

Jean-Michel Alberola Sir Michael Atiyah Jean-Pierre Bourguignon BUF Alain Connes

Raymond Depardon and Claudine Nougaret Nicole El Karoui Flowers Fields (INRIA-LABRI) Misha Gromov

Takeshi Kitano David Lynch Beatriz Milhazes Planck Spacecraft (ESA) + Large Hadron Collider (LHC)

Patti Smith Hiroshi Sugimoto Cédric Villani Tadanori Yokoo Don Zagier



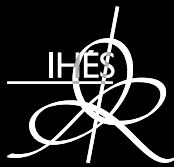
Mathematics – A Beautiful Elsewhere
October, 21 2011 – March 18, 2012

Fondation *Cartier*
pour l'art contemporain

L'exposition *Mathématiques, un dépaysement soudain* a été conçue
en collaboration avec l'IHÉS.

Elle est présentée sous le patronage de L'UNESCO, avec le
concours de la Commission nationale française pour l'UNESCO.

The exhibition *Mathematics: A Beautiful Elsewhere* was developed
in association with the Institut des Hautes Études Scientifiques
(IHÉS) and is presented under the patronage of UNESCO, with
the support of the French National Commission for UNESCO.



Mathematics: A Beautiful Elsewhere

Oct. 21, 2011–March 18, 2012

Mathematics: A Beautiful Elsewhere is a unique exhibition created by the Fondation Cartier pour l'art contemporain with the aim of offering visitors, to use the mathematician Alexandre Grothendieck's expression, "a sudden change of scenery." The Fondation Cartier has opened its doors to the community of mathematicians and invited a number of artists to accompany them. They are the artisans and thinkers, the explorers and builders of this exhibition.

A large number of mathematicians and scientists contributed to the creation of this exhibition, and eight of them acted as its overseers: SIR MICHAEL ATIYAH, JEAN-PIERRE BOURGUIGNON, ALAIN CONNES, NICOLE EL KAROUI, MISHA GROMOV, GIANCARLO LUCCHINI, CÉDRIC VILLANI and DON ZAGIER. Representing a wide range of geographical backgrounds and mathematical disciplines, they work in areas such as number theory, algebraic geometry, differential geometry, topology, partial differential equations, probability, mathematics applied to biology...

They were accompanied by nine artists chosen for their exceptional ability to listen, as well as for their great sense of curiosity and wonder. All of these artists have exhibited at the Fondation Cartier in the past: JEAN-MICHEL ALBEROLA, RAYMOND DEPARDON and CLAUDINE NOUGARET, TAKESHI KITANO, DAVID LYNCH, BEATRIZ MILHAZES, PATTI SMITH, HIROSHI SUGIMOTO and TADANORI YOKOO, as well as Pierre Buffin and his crew (BUF). They worked together to transform the abstract thinking of mathematics into a stimulating experience for the mind and the senses, an experience accessible to everyone.

The Fondation Cartier also invited a group of prestigious scientific institutions to participate: the Institut Henri Poincaré (IHP), the Institut d'Astrophysique de Paris (IAP), the European Laboratory for Particle Physics (CERN), the Institut National de Recherche en Informatique et en Automatique (INRIA), the University of Bordeaux/LABRI and the European Space Agency (ESA).

The exhibition was developed in association with the Institut des Hautes Études Scientifiques (IHÉS) and under the patronage of UNESCO. It was coordinated by Hervé Chandès (General Director of the Fondation Cartier), Jean-Pierre Bourguignon (CNRS Research Director and Director of IHÉS), Michel Cassé (astrophysicist, CEA Research Director and Associate Researcher at IAP), with Giancarlo Luc-

chini, Thomas Delamarre and the entire staff at the Fondation Cartier. Visitors may continue to experience this "sudden change of scenery" via the exhibition catalog, an iPad application, the Fondation Cartier website, as well as by attending a series of events, the Nights of Uncertainty. *Mathematics: A Beautiful Elsewhere* is a geometric, algebraic, artistic and cinematographic mosaic that gives everyone a chance to experience fragments of mathematical beauty.

Hervé Chandès,
General Director of the Fondation Cartier
pour l'art contemporain

Visit of the exhibition

The exhibition invites visitors to journey deep into the heart of mathematical thought, from pure to applied mathematics, from the discipline itself to the women and men who make it. Inspired by the thoughts and ideas of all of the mathematicians involved in the exhibition, David Lynch has invented a structure in the shape of a zero to accommodate Misha Gromov's Library of Mysteries. From Archimedes to Poincaré, Descartes to Einstein, this library provides a retrospective of the major events in the history of mathematics and human thought via an audiovisual installation designed by the American filmmaker with the help of Patti Smith: "The symbols you recognize are words and the mirrors are books. You start reading and your conversation with the Universe begins."¹ In addition, as a counterpart to this historical, scientific and philosophical perspective, David Lynch has teamed up with Takeshi Kitano and Beatriz Milhazes to create an arrangement of visuals and installations that show the diversity of mathematics and, in particular, its contribution to the most advanced areas of scientific research. Two exceptional contributions will make it possible to observe the real-time evolution of two major projects of contemporary science: experiments with matter being conducted by the CERN inside the Large Hadron Collider (LHC), and the mapping of the early universe as recorded by the Planck spacecraft of the ESA whose data is being studied by European astronomers, notably at the IAP. In addition, Pierre-Yves Oudeyer and his colleagues at INRIA and Bordeaux University will display the latest results from their work, which concerns a society of robots endowed with artificial curiosity. Their active presence in the exhibition is in itself an experiment that will allow these scientists to advance even further in their revolutionary research program. Visitors will then be able to get to know the women and men who breathe

life into mathematics. In a film made by Raymond Depardon and Claudine Nougaret, they are each given four minutes to express themselves freely about the passion that illuminates them. Jean-Michel Alberola charts the ideas of one of the last universal scholars, Henri Poincaré (1854-1912), by creating a work in the form of a mathematical firmament. He also shows how an idea is born in the mind of a mathematician through a film that captures the hand of Cédric Villani. Hiroshi Sugimoto concludes the visit with a hyperbolic form, a surface of revolution with constant negative curvature, which reflects the elegance of the abstract thinking expressed by the mathematicians in the film of Raymond Depardon and Claudine Nougaret. Like a culminating point rising toward infinity, Sugimoto's work asks the inevitable question at the heart of this project: how can mathematical abstraction be represented?

1. Misha Gromov, from the text *Between Two Mirrors*, published in the exhibition catalog.

Ground floor

Inspired by the ideas of mathematician Misha Gromov, David Lynch created the exhibition design and layout for the ground floor. He composed a soundscape for these spaces entitled *Mathematics Tripscape*.

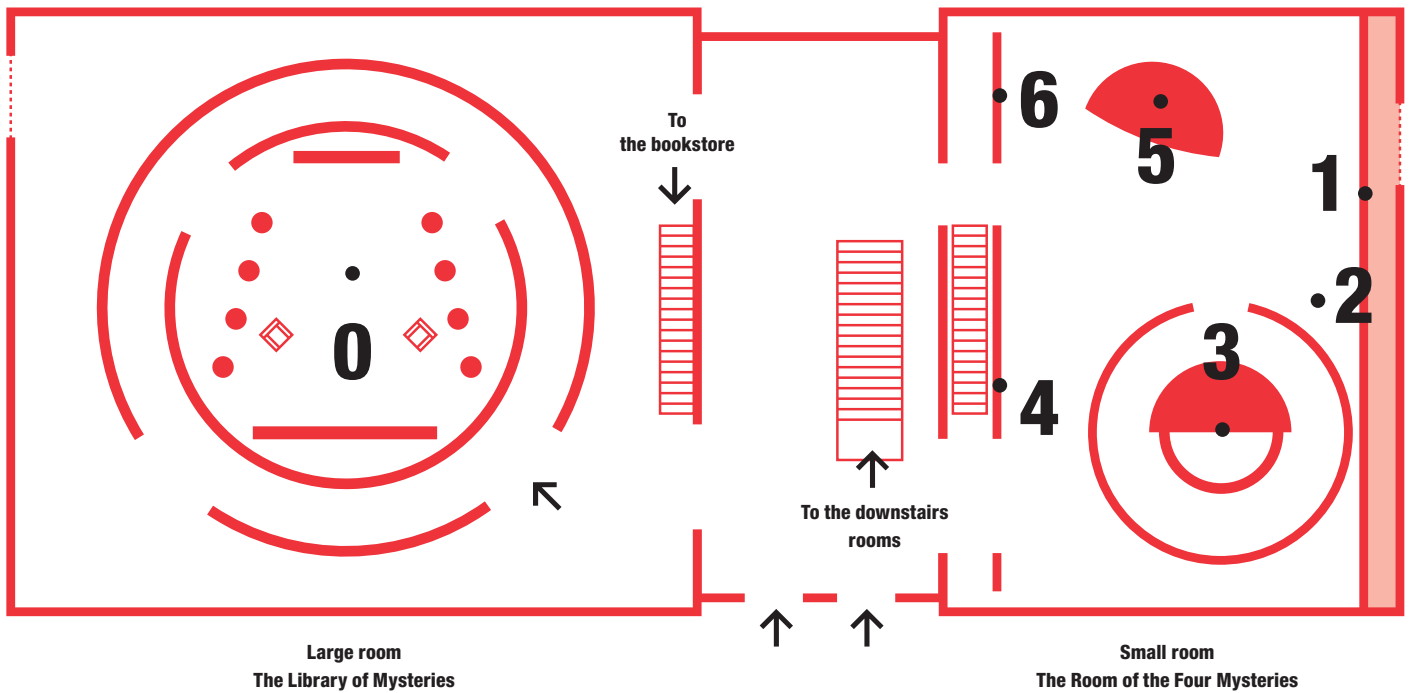
0 The Library of Mysteries

A structure in the form of a zero houses the Library of Mysteries imagined by Misha Gromov and David Lynch. The American filmmaker put together an audiovisual installation for this library that presents a collection of books selected by Misha Gromov for their importance in the history of mathematics and of human thought in general. Across its dome is depicted the multitude of objects found in the universe arranged according to size: from Planck's tiniest speck (the smallest conceivable object with a radius of 10^{-33} cm) up to the observable universe (a sphere with a radius of 10^{28} cm). In between, laid out in ascending order, are the protons and neutrons, atomic nuclei, atoms, molecules, crystals, mountains, continents, planets, galaxies, galaxy clusters and superclusters.

