symbolising scientific excellence and knowledge sharing, which are two of the Institute's core values.

from String Theory to Algebra

Yiannis VLASSOPOULOS was born in Athens, in 1969, obtained a Ph.D from Duke University and has worked in the Universities of Athens and Vienna. He has been a regular visitor of IHÉS for more than ten years.

Mathematical structures are used in the description of physics and advances in one subject have usually reflected on the other. Such is also the case with string theory, a proposal in physics for constructing a unified description of the four forces of nature. It has not yet been experimentally verified, but the mathematical structures arising from it have been extremely fruitful and interesting. Work I have been conducting at IHÉS, in collaboration with permanent professor M. KONTSEVICH, is related to a part of string theory called topological string theory. One of the main conjectures arising from it is the so called mirror symmetry, later reformulated as homological mirror

In string theory particles are considered to be, well, strings open or closed. A closed string is a loop. String theory is a quantum theory and in quantum physics there is no unique path from an initial to a final state. Instead, any possible path has to be considered with an appropriate weight and the only calculation that makes sense is a weighted average over all of them that gives the probability of reaching some final state. Now, paths of loops form cylinders and when two of them meet and join, they form a pair of pants. In general any surface with complex structure (a certain “shape”) and boundary (like the waist and legs of a pair of pants) appears as a possible path. Therefore one has to average (integrate) over all such, so called, Riemann surfaces. In topological string theory, the integral depends only on the topology¹ of the space parameterizing all Riemann surfaces. An algebra on the other hand, is a

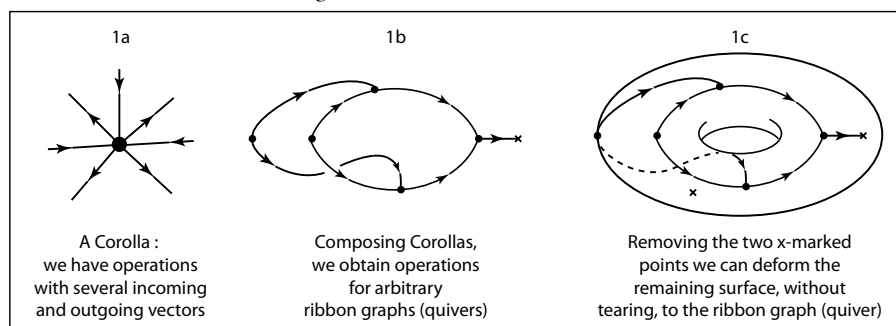


Figure 1

symmetry (HMS) by KONTSEVICH. Roughly speaking HMS connects two previously unrelated domains of mathematics. One related to complex geometry and the other to symplectic geometry (loosely speaking, the first has to do with shape and the second with size). My work has been on the common algebraic structure underlying both sides of the conjecture, called, in its most general version, pre-Calabi-Yau (CY) algebra. It turns out that this falls within the well-established principle in mathematics, of replacing a geometric space by an algebraic structure and generalizing in this fashion the notion of space itself in order to solve specific problems.

Now how are pre-CY-algebras related to string theory?

mathematical structure which generalizes the usual multiplication of numbers, namely it's a linear operation that from two vectors gives a third, satisfying associativity, that is, brackets don't matter in this “multiplication”. A pre-CY² algebra is a generalization of this, where we have operations with an arbitrary number of cyclically ordered, incoming and outgoing vectors. Depict this as a so called corolla with incoming and outgoing arrows (see Fig 1a). The number of outgoing vectors has to be at least one but we also add a special corolla with only incoming vectors, which has no operation attached to it. Now composing these operations, namely gluing an outgoing arrow of one corolla to an incoming of another, we obtain arbitrary graphs made of vertices and arrows connecting them (see Fig 1b). Such graphs are called quivers. We only



Yiannis VLASSOPOULOS, Maxim KONTSEVITCH,
Pierre VANHOVE

have operations for vertices with at least one output vector so we move along the graph until we reach a vertex with no output arrow (a special corolla) where we read the result. Since for every vertex we have a cyclic ordering of incident arrows, it means that the graph is locally planar around any vertex (it's called a ribbon quiver) and therefore it can be drawn on a surface (see Fig 1c).

Actually, we have proven that any Riemann surface with at least two boundary components (equivalently two points removed) can be continuously deformed, without tearing, to a unique such ribbon quiver drawn on it, where the complex structure is fully specified simply by assigning distances between vertices. Therefore, given the pre-CY algebra operations, we obtain operations depending on surfaces. One more property, generalizing associativity, guarantees these operations depend only on the topology of families of Riemann surfaces, which is what is required in topological string theory.

Many examples of pre-CY algebras arise in topology, algebraic geometry and symplectic geometry. Our work has been mainly in defining, studying and classifying these algebras with an eye towards applications to other parts of mathematics.