1 Microcosm, Macrocosm and the Beginning of Time

The Large Hadron Collider (LHC) particle accelerator and the Planck spacecraft are two of the most important scientific and technological experiments of our time. They clearly illustrate the interconnections that exist between physics and mathematics, which, as Henri Poincaré pointed out, are "not merely adjacent powers, maintaining good neighborly relations; they mutually interpenetrate and their spirit is the same."¹

GROUND FLOOR



Via the LHC collision ring, CERN researchers use electric and magnetic fields to guide and accelerate particles to speeds approaching the speed of light in order to create unknown matter and particles, thereby reproducing the high-energy conditions that existed 10^{-12} second (one trillionth) after the Big Bang. The role of mathematics is to help separate the known from the unknown during the billions of collisions that will be observed. Highly complex mathematical models also underlie the physics theories that are being tested by these experiments.

The Planck spacecraft piloted by ESA seeks to capture cosmic background or “fossil” radiation, the first light emitted by the universe approximately 380,000 years after the Big Bang. The satellite is mapping the early universe in order to precisely reconstruct the seminal events of the history of the universe. This powerful astronomical instrument converts messages from radiation into a series of electronic signals and then transfers them down to earth where they are filtered, analyzed and interpreted with the aid of physico-mathematical models.

These two experiments are presented in real time in the form of freeze frames that are renewed at regular intervals. A direct link makes it possible to view the data being analyzed on the control screens of the respective research sites:

- From October 21 to December 4, 2011: images from the LHC transmitted by CERN from Geneva.
- From December 6, 2011 to March 18, 2012: images from the Planck spacecraft transmitted by IAP, in connection with ESA.

1. Henri Poincaré, *The Value of Science*, 1905

2 & 5 Mathematical Landscape

O Paraiso (Paradise) is a collage created by Beatriz Milhazes based on a suggestion by Cédric Villani. The artist has composed a landscape in which plants, animals and various other natural phenomena are interspersed with triangles, circles and other geometrical forms inspired by Japanese *sangaku*. A set of equations is added to this landscape to show how illustrated natural phenomena can be described using mathematics: discontinuity of light (the sun’s rays), the Bernoulli Principle (birds in flight), iridescence (the peacock’s tail), electromagnetism (lightning), waves (sea waves), diffusion of heat (fire) and morphogenesis (the jaguar’s spots).

O Paraiso is the starting point for a film produced by BUF that can be viewed in the demisphere. (5)

3 Flowers Fields: Artificial Curiosity and Language

In a big egg that has just hatched, a tribe of young robotic creatures evolves and explores its environment. In addition to their innate capacities, they are equipped with mechanisms that enable them to learn new skills and invent their own language. Endowed with artificial curiosity, they explore the objects around them, as well as the effects their vocalizations have on human beings. When the latter react, via gestures or movements, they create an interactive loop, and a new form of communication between robots and humans takes shape over time.

“Flowers Fields” is an installation developed by INRIA in conjunction with the University of Bordeaux. It is the embodiment of Misha Gromov’s theoretical

concept of an ergosystem using the robotic models of artificial curiosity and linguistic interactivity devised by Pierre-Yves Oudeyer and Frédéric Kaplan.

4 & 5 Penrose Tilings

A tiling is a set of one or more types of shapes arranged in such a way as to cover a plane without any overlapping or gaps. For example, a honeycomb or a brick wall represents tilings that are made up of a single kind of shape.

Certain types of tilings are called periodic: in such cases the entire plane can be covered by simply taking a specific part of the tiling and moving it over. For example, the mosaics in the Alhambra palace in Granada (13th-14th century) are made up of several kinds of periodic tilings with a regular pattern.

There are also non-periodic tilings: in this case, no part of the tiling can be used to cover the whole area by being copied and moved over. The patterns are thus irregular.

The great British mathematician and physicist Sir Roger Penrose discovered several kinds of non-periodic tilings—now called Penrose tilings—in the 1970s that have very remarkable mathematical properties. On one of the walls of the small gallery, a giant collective Penrose tiling awaits visitors who are invited to arrange two types of magnetic tiles: “kites” and “darts.”

5 Ulam’s Spiral

One day in 1963, the American mathematician Stanislaw M. Ulam was feeling rather bored during a scientific meeting. In order to kill time he started jotting down the sequence of positive integers in the form of

BETWEEN TWO MIRRORS

INTRODUCTION TO THE LIBRARY OF MYSTERIES

Two semi-transparent mirrors: one hides the depths of your mind behind itself, the other screens the Universe from you. Multiple reflections of light patterns overwhelm you. Are these red splashes on the screen smoldering remains of a dead galaxy millions of light years away or are they your mind's eye dazzled by glowing embers of reptilian fears and desires, millions of years old, in a hidden chamber of your brain?

Lost... But deeply peering into the darkness of nobody's space, neither inside nor outside of what you call "myself" you perceive whispers without sound, visions without light—the Universe, reflected in the mirrors of other peoples' minds, tries to talk to you in a language of silent invisible strings of hieroglyphic symbols.

Painfully, with an effort, almost as if in a dream, the symbols, you recognize, are words and the mirrors are books. You start reading and your conversation with the Universe begins.

Misha Gromov

List of works in the Library of Mysteries: Heraclitus, *Fragments* – Plato, *Timaeus* – Aristotle, *On the Heavens* – Archimedes, *The Sand Reckoner* – René Descartes, *Geometry* – Galileo Galilei, *The Assayer* – Galileo Galilei, *Dialogues Concerning Two New Sciences* – Blaise Pascal, *Of the Geometrical Spirit* – Isaac Newton, *The Mathematical Principles of Natural Philosophy* – Buffon, *Natural History* – Pierre de Maupertuis, *Essay on Cosmology* – Antoine-Laurent de Lavoisier, *Elements of Chemistry* – Lamarck, *Zoological Philosophy* – Georges Cuvier, *Research on the Fossil Bones of Quadrupeds* – Bernhard Riemann, *Collected Mathematical Works* – Alfred Russel Wallace, *On the Tendency of Species to form Varieties* – Charles Darwin, *On the Origin of Species* – Claude Bernard, *An Introduction to the Study of Experimental Medicine* – Gregor Mendel, *Experiments in Plant Hybridisation* – Hermann von Helmholtz, *Epistemological Writings* – Henri Poincaré, *Analysis Situs, the first systematic study of topology* – Henri Poincaré, *Science and Hypothesis* – Henri Poincaré, *The Value of Science* – Henri Poincaré, *Science and Method* – Albert Einstein, *Relativity* – Linus Pauling, *The Nature of the Chemical Bond and the Structure of Molecules and Crystals* – Erwin Schrödinger, *What is Life? The Physical Aspect of the Living Cell* – Alan Turing, *Computing Machinery and Intelligence* – Richard P. Feynman, *QED: The Strange Theory of Light and Matter* – Alexandre Grothendieck, *Crops and Sowing*

THE FOUR MYSTERIES OF THE WORLD

INTRODUCTION TO THE ROOM OF THE FOUR MYSTERIES

The first mystery in the world is that of the nature of physical laws. One believes the structure radiates from a single point, something uniquely distinguished by the highest imaginable degree of symmetry, the symmetry that gets diluted and dissipates as the universe unravels itself to a human observer. The second mystery is that of life. The dissipated structural symmetry of physical matter evolves into another kind of structure, condenses to structural islands in the exponentially large sea of all imaginable outcomes.

The third mystery is the function of the brain. Here an accidentally developed, seemingly amorphous mass of organic matter is able, by following physically dictated pathways, to select a proper response from the double exponential space of (imaginary?) possibilities.

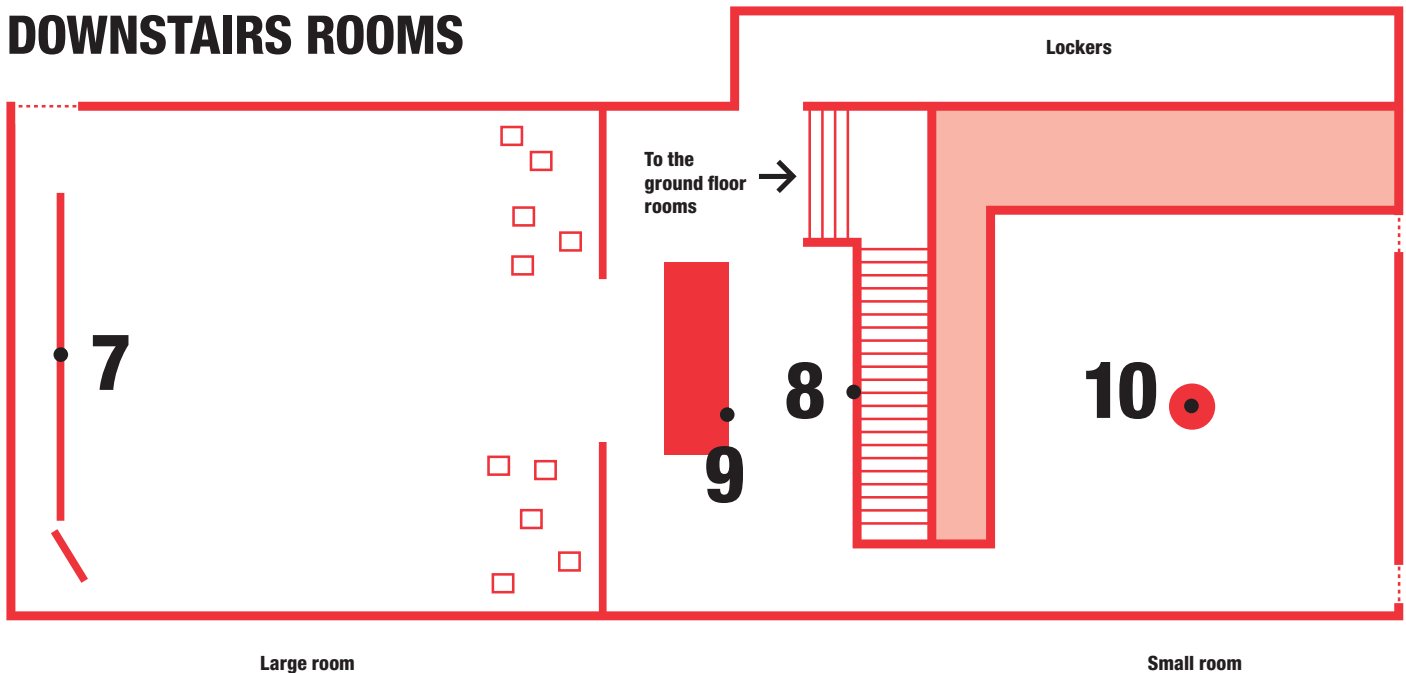
The only way to represent any of the three structures in a format comprehensible to the human mind (brain?) is to construct mathematical models.

Almost all we see in mathematics today has evolved under the influence of the first of the three mysteries. Mathematicians keep searching for the ultimate symmetry of the universe projected onto the human reasoning. But nothing like that has ever helped in elucidating the structures of life and of the mind (brain).

And here the fourth mystery comes in, the mystery of mathematical structure. Why and when does it appear, how can we model it, and how does the brain manage to create it out of the chaos of the external input?

Misha Gromov

DOWNSTAIRS ROOMS



Large room

Small room

a spiral grid. Without thinking, he circled all of the prime numbers—those numbers that can only be divided by 1 or by themselves (2, 3, 5, 7, 11, 13, 17...)—and discovered to his surprise that these numbers had a tendency to gather along lines and diagonals (or in regular curves, as in the round version of Ulam’s spiral devised by Robert Sacks in 1994). While their distribution in the sequence of positive integers seems to be random, the prime numbers and their spirals reveal the existence of hidden structures that are the focus of research that eminent mathematicians like Don Zagier are doing in number theory.

5 Sangaku

In Japan, from the 17th to the 19th century, painted tablets made of wood or other materials were traditionally placed at the entrance to temples or shrines. Called *sangaku*, these tablets featured mathematical problems based on simple geometrical forms such as circles, squares, triangles and ellipses that were displayed with or without solutions. They were hung up in sacred places as offerings to the gods and were thus accessible to everyone.

5 Sangi

For over a thousand years, beginning in the 5th century BCE, the Chinese used a method of calculation involving rods (*sangi*, in Japanese) laid out on the ground or on a surface with a grid. This remarkable method led to the development and use of fundamental mathematical techniques in Chinese civilization over 1,000 years before they were known in the West. During the calculation process, the rods are moved, the figures are taken apart

step by step and the different rows in the operation gradually disappear as the result is obtained. In the end, the initial problem to be solved is erased and only the answer remains.

6 The Answer is 2011

Takeshi Kitano created a series of television programs in Japan on the theme of mathematics. For this exhibition he invites visitors to invent their own equations using a touch screen. The Japanese filmmaker defined the rules of the game:

1. Numbers must be set in the following numerical order: 1, 2, 3, 4, and so on.
2. Between the numbers, any equation sign, such as +, −, ×, ÷, √, !, can be used.
3. The game is a sort of competition—the shorter the formula, the better.

Downstairs rooms

7 The Joys of Math

A film by Raymond Depardon and Claudine Nougaret, commissioned by the Fondation Cartier, allows mathematicians involved in the creation of the exhibition to express themselves in their own words. Shot in CinemaScope, it presents nine personal perspectives on the passion that is mathematics: Sir Michael Atiyah, Jean-Pierre Bourguignon, Carolina Canales González and Giancarlo Lucchini, Alain Connes, Nicole El Karoui, Misha Gromov, Cédric Villani and Don Zagier.

8 A Mathematical Sky—Henri Poincaré (1854-1912)

The French mathematician, physicist and philosopher Henri Poincaré is considered one of the last great universal scientists, a man whose thinking and ideas embraced many different areas of science. Jean-Michel Alberola set out to probe this exceptional mind and, with the assistance of Giancarlo Lucchini, he created a mural that highlights a subjective selection of the scientist’s writings. The titles of his works are connected on the basis of their scientific content and arranged on the wall in thematic “constellations.” The mural is in fact a way of “mapping” Henri Poincaré’s thinking, with additional links to writings with similar content by other great scientists.

9 Cédric Villani’s Hand

Jean-Michel Alberola filmed Cédric Villani writing out, on a blackboard, the

problem that provided him with his first significant achievement: Cercignani's conjecture. The statement that was ultimately proven, the proof and its implications are written.

10

Surface of Revolution with Constant Negative Curvature

In the exhibition *Étant donné: Le Grand Verre* presented by the Fondation Cartier in 2004, Hiroshi Sugimoto exhibited a series of photographs of objects that illustrated mathematical functions. One of these objects was a plaster sculpture that was approximately twenty centimeters high. It represented a surface that mathematicians call a pseudosphere, which is a hyperbolic object. Just as a circle that is rotated around its diameter creates a sphere, a pseudosphere is a surface obtained by the rotation of a curve composed of two separate lines that, as they rise, continue to approach each other without ever meeting. This behavior is called asymptotic: two curves can only meet at a point located "at infinity."

In contrast to the original plaster sculpture, whose tapering end was relatively thick, this model of the surface recreated in aluminum by the artist is three meters high and has a tip that is only two millimeters in diameter. The piece was produced using some of the latest developments in advanced robotics technology.

Captions of the works

Exhibition design: David Lynch

Previsualization: John Chalfant.

Production: Atelier Boutin

Mathematics Tripscape

Time: 1h, looped. Composition: David Lynch and Dean Hurley

0

David Lynch, *Universe Coming From Zero*

Animated film. Projection. Time: 7 min 43 sec., looped. Animation, production, editing: David Lynch. Technical director and co-editor: Noriko Miyakawa. Sound: David Lynch and Dean Hurley

David Lynch, *Library of Mysteries*

Animated film. Projection. Time: 1 hour 21 min., looped. Animation and production: David Lynch. Technical director: Noriko Miyakawa. Sound: David Lynch and Dean Hurley

***Baa, Baa, Black Sheep* is a nursery rhyme sung by Patti Smith and recorded by Tony Shanahan.**

David Lynch, *Mathematical Fire*

Animated film. Video. Time: 12 sec., looped. Animation and production: David Lynch. Technical director: Noriko Miyakawa. Sound: David Lynch and Dean Hurley

Proust armchairs by Alessandro Mendini

1

These projects were designed and produced with the invaluable assistance of Bruno Mansoulié (Research Director at CEA and researcher with the ATLAS/CERN collaboration) and François Bouchet (astrophysicist at IAP and Science and Data processing coordinator for Planck-HFI). Set-up and live transmission: CERN, IAP, ESA

2

Beatriz Milhazes, *O Paraíso*

Collage on paper. 36.5 × 50.5 cm. Enlargement: 7.30 × 10.10 m

3

Design, development and installation: INRIA Bordeaux Sud-Ouest (Jérôme Béchu, Fabien Bénéreau, Haylee Fogg, Paul Fudal, Matthieu Lapeyre, Olivier Mangin, Pierre Rouanet and Pierre-Yves Oudeyer, Coordinator), University of Bordeaux/LABRI (Hugo Gimbert, Olivier Ly). Exhibition and object design: David Lynch

5

Beatriz Milhazes and BUF, *Mathematical Paradises*

Animated film. Projection. Time: 10 min., looped. Filming and production: BUF. Artistic Director: Beatriz Milhazes

6

Takeshi Kitano, *The Answer is 2011*

Concept: Takeshi Kitano. Design: David Lynch. Programming (touch screen): Frédéric Kaplan and Laurent Bolli/OZWE

7

Raymond Depardon and Claudine Nougaret, *Au Bonheur des Maths*

35mm film, black and white, Scope 2.40. Digital sound 5.1. Projection. Time: 32 min., looped. Directors: Raymond Depardon and Claudine Nougaret. Production: Palmeraie et désert

8

Jean-Michel Alberola,

Un ciel mathématique - Henri Poincaré

Mural. Acrylic paint. 3.93 × 9.80 m. Painters: Michel Bertrand and Alicia Vaisse. Portrait of Henri Poincaré: Laboratoire d'Histoire des Sciences et de Philosophie - Archives Poincaré (CNRS/Université de Lorraine). Mathematical objects: Library of the Institut Henri Poincaré, Paris

9

Jean-Michel Alberola, *La Main de Cédric Villani (la conjecture de Cercignani)*

Video. Time: 8 min., looped. Director: Jean-Michel Alberola. Cameraman: Thomas Lallier, assisted by Cyril Colmant

10

Hiroshi Sugimoto, *Conceptual Form 011, 2008.*

Surface of Revolution with Constant Negative Curvature. Aluminum, mirror. 3 × 0.7 m

Biographies

Jean-Michel Alberola

Born in 1953, Jean-Michel Alberola is a French painter, who has been exploring the themes of history, religion, mythology, the role of the artist, and the power of the painted image through his art. A veritable art of global thinking, his painting is often supplemented by various other forms of expression: sculpture, objects, display cases, texts, films, etc. His oeuvre is syncretic, hybrid, incorporating references to classical painting or non-Occidental culture. An intermixture of “signs” and fragmented references, his works retain a memory of the past that defies any kind of unity, in which abstraction subverts recognizable forms and words encounter colors. Jean-Michel Alberola created a monumental installation for the Fondation Cartier in 1995 entitled *L’Effondrement des enseignes lumineuses* (The Fall of Neon Lighting), which acts as a fragment of discourse on the place of painting in today’s image-oriented society.