Yiannis VLASSOPOULOS

It's a pleasure to thank Marie-Claude VERGNE for expert help with the figures.

¹ Roughly speaking, in topology we identify two spaces if we can deform one to the other continuously, without tearing.

² Also introduced V -infinity (T. TRADLER & M. ZEINALIAN) or boundary (P. SEIDEL) algebra in special cases.

Maxim KONTSEVICH

conference in honour of Maxim KONTSEVICH

A conference in honour of Maxim KONTSEVICH was held at IHÉS from 23 to 27 June 2014, with leading mathematicians and theoretical physicists coming to celebrate his work on his fiftieth birthday. The conference theme was *Algebra, Geometry and Physics*.

According to the organisers D. AUROUX, J.P. BOURGUIGNON, L. KATZARKOV, Y. SOIBELMAN and Y. TSCHINKEL, geometry with applications to physics will probably involve the study of new types of objects, the category structures of which will play a fundamental role in the 21st century. Over the past 20 years, M. KONTSEVICH has been a driving force in the creation of these new structures. The aim of this conference, which brought together 30 speakers, was to pay tribute to his contributions to mathematics and physics. The 120 or so participants were able to take part in highly specialised research work.



Simon DONALDSON

According to D. AUROUX, professor at Berkeley University, this was the “mathematical event of 2014”.

At the start of the week, M. KONTSEVICH learned that he was one of the five winners of the inaugural Breakthrough Prize in Mathematics, as was S. DONALDSON, who was also at Bures-sur-Yvette for the conference.



Yan SOIBELMAN,
Alexander GONCHAROV



Don ZAGIER



The funny animal in the hands of Maxim KONTSEVICH is a model of a so called «square-tiled surface»; such surfaces appear in various contexts in the study of geometry and dynamics of the moduli spaces.

portrait

French-Russian, born in 1964 in Khimki (Russia), Maxim KONTSEVICH is an insatiable researcher who opens up an ever wider area around mathematics, working at the interface with mathematics and theoretical physics.

He has been permanent professor at IHÉS since 1995 and holder of the AXA chair in mathematics at IHÉS since 2009. It is the first permanent professor chair to be funded by two IHÉS partners: AXA Research Fund and the Simons Foundation.

The richness and depth of his work have been recognized internationally in many different ways, in particular through the award of prestigious prizes. He has already received the Otto Hahn Medal in 1992, the European Prize from the City of Paris in 1992, the Henri Poincaré Prize from the International Association of Mathematical

Physics (IAMP) in 1997, the Fields Medal in 1998 and the Crafoord Prize in 2009. He was elected Member of the Académie des Sciences, Paris, in 2002. He was the first French mathematician to receive the Shaw Prize in 2012. The very same year, he was awarded the inaugural Breakthrough Prize in Physics and recently the inaugural Breakthrough Prize in Mathematics in 2014.

Maxim KONTSEVICH belongs to a new generation of mathematicians who have been able to integrate in their area of work aspects of quantum theory, opening up radically new perspectives. On the mathematical side, he has drawn on the systematic use of known algebraic structure deformations and on the introduction of new ones, that turned out to be relevant in many other areas.

Delhi technology summit

IHÉS took part in the Technology Summit in Delhi on 23 and 24 October 2013 and would like to once again thank the eminent Indian mathematicians from the Tata Institute of Fundamental Research Centre, the Chennai Mathematical Institute and the Institute of Mathematical Sciences as well as the industrial partners from Dassault, Airbus Group, Total who came to share their views on the impact of mathematics in technological innovation.



Société Générale Private Banking conference cycle

As part of its "Ateliers de l'esprit" ("Workshops for the Mind"), Société Générale Private Banking invited Thibault DAMOUR to make a series of conferences the topic of which was *Physics and Reality - Does Time Exist?*, which began in the autumn of 2013. Two conferences have already taken place (in Paris on 20 November 2013 and in Luxembourg on 25 March 2014) and the cycle will continue in 2015. IHÉS is delighted with this new partnership with one of its major donors.

DEVELOPPEMENT ENSEIGNEMENT RECHERCHE
SOCIÉTÉ GÉNÉRALE
Private Banking



Thibault DAMOUR in Luxembourg

two conferences in London

The Support Committee for IHÉS in the UK, which was created in the summer of 2013 already has two events to its credit, to make the Institute better known and build new partnerships.

On 8 October 2013, participants debated the impact of theoretical sciences on innovation with the two holders of the Schlumberger Chair for Mathematics. Josselin GARNIER presented applications in seismology of imaging in random media and George PAPANICOLAOU spoke of recent developments in financial mathematics.

On 24 June 2014, Francis BROWN, CNRS Senior Researcher at IHÉS, talked about *The unreasonable effectiveness of mathematics* at AXA's London office. This talk, which was both scholarly and accessible, demonstrated how pointless it is to speak of fundamental mathematics and applied mathematics as opposites.