Sir Michael Atiyah

Sir Michael Francis Atiyah is a British mathematician born in London in 1929. His father was Lebanese and his mother was Scottish. Most of his academic career has been spent in the United Kingdom and the United States. He is now an honorary professor at the University of Edinburgh. Sir Michael Atiyah received the Fields Medal in 1966, the Copley Medal in 1988, and the Abel Prize in 2004.

The index theorem he established with Isadore Singer revealed important links between analysis and geometry and is an essential tool for the global study of spaces. His most recent work concerns the interface between geometry and theoretical physics.

Jean-Pierre Bourguignon

Jean-Pierre Bourguignon, born in 1947, is a French mathematician who holds an engineering degree from the École Polytechnique (1968) and a PhD in mathematics from Université Paris VII (1974). He is a *directeur de recherche* at CNRS, a part-time professor of mathematics at the École Polytechnique, and has headed the Institut des Hautes Études Scientifiques (IHÉS) in Bures-sur-Yvette since 1994. His main field of interest is differential geometry and, in particular, its relationship to partial differential equations and mathematical physics. A special focus of his work is the Ricci curvature, its impact on mathematical questions as well as the role it plays in general relativity.

Alain Connes

Alain Connes is a French mathematician born in 1947. He is a professor at the Collège de France where he holds the chair in Analysis and Geometry, and

at the Institut des Hautes Études Scientifiques (IHÉS). He is also a member of the French Academy of Sciences. Alain Connes received the Fields Medal in 1982, the Crafoord Prize in 2001 and the CNRS Gold Medal in 2004. He is a well-known specialist in operator algebras and the founder of noncommutative differential geometry. The scope of his work ranges from mathematics to theoretical physics, in areas as diverse as number theory, differential geometry and particle physics.

Raymond Depardon and Claudine Nougaret

Raymond Depardon and Claudine Nougaret have shared a mutual passion for filmmaking for twenty-five years. Their films, in which he captures the image and she captures the sound, include *Urgences* (1988), *Prisoner of the Desert* (1990), *Caught in the Act* (1994), *Paris* (1998), and *The 10th District Court* (2004). Autodidacts who cherish their freedom, they set up their own production company, Palmeraie et désert, in 1992.

Claudine Nougaret became the first female sound recordist in French cinema when she signed on to do the live sound recording for Eric Rohmer’s movie *The Green Ray* (Golden Lion at the 1986 Venice Film Festival), and her love of direct sound continues to prevail in her own productions.

Raymond Depardon occupies a singular position in the world of contemporary photography and film. He has made a name for himself in both media, using the still or moving image to express a simple, unique style, with a manifest desire to show society as it is, whether it be through the day-to-day chronicling of itinerancy, or through a glimpse into the psychiatric institution or the experience of abandoned childhood. He spent five years photographing France with a view camera and a part of this road trip was exhibited at the François Mitterrand Library (BnF) in 2010 and 2011.

Raymond Depardon and Claudine Nougaret have made several film installations for projects initiated by the Fondation Cartier pour l’art contemporain: *Amours* (1997), *The Desert* (2000), *Chasseurs et Chamans* (2002), *7x3* (2004). For *Native Land, Stop Eject*, a joint exhibition with Paul Virilio, they presented *Hear Them Speak* (2008), a film that raises awareness about the disappearance of vernacular languages around the world. Their latest film, *Modern Life*, was awarded the Louis-Delluc prize in 2008. They are currently in the process of editing their next film, *Journal de France* to be released in 2012.

Nicole El Karoui

Born in 1944, Nicole El Karoui is a French mathematician who graduated from the École Normale Supérieure de Jeunes Filles (Sèvres, France). While studying at the ENS, she became fascinated by probability and has sought ever since, as a professor, to pass on her passion for this field to her students at institutions such as the Uni-

versity of Le Mans, the ENS in Fontenay, Pierre and Marie Curie University, and the École Polytechnique.

While working in the banking sector on a six-month sabbatical in the late 1980s, she discovered applied mathematics for financial markets. This led her to take up the challenge of confronting theory with practice by creating the “Probability and Finance” masters program at the University of Paris VI-École Polytechnique, and she continues to teach these courses which have widely contributed to the international reputation of the “French quants.” She taught for ten years at the École Polytechnique where she built up a research group in financial mathematics. Nicole El Karoui holds the Financial Risks chair sponsored by the Société Générale bank and is considered to be one of the leading pioneers in the internationalization of financial mathematics research, to which the “French school” has largely contributed.

Misha Gromov

Born in 1943 in Boksitogorsk (Russia), Mikhail Leonidovitch Gromov is a Franco-Russian mathematician who has lived in France since 1981. He is a permanent professor at the IHÉS. He received the Abel Prize in 2009 “for his revolutionary contributions to geometry.”

He is indeed known for his many contributions to different areas of geometry, notably Riemannian geometry, geometric group theory, and symplectic topology. In addition to analysis and algebra, he is interested in mathematical contributions to biology.

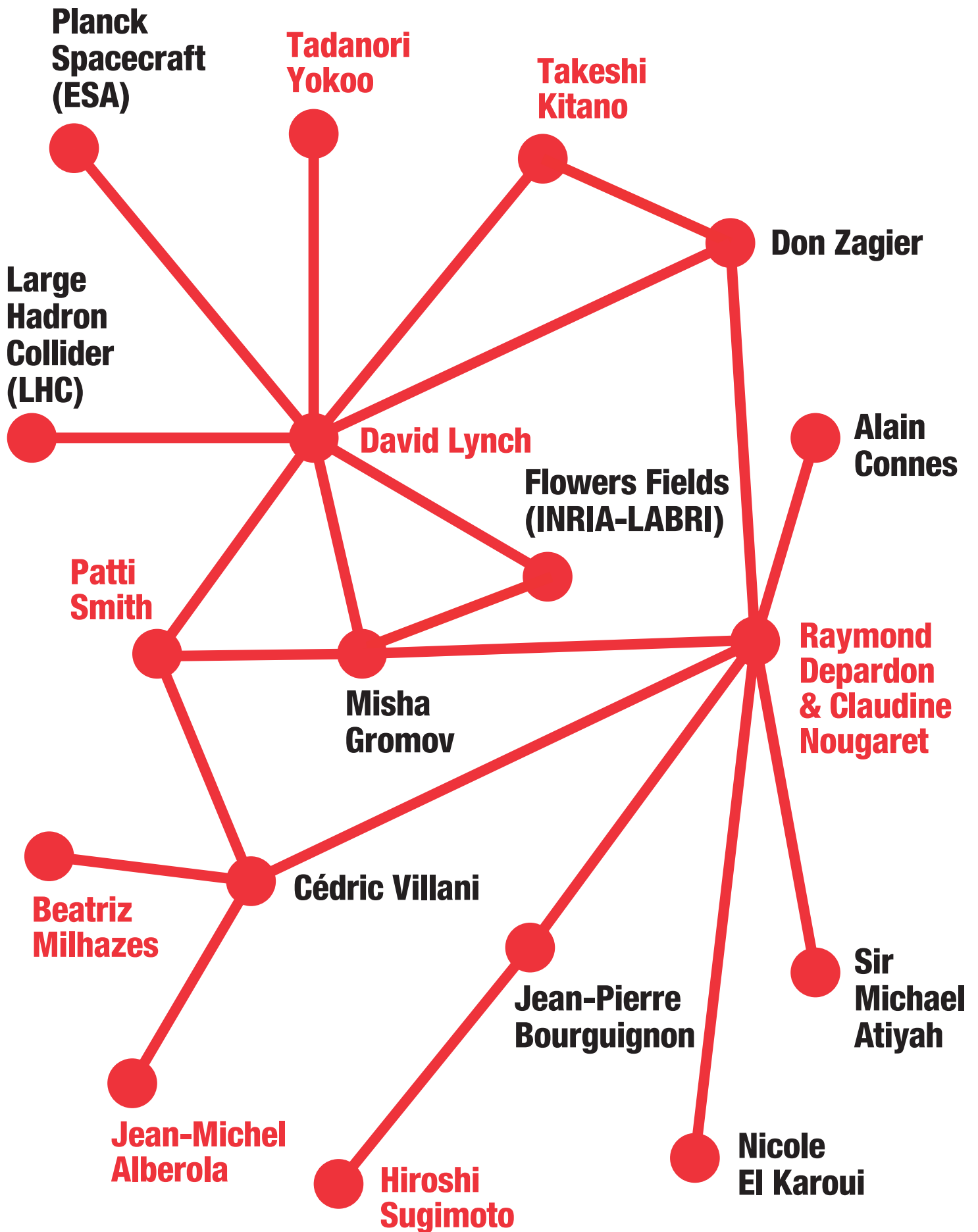
Takeshi Kitano

Born in 1947, Takeshi Kitano is a Japanese filmmaker whose main works include *Sonatine* (1993), *Hana-bi* (1997), *Zatôichi* (2003), *Achilles and the Tortoise* (2008), and *Outrage* (2010).

Famous throughout the world for his films, Takeshi Kitano commands an unequalled popularity in Japan as a comic and TV celebrity. Irrepressibly curious, passionate about the acquisition and passing on of knowledge, he adroitly switches genres and idioms, moving from violence to comedy, from over-the-top performances to deeply restrained ones. In 2010 he presented his first solo exhibition at the Fondation Cartier pour l’art contemporain entitled *Beat Takeshi Kitano, Gosse de peintre*. With paintings and videos, whimsical installations and fantastic machines, Kitano led the visitor through surprises, all the while mocking contemporary art, experimenting with the sciences and toying with clichés associated with his country.

David Lynch

Born in Montana (USA) in 1946, David Lynch spent most of his childhood painting and drawing. In 1965, he made his first experimental film at the Pennsylvania Academy of the Fine Arts. He has since



directed ten feature-length films, including *Sailor and Lula*, winner of the Palme d'Or at the Cannes Film Festival in 1990. One of the most original filmmakers of his time, he is also a photographer, musician, and painter. He was the youngest filmmaker to be awarded the Golden Lion for lifetime achievement in Venice in 2006. David Lynch's exhibition at the Fondation Cartier in 2007 entitled *The Air is on Fire* featured a large selection of works, including some that went back to the 1960s: drawings, paintings, photographs, experimental films, and sound environments specially created for the exhibition space.

Beatriz Milhazes

Beatriz Milhazes was born in 1960 in Rio de Janeiro. From 1978 to 1982 she studied at the Curso de Comunicação Social (FACHA) and the Escola de Artes Visuais in Parque Lage, Brazil. Intricately layered with a profusion of ornamental motifs, her vibrant and hypnotic paintings refer to sources as diverse as the Colonial baroque, high modernism, and popular Brazilian art. Exhibited in many galleries and at several international biennales (Venice Biennial, 2003), her work is represented in the collections of some of the world's greatest museums such as the Museo Nacional Centro de Arte Reina Sofia in Madrid and the 21st Century Museum of Contemporary Art in Kanazawa. In New York, she is one of the few artists of her generation to have major paintings in the collections of the Museum of Modern Art, the Guggenheim, and the Metropolitan. For her exhibition at the Fondation Cartier in 2009, the artist presented a focused selection of large format acrylic paintings, chosen from her work of the past decade, as well as a monumental collage created especially for the show.

Pierre-Yves Oudeyer

Born in 1977 in Vendôme (France), Pierre-Yves Oudeyer is a researcher at INRIA where he is also in charge of the FLOWERS team. He formerly worked as a researcher for eight years at the Sony Computer Science Laboratory in Paris (1999–2007). He is interested in developmental and social robotics with a special focus on the modeling of sensorimotor development and on language acquisition in robots and children. He has received several awards for his work, including the Prix Le Monde de la Recherche Universitaire in 2004, the Prix ASTI in 2005 and has been a recipient of the ERC Starting Grant since 2009.

<http://www.pyoudeyer.com>

<http://flowers.inria.fr>

Patti Smith

Born in Chicago in 1946, Patti Smith moved to New York in 1967, where she met artists and writers such as Robert Mapplethorpe, Sam Shepard, Brice Marden, Allen Ginsberg, and William Burroughs. She quickly took a keen interest in poetry

and art and devoted all the early 1970s to painting, writing, and the performing arts. Over the following years, she focused on music, combining rock'n'roll and poetic performance. During the 1980s and 1990s, in parallel to her musical creations Patti Smith carried on her artistic work, combining drawing, photography and writing. In 2008, Patti Smith presented at the Fondation Cartier pour l'art contemporain *Land 250*, a major solo exhibition of Polaroids, drawings, and films providing an insight into her spiritual and poetic universe. In 2005, she was awarded the Insignes de Commandeur de l'Ordre des Arts et des Lettres by the French Republic and was inducted in 2007 into the Rock'n'Roll Hall of Fame. Her autobiographical book, *Just Kids*, won the 2010 National Book Award for non-fiction.

Hiroshi Sugimoto

Born in Tokyo in 1948, Hiroshi Sugimoto left Japan in 1970 to study art in Los Angeles at a time when Minimalism and Conceptualism were the predominant movements in the art world. These movements helped to define his unique approach to photography, characterized by a profound sense of seriality, a probing analysis of empirical reality, and aspirations towards the metaphysical. Hiroshi Sugimoto develops his works in series; a carefully considered concept serves as the point of departure for the creation of a body of work devoted to a specific theme. Five important photographic series have dominated the artist's career thus far: *Dioramas and Wax Museums* (1976), *Theaters* (1978), *Seascapes* (1980), *Sanjusangendo, Hall of Thirty-Three Bays* (1995), and *Architecture* (1997).

In 2004 the Fondation Cartier presented Hiroshi Sugimoto's monographic exhibition *Étant donné: Le Grand Verre* in which he exhibited two series of photographs of scientific objects from the Museum of the University of Tokyo: *Mathematical Forms* and *Mechanical Forms*.

Cédric Villani

Cédric Villani is a French mathematician born in 1973. He is a professor at Claude Bernard University in Lyon and the director of the Institut Henri Poincaré (IHP) in Paris. He was awarded the European Mathematical Society Prize in 2008, the Fermat Prize and the Henri Poincaré Prize in 2009, and received the Fields Medal in 2010.

His research mainly concerns applying mathematical methods to problems in physics and the theory of partial differential equations. In particular, he has worked extensively on the theory of optimal transport and the kinetic theory of gases.

Tadanori Yokoo

Tadanori Yokoo was born in 1936 in Nishiwaki, Japan (Hyogo Prefecture). At the age of 24, he left to study at the Nippon Design Center in Tokyo and began working in advertising and illustration. He was

soon remarked by figures like the writer Yukio Mishima and the fashion designer Issey Miyake, and he would go on to collaborate closely with them for many years. A prolific artist who has worked in a wide variety of disciplines including painting and graphic design, as well as sets and costumes for *kyogen* and *kabuki* theatre, Tadanori Yokoo has become a veritable icon in the Japanese art world. In 1980, painting became a priority in his artistic practice. While many solo exhibitions have been dedicated to his graphic arts work in Japan, the United States and Europe, his exhibition at the Fondation Cartier pour l'art contemporain in 2006 was the first European exhibition devoted to his paintings.

He created the exhibition poster for *Mathematics: A Beautiful Elsewhere*.

Don Zagier

Born in 1951, Don Bernard Zagier is an American mathematician who has worked in the United States, Germany, and the Netherlands. He is one of the directors of the Max Planck Institute for Mathematics in Bonn and holds the chair in Number Theory at the Collège de France. He received the Cole Prize in Number Theory in 1987 and the von Staudt Prize in 2001.

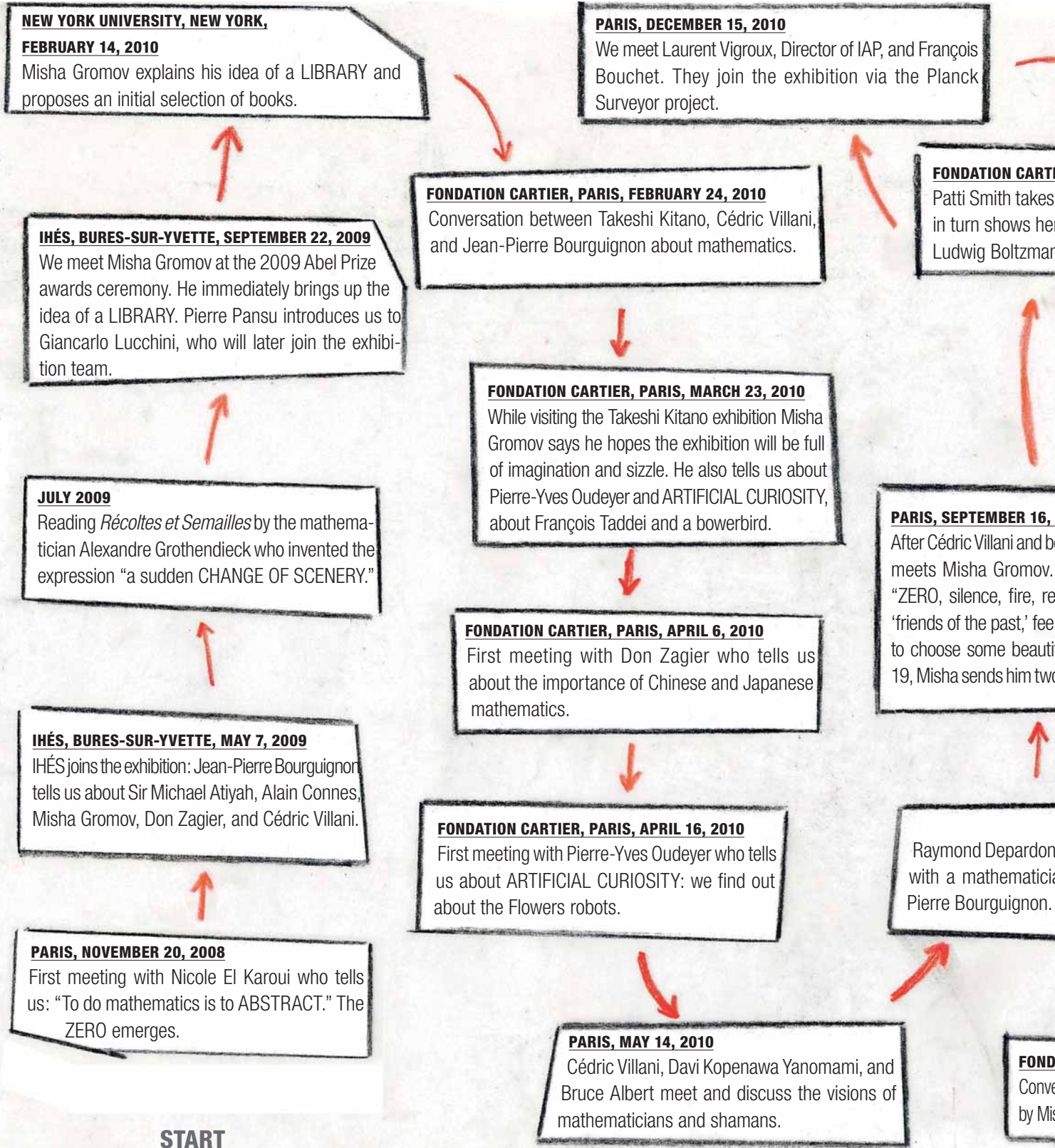
After working in the fields of topology and algebraic geometry, Don Zagier concentrated his research on number theory and the theory of modular forms, and he is now one of the leading specialists in these areas. In the 1980s, he developed the theory of Jacobi forms with Martin Eichler, which has had many applications both in number theory and in theoretical physics, particularly string theory.