Francis BROWN

change of chairmanship

On 23 May 2014, members of the Board of Directors unanimously elected Marwan LAHOUD Chairman of IHÉS.

Chief armament engineer and a graduate of both the École polytechnique and the École nationale supérieure de l'aéronautique et de l'espace (French "grandes écoles" in engineering), he started his career in the DGA (French Defence procurement agency) at the test range in the Landes, where he was the head of the computation centre. Marwan LAHOUD was appointed Chief Marketing and Strategy Officer on 11 June 2007 at AIRBUS Group (formerly EADS) and Chairman of EADS France on 31 July 2012.

A ceremony in honour of Philippe LAGAYETTE, Board Chairman for 20 years and now Honorary Chairman, brought together the staff and permanent professors at the Institute on 8 July. Jean-Pierre BOURGUIGNON, President of the European Research Council and former IHÉS Director spoke of important moments in the former Chairman's term, such as LAFFORGUE's and KONTSEVICH's Fields Medals, the two fundraising campaigns and the events celebrating the Institute's fiftieth anniversary.



Marwan LAHOUD, Philippe LAGAYETTE

international campaign

Although the Institute is first and foremost supported by the French Ministry of Higher Education and Research, which provides half of its operating budget, its legal status as a private foundation led it to engage in two fundraising campaigns. The generosity shown by individuals, companies and foundations during this ongoing development effort is a vote of confidence from the Institute's partners. IHÉS is fully aware of the responsibility it bears to carry on defending its vision of scientific excellence, freedom and interdisciplinarity.

Friends of IHES gala dinner in New York



The annual Friends of IHES gala dinner took place in New York on 18 November 2013. Many prominent scientists, business people and philanthropists had come to hear Andrew REVKIN, Kenneth GOLDEN and Jean-Louis ÉTIENNE on the “mathematics of the earth” for this second gala event.

The fundraising objective was exceeded with \$325 000 collected that evening. The funds served to finance the research visits in Bures of scientists from the US and the Institute thanks its American friends for their support and generosity.

bequest from the Lanford family

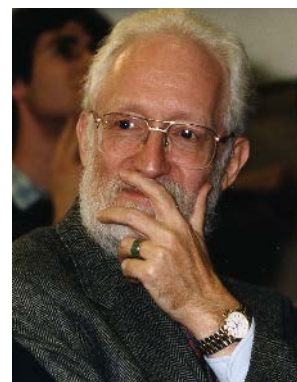
A theoretical physicist, Oscar E. LANFORD III was permanent professor at IHÉS from 1982 to 1987.

He studied how macroscopic – irreversible – evolutions could be deduced from certain – reversible – microscopic models. In particular, he demonstrated that a hard gas sphere diluted in \mathbf{R}^3 obeys the Boltzmann equation within the Boltzmann-Grad limit, at least for a very short time, equal only to one fifth of the average travel time of an atom. Despite this restriction on duration, this very robust mathematical theorem is conceptually very important, as the Boltzmann equation leads to the H theorem.

Oscar E. LANFORD III also acted as interim Director for the Institute from 2007 to 2011 during former Director Jean-Pierre BOURGUIGNON's research trips abroad.

His wife and daughter explained that he had wanted to donate an apartment to IHÉS, as “a way of giving something back in return for the many opportunities that had been offered him over the years”.

IHÉS thanks the family most sincerely for their great generosity and wanted to honour Oscar by naming the Director's science office after him, in perpetuity.



Oscar Erasmus LANFORD III
(6 June 1940 - 16 November 2013)

gift from Robert PENNER

Robert PENNER (Caltech), a regular visitor to IHÉS (René Thom Chair) who works with Misha GROMOV on topics of theoretical biology, made a gift to Friends of IHES of the entirety of his mathematical book collection, which was included in the Institute's library collection in September 2013.

IHÉS warmly thanks Robert for his generous gift, which will benefit generations of visitors.



point of view by ...

Xinan MA

Xinan MA is a professor of mathematics at the University of Science and Technology (USTC) of China in Hefei. His area of research is fully nonlinear elliptic partial differential equations and their application to geometry.

I knew IHÉS when I was an undergraduate student in Hangzhou University. It is as famous for mathematical and theoretical physics research as IAS in Princeton. My young brother, Xiaonan MA, studied in the Department of Mathematics in Orsay from 1994 to 1998. Through him, I got to know more about IHÉS. A CRNS researcher in IHÉS, Professor Shi WEISHU suggested Xiaonan MA translate a paper written by Arnold on ICM 1994, I then completed this work and published it in a well-known Chinese journal *Shu Xue Yi Lin* in 1995. In the spring of 2011, Xiaonan suggested to me that I should apply for a short visit to IHÉS. My application was accepted and my visit was split into three: one month in February 2012, one in January 2013 and two months in the Summer 2014. So, in total, I visited IHÉS for four months.