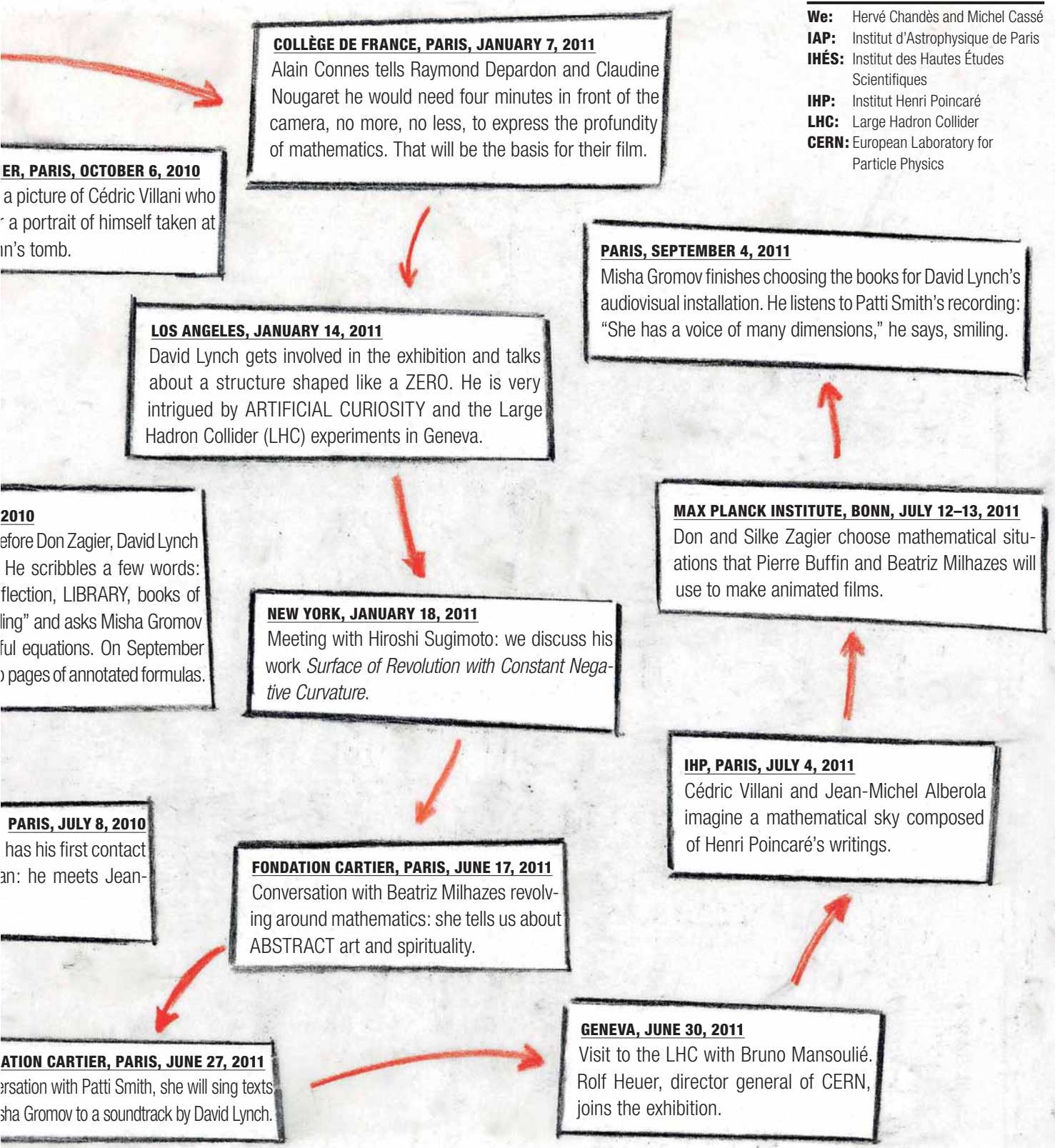
PATHWAYS

For two years, under the guiding light of the mathematician Jean-Pierre Bourguignon, director of the Institut des Hautes Études Scientifiques, and with the assistance of the astrophysicist Michel Cassé, we met with mathematicians of all kinds and from many different horizons. Later on, we were joined by the artists, the Fondation Cartier's "friends of the past." They all worked together to design this exhibition which presents mathematics, on the one hand, as something to be seen, listened to, played with and meditated on, and mathematicians, on the other, who expose the interiority of their art. The drawing on the following pages shows some of the key moments and productive pathways that shaped its creation.

Hervé Chandès

Excerpt from the introduction of the exhibition catalog. Drawing by Jean-Michel Alberola.





We: Hervé Chandès and Michel Cassé
IAP: Institut d'Astrophysique de Paris
IHÉS: Institut des Hautes Études
 Scientifiques
IHP: Institut Henri Poincaré
LHC: Large Hadron Collider
CERN: European Laboratory for
 Particle Physics

Excerpts from the catalog

Questions for mathematicians

Is a proof eternal? Is a theorem eternal?

Sir Michael Atiyah: “No, proofs can be modified, improved, generalized, absorbed into the literature. Theorems have a better claim but proofs are technical and techniques alter.”

Don Zagier: “My brain tells me that neither is eternal: even the universe is not eternal, let alone anything related to human endeavor. But my heart answers “yes” to both questions: proofs may be modified or refined in the course of time as the depth of mathematical understanding and the standards of rigor evolve, but a correct theorem and a correct proof will outlast their author, the human race, and even the physical universe. It is mankind who discovered that all prime numbers of the form $4n + 1$ can be written uniquely as the sum of two square numbers, but this statement is true independent of all human or even material underpinnings and will surely be true even after the universe in which we observed it has ceased to exist.”

Can you remember a mathematical dream?

Nicole El Karoui: “What I remember even better was how uneasy the zero made me feel when I was a little girl. It was a symbol that seemed to be a sign of some kind of major transgression, especially for a girl: to articulate the void, give it substance, even God hadn’t done that. At the same time, that circle, which was empty on the inside, that hoop seemed to me to be the entrance to a mysterious, very alluring world, the promise of a swirling, unlimited way of thinking... Alice in Wonderland...”

Cédric Villani: “I often have mathematical dreams, but the mathematics in them are absurd and mixed up with everything else.

– A husband whose wife is unfaithful is afraid of losing control of the Fokker-Planck equation.

– A mathematician dancing in a rabbit costume.

– An air raid in the form of an interpolation.

– Divergent sums and the recurrence of random walks come and ‘mess up’ an adventure on an ocean liner.”

When you shut your eyes do you see something mathematical?

Misha Gromov: “I do not have to shut my eyes for this, but what I see is not visual.”

Nicole El Karoui: “When I shut my eyes, the mathematics I am working on are very

present: in the form of equations, if that’s my focus, but more often in the form of statements or sentences that are mute, but extremely resonant. Quite often, ideas gush forth or spin around, go off on a tangent and come to a dead end, or break open to give rise to the unexpected—which often turns out to be wrong when you open your eyes. But what an intense moment...”

Misha Gromov distinguishes four mysteries in the world: the nature of physical laws, the mystery of life, the function of the brain, and the mystery of mathematical structure related to the first three. Do you see as many, less, or more?

Alain Connes: “Many questions can be formulated. One of the most striking developments today is the progressive but very real emergence of a ‘super-intelligence’ which is linked in terms of experimentation in physics, for example, to the LHC experiments at CERN, or in terms of global memory to Google. In assisting mathematicians, the power of computers is undeniable. Fortunately, one realm that continues to be inaccessible for the moment is that of intuition, of analogy in which the human brain is still very far ahead, and which we should cherish and preserve at all costs.”

Jean-Pierre Bourguignon: “The very beautiful text by Misha Gromov you are referring to follows, in a way, the evolutionary timeline of the universe, except for the fourth mystery, which has to do with the question of structure and is thus relevant at each level. It is, however, in the right place on the timeline if we see it as meaning the identification and use of these structures by human beings. If we accept that interpretation, which I do, it’s hard to suggest any other ways of delineating the mysteries of the world. However, we also need to see this as a convention because each of the three first ‘mysteries’ is contained in the fourth.”