USTC is a top five university in mainland China. In our Mathematics Department, usually 35–40 percent of the undergraduate students choose

the USA as their first choice to continue their PhD study. Since 2006, I have recommended some excellent students to continue their PhD in France. Up to now, almost 20 talented students have come to study mathematics in the greater Paris area. In May 2014, the first student, Shu SHEN obtained his PhD degree in Orsay. On 12 July 2014, I attended a PhD thesis defense at École Polytechnique, and Junyi XIE obtained his PhD. In September 2014, another student, Benben LIAO defended his PhD thesis in Jussieu. So I was glad to visit France and have the opportunity to meet them again. They told me that the greater Paris area is one of the best places to study mathematics. There are so many famous professors in the greater Paris area. I wish that more USTC students chose France for their PhD. In September 2014, I have known six undergraduate students in our University who arrived in France to continue their mathematical research. From 2013 to 2014, four students in our department were recruited to ENS (Paris).

I study fully nonlinear elliptic partial differential equations and their application to geometry. In the first week of July 2014, I attended the Conference in honour of the



70th Birthday of Professor BREZIS in IHP in Paris. I listened to some exciting talks, for example the talk by Professor VILLANI on *Optimal Mass Transport*. I also listened to some Number Theory talks last July as at that time, IHÉS held a summer school on *Analytic Number Theory*.

It is easy to take the train from IHÉS to Paris and from there to other places. For example in February 2013, I went to the University of Florence (Italy) for four days to work with colleagues. At IHÉS, offices and apartments are so quiet it helps us to concentrate more on research. When I visited IHÉS in Feb. 2012, I concentrated on the study of level sets of a space-time quasiconcave solution of the heat equation. In IHÉS, I was able to complete the proof of an important lemma in the two dimensional case, which is about forty pages long. I also completed the long joint paper *On space-time quasiconcave solutions of the heat equation* with C. CHEN and P. SALANI. In 2013–2014, I studied the Neumann boundary value problems for quasilinear and fully nonlinear elliptic equations.

I shall always have pleasant memories of my time at IHÉS.

agenda 2014/2015

October 2014, every Tuesday, IHÉS

IHÉS Lectures: V. PESTUN, *Quantum Gauge Theories and Integrable Systems*.

From 8 October to 12 November 2014, every Wednesday, Université Paris 6

IHÉS Lectures: M. GROMOV, *Probability, Symmetry, Linearity*.

18 November 2014, Simons Foundation, New York
A day of exploring Maxim KONTSEVICH's contribution to mathematics

18 November 2014, The Intrepid, New York
Gala dinner organised by Friends of IHÉS.

2 December 2014, IHÉS

4th Itzykson Seminar, *Espaces de modules et courbes quantiques*, organised by FMJH.

February and March 2015, every Wednesday, IHÉS
Mécanique Quantique trimester, organised by T. DAMOUR, J. FRÖHLICH et D. RUELLE.

12 February to 19 March 2015, IHÉS

IHÉS Lectures: M. KASHIWARA and P. SCHAPIRA, *Indsheaves, temperate holomorphic functions and irregular Riemann-Hilbert correspondence*.

Spring 2015, IHÉS

IHÉS Lectures: M. LEWIN, *Mesures de Gibbs non linéaires et leur dérivation à partir de la mécanique quantique*.

April 2015, IHÉS

IHÉS Lectures: M. KONTSEVICH, *Exponential Integral*.

May and June 2015, IHÉS

IHÉS Lectures: F. BROWN, *Périodes motiviques et groupe de Galois cosmique*.

21 May to 11 June, every Thursday, IHÉS

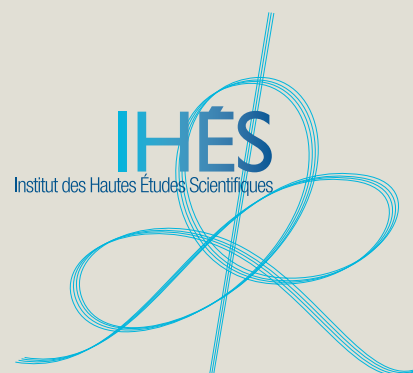
IHÉS Lectures: D. GAITSGORY, *Singular support of coherent sheaves*.

6 to 7 July, IHÉS

Moduli Problems in Symplectic Geometry Summer School organised by D. CRISTOFARO-GARDINER, J. NELSON and J. WATSON FISH.

23 to 25 September, IHÉS

Conference in honour of Arthur OGUS on the occasion of his 70th birthday organised by A. ABBES and L. ILLUSIE.



For more information: www.ihes.fr