Questions for artists

Why did you decide to become involved in this exhibition?

Patti Smith: “I have always found mathematical models beautiful. I have always loved the perfection of geometry, although my relationship is an aesthetic one. The diagrams produced by Piero della Francesca, to illustrate his studies of Archimedes are exquisite. This exhibition celebrates such inherent beauty, and reminds us why E. T. Bell called mathematics ‘the queen of science.’ It also offers everyone a humanistic and accessible entrance into this wonderful realm.”

Beatriz Milhazes: “When Hervé Chandès

explained to me the project I immediately found it a very unusual, intelligent, and quite unique idea.

Math has been connected to art works for ever, as artists have used it as a reference and an element to help them develop their artistic research.

I’m very interested in geometry, which is a math subject. However what I think that the key answer or question for this project is that from an artistic point to discover how math is everywhere in the world, how math is part of our lives!”

Hiroshi Sugimoto: “I think art and mathematics and even religion all serve the same purpose, to explain things we do not understand. The pairing of art and mathematics made perfect sense for an exhibition.”

For Misha Gromov, scientific feeling is “Round us, near us, in depth and height, soft as darkness and keen as light” (Algernon Charles Swinburne, Loch Torridon). What does this thought inspire in you?

Raymond Depardon and Claudine Nougaret: “How immense the thinking of scientists is and how small we are in relation to it.”

Patti Smith: “I think these lines of Swinburne intimate that we are not alone. That something both measurable and immeasurable surrounds us. However that translates to one it is comforting, both in its infinite expanse and containment.”

Takeshi Kitano: “I agree with Mr. Gromov. In particular, science is great, as it can be all around us, including you and me, without us noticing it.”

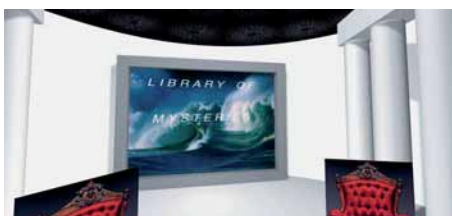
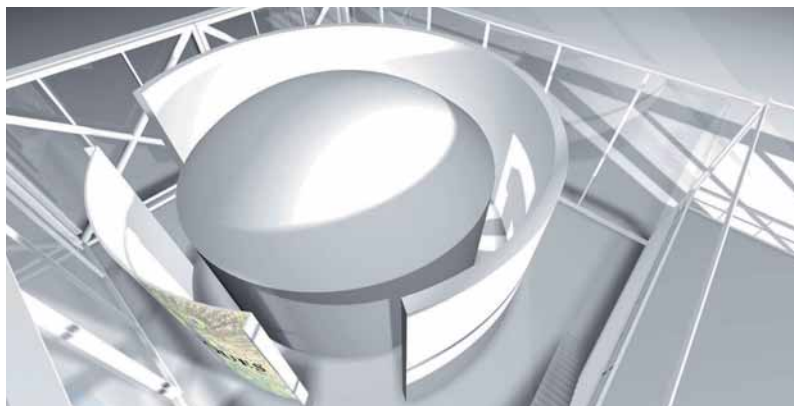
Misha Gromov distinguishes four mysteries in the world: the nature of physical laws, the mystery of life, the function of the brain, and the mystery of mathematical structure related to the first three. What would be the fifth mystery for you?

Jean-Michel Alberola: “The fifth mystery is thus the mystery that cannot be named, the mystery that embraces the other four, that is to say, the stuff of the waking dreams of magicians, storytellers, shamans, sorcerers, healers, saints, artists, ghosts, and the dead that roam around the Earth... spirits of the forest, rocks, rivers, animals and stars. All of this warm density that continues to keep us, even today, from getting lost.”

David Lynch: “What it is like living in ‘Totality.’”

Takeshi Kitano: “The fifth mystery would be your comprehension of my ability—that I would be able to answer your question!”

Misha Gromov's Library of Mysteries
David Lynch



David Lynch
 Scenography project for the exhibition
Mathematics, A Beautiful Elsewhere,
 2011
 Concept design: David Lynch
 Animation: John Chalfant
 See also pp. 8–9

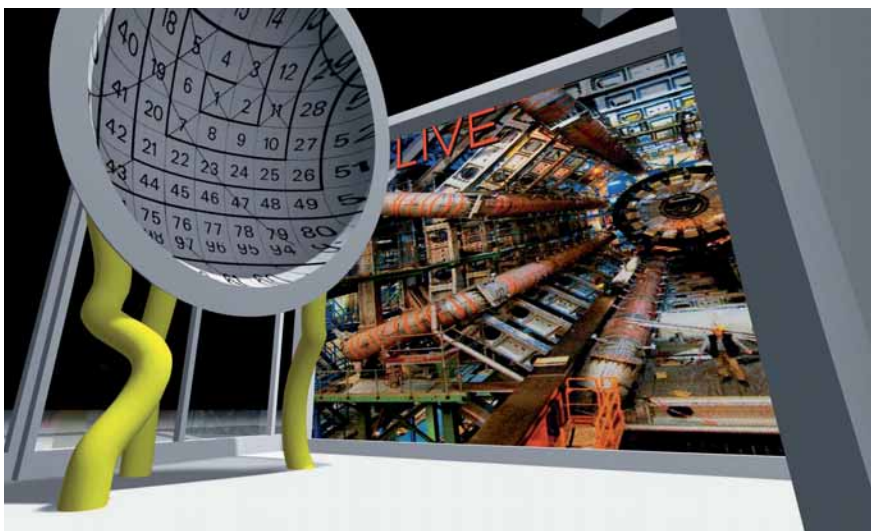
Pages suivantes:
David Lynch
Galaxy, 2011
 Animated film created for the exhibi-
 tion *Mathematics, A Beautiful*
Elsewhere, 3
 Concept and animation: David Lynch



MISHA GROMOV LIBRARY OF MYSTERIES DAVID LYNCH



The Room of the Four Mysteries
David Lynch



David Lynch
 Scenography project for the exhibi-
 tion *Mathematics, A Beautiful*
Elsewhere, 2011
 Concept design: David Lynch
 Animation: John Chalfant
 See also pp. 130–131

THE ROOM OF THE FOUR MYSTERIES DAVID LYNCH

EXHIBITION CATALOG

$R_p - \frac{1}{2} \varepsilon_p R = \frac{8\pi G}{c^3} T_p$

Sir Michael Atiyah
Tadanori Yokoo

Hiroshi Sugimoto

MATHÉMATIQUES

Un dépaysement soudain

Jean-Pierre Bourguignon
Beatriz Milhazes

David Lynch
Misha Gromov

Alain Connes
Takeshi Kitano

Patti Smith
Cédric Villani

Nicole El Karoui

Bruce Albert

Ergo-Robots (INRIA-LABRI)
Michel Cassé

Raymond Depardon et Claudine Nougaret
Davi Kopenawa Yanomami

Don Zagier

Satellite Planck (ESA) + Grand Collisionneur de hadrons (LHC)

Jean-Michel Alberola

$\lim_{n \rightarrow \infty} \Pr\left(\frac{S_n}{\sqrt{n}} \leq z\right) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^z e^{-\frac{t^2}{2}} dt$

Fondation Cartier pour l'art contemporain

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LES MATHÉMATIQUES, UN FANTASME DE LA PERCEPTION ?

Entretien entre Hiroshi Sugimoto et Jean-Pierre Bourguignon

LES MATHÉMATIQUES Les mathématiques ont-elles un lien avec la perception ?

LES MATHÉMATIQUES Les mathématiques ont un lien avec la perception, mais pas de la manière dont on le croit. Elles sont une langue, un langage, un moyen de communiquer. Elles sont une manière de penser, une manière de voir le monde. Elles sont une manière de résoudre des problèmes, une manière de trouver des solutions. Elles sont une manière de créer, une manière d'imaginer. Elles sont une manière de vivre, une manière d'être.

Cédric Villani

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MATHÉMATIQUE EN VIE

Michel Cassé

LES MATHÉMATIQUES, UN FANTASME DE LA PERCEPTION ?

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O Paraiso Beatriz Milhazes

LES MATHÉMATIQUES, UN FANTASME DE LA PERCEPTION ?

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Le cerveau

LES MATHÉMATIQUES, UN FANTASME DE LA PERCEPTION ?

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Les plumes du paon

LES MATHÉMATIQUES, UN FANTASME DE LA PERCEPTION ?

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Patti Smith: “And the fifth mystery is poetry.”

Hiroshi Sugimoto: “The mystery of time.”

Tadanori Yokoo: “Fate and destiny.”

Beatriz Milhazes: “Love and Passion!”

Raymond Depardon and Claudine Nougaret: “For us, the fifth mystery is the incredible sense of joy that mathematicians exude.”

The Mathematician and the Shaman, With Closed Eyes

What thrills mathematicians, or what can actually send them into a trance, is not images or combinations of syllables, but rather, relationships between mathematical objects, unexpected symmetries, unseen connections. Relationships that are so beautiful that you are immediately convinced of their reality, struck by how blindingly obvious they are.

What is beautiful for a mathematician? Or for a scientist?

Lord Kelvin spoke with a sense of wonder about Fourier’s “great mathematical poem.” A poem of concepts in which all kinds of signals are represented geometrically, in which even fire is governed by equations, in which a universe that is so unfathomably complex can be summed up in a few well-chosen equations. Concision, power, the ability to explain are all part of mathematical beauty.

Partial differential equations are powerful because they sum up a continuous and frightfully complex world in one compact entity, and they are found in every aspect of the world. Partial differential equations, from the very first day of the world until the end of the world...

But in order to appreciate Fourier’s great poem, in order to understand each and every detail, you have to practice it, train mercilessly, as Bruce Albert so rightly guessed. A poet doesn’t necessarily seek to understand every aspect of his work, or of the work of other poets, but a mathematician seeks to understand every little detail, which doesn’t lessen the sense of beauty he feels about it.

Clarity is a quality that is indispensable to mathematical aesthetics. And so we are wary of words, which often tend to obscure things, and which are so powerful! Von Neumann understood the tyranny of words very well. When Shannon explained his concept of information to him, he suggested the word “entropy,” a word that was sure to impress, an improbable word to measure improbability, a magical word that would evoke wonder, a cruel word that would confound adversaries. The world is so frightening! I’m often asked if I’m looking for the ultimate equa-

tion. My answer is that there isn’t one. The universe will continue to be incomprehensible, forever. We will only understand little bits of it, and never fully apprehend it. It’s no longer an elephant explored by blind men, but a baobab explored by termites (blind, of course, as they should be). And it’s the ultimate poem. The mathematician reads it through the prism of mathematics and builds up a picture of it, incorporates the world into mathematics and mathematics into the world. But in order to be able to tell others about this world, stories have to be made out of it.

In order to capture people’s attention, the stories have to be astonishing and harmonious, tender and cruel.

The storyteller is definitely an important and universal figure. A storyteller can be scientific or shamanic, it’s a question of communion. “We owe it to each other to tell stories,” said the great storyteller Neil Gaiman.

However, we should be careful about using the image of the “exceptional being,” to use Bruce Albert’s expression; it gives the impression of someone who is placed above the crowd and above the world. I see myself, on the contrary, as being in the middle of the world—catalyst, synthesizer, a relay antenna rather than a transmitter.

And always behind mathematics, which is much greater and more amazing than the brain that deciphers it.

Cédric Villani

Excerpt from the conversation between Cédric Villani, Davi Kopenawa, Bruce Albert, and Michel Cassé

Publications

Mathematics: A Beautiful Elsewhere

A combination of written texts, questionnaires and portraits, the catalog *Mathematics: A Beautiful Elsewhere* illustrates the diversity of mathematical thought as expressed by the scientists as well as the artists, and emphasizes the importance of creativity in this field.

Published by Fondation Cartier pour l’art contemporain, Paris

Available in French and English

Hardcover, 224 pages, 22x28 cm

100 color and black-and-white reproductions

Special edition CD included: Patti Smith, David Lynch, Misha Gromov

Price: \$55.00/£35.00

Coloring Book

The Fondation Cartier has asked Beatriz Milhazes to create a mathematical coloring book. After three similar books designed by Beat Takeshi Kitano, Mœbius and Patrick Vilaire, this is the fourth in a series of coloring books published by the Fondation Cartier.

Coloring book #4

Published by Fondation Cartier pour l’art contemporain, Paris

24 pages, 24x34 cm

All of the Fondation Cartier’s publications and books can be found and ordered online on:

fondation.cartier.com/publications

Accompanying the exhibition

The Nights of Uncertainty

A series of special events, the Nights of Uncertainty, provides opportunities to meet the exhibition's scientists in an informal, intimate setting. Through the participation of Don Zagier, Jean-Pierre Bourguignon, Misha Gromov, Cédric Villani, Pierre Pansu and others, the Fondation Cartier seeks to promote further discussion of the issues raised in this project by exploring subjects dear to the mathematicians themselves.

Program information available at: fondation.cartier.com

Mathematics for Everyone? Symposium-UNESCO

On January 30-31, 2012 the French National Commission for UNESCO will be organizing, in association with the Fondation Cartier and IHÉS, a symposium on the role of mathematics in our everyday environment, exploring issues such as teaching, finance, and the life sciences. The departure point for this symposium will be the exhibition as a possible experiment in helping to spread interest in the discipline.

More information on fondation.cartier.com

iPad Application

The Fondation Cartier and Frédéric Kaplan have developed an iPad application designed to complement the exhibition *Mathematics: A Beautiful Elsewhere*. It features the contributions of the exhibition's scientists, as well as those of its artists, and includes videos, images and texts from their past exhibits at the Fondation Cartier. Taking Alexandre Grothendieck's expression "a sudden change of scenery" to heart, the application encourages everyone to forge their own path—guided by an artificial curiosity algorithm—through the events, the places, the people, the exchanges, the ideas that contributed to the creation of this exhibition.

Concept, design and programming: Frédéric Kaplan and Laurent Bolli/OZWE



Available early November 2011.

Fondation Cartier › iTunesU

As one of the pioneering cultural institutions on iTunes U—Apple's free university podcast platform—the Fondation Cartier pursues this undertaking with the exhibition *Mathematics: A Beautiful Elsewhere*: a special page devoted to the exhibition provides opportunities to access the conferences, classes and educational materials of several prestigious scientific institutions. The Institut des Hautes Études Scientifiques (IHÉS), Université Pierre et Marie Curie (UPMC, Paris VI), the Institut Henri Poincaré (IHP), the Collège de France and UNESCO share their mathematics-related resources, organized by level of skill and complexity, in order to continue the effort to foster a greater understanding of mathematics.

fondation.cartier.com/itunes

Join us on:



Activities for children

In conjunction with the exhibition *Mathematics: A Beautiful Elsewhere*, the Fondation Cartier pour l'art contemporain invites children to its original workshops and family visits Wednesdays and Saturdays at 3 p.m.

Family Visits

Saturdays November 5, 12, 19 and 26; December 3, 10 and 17; January 7, 14, 21 and 28; February 4, 11, 18 and 25 at 3 p.m.; age 7 and older, 1½ hours.

Children and parents participate in a fun-filled guided visit of the exhibition.

Mathematics: Child-size

Mathematical games hosted by Giancarlo Lucchini, research mathematician. Wednesday, February 1 at 3 p.m.; age 7 and older, 1½ hours. A mathematician invites children to discuss the logic of mathematical games and puzzles, while having a lot of fun solving them!

Weird Mental Space

Model workshop with Margaret Iragui, interior architect and teacher at the Camondo School. Wednesdays December 7 and January 11 at 3 p.m.; age 8 and older, 2 hours.

With a set designed by David Lynch expressly for this exhibition, the visitor is invited to delve into mathematic reverie. Children plot points, lines, planes and volumes to construct an amazing model of a mathematician's brain.

A Garden. Big, yet so small

Landscape workshop with Marion Dutoit, landscape artist. Wednesdays November 16 and February 15 at 3 p.m.; age 7 and older, 2 hours. After a walk following the geometry of the Fondation Cartier gardens, children will create an organic model using the plants they've harvested.

The Four Mysteries of the World

Children are invited to a series of workshops about the four mysteries of the world as proposed by the mathematician Misha Gromov. **Physics, life, the brain and mathematics.**

Cosmic Suspension (Physics)

Mobile workshop with Florence Kormann, set designer. Wednesdays November 23, December 21 and January 18 at 3 p.m.; age 7 and older, 1½ hours.

Children create colorful mobiles of imaginary constellations.

Geometric Fur (Life)

Collage workshop with Clémence Passot, graphic designer. Wednesdays December 28, January 25 and February 22 at 3 p.m.; age 7 and older, 1½ hours.

Children create a frieze of the growth of a feline following the mathematical evolution of its spots.

Strange Robots (The Brain)

Robotic workshop with the Flowers team from INRIA, digital gardeners. Wednesdays November 30, January 4 and February 8 at 3 p.m.; age 8 and older, 2 hours.

Children converse and interact with two researchers and their fascinating robots and then make their own little photosensitive creature.

Penrose Tilings (Mathematics)

Graphics workshop with Clémence Passot, graphic artist. Wednesdays December 14 and February 29 at 3 p.m.; age 7 and older, 2 hours.

From simple geometric shapes, children make their own set of tiling to create and assemble an infinity of amazing, colored designs.

Practical information

Information and required registration (available one month prior to date of workshop) every day except Monday, from 11 a.m. to 7 p.m.

Visitors Department:

Tel. +33 (0)1 42 18 56 67

info.reservation@fondation.cartier.com

fondation.cartier.com/children

Admission: 9 €

Nomadic Nights

In conjunction with the exhibition *Mathematics: A Beautiful Elsewhere*, Nomadic Nights presents an outstanding programme of performances and concerts.

Monday, November 14, 8.30 p.m.

Patrick Corillon, *The benshi from Angers*
Performance (60 min.)

Patrick Corillon borrows the technique of the *benshi*, Japanese storytellers who used to interpret films in the era of silent cinema: he projects and interprets the pages of a book designed by himself, telling a personal story interspersed with family memories and legends of long ago.

Monday, November 21, 8.30 p.m.

Scanner, *Toute la mémoire du monde & Le Chant du styrène* by Alain Resnais
Film-concert (45 min.)

Scanner, a British musician and sound artist, recreates the musical world of two remarkable documentaries that Alain Resnais was commissioned to make in the 1950s. He has composed mesmerising electronic soundtracks to accompany these quasi-surrealistic films.

Monday, November 28, 8.30 p.m.

Cristian Chironi, *Cutter*
Performance (45 min.)

For this performance Italian artist Cristian Chironi takes old picture books and cuts them up, selecting images of natural objects threatened with extinction. He gathers together these images of animals, plants, glaciers, and ocean depths, then recombines them to create baffling new landscapes.

+

Ali Moini, *My Paradoxical Knives*
Performance (25 min.)

Ali Moini recreates the sacred dances of the Dervishes, adding a sense of danger: a man revolves on one spot, knives circling around him as he chants Sufi poems, begging the heavens not to keep turning without him.

Monday, December 5, 8.30 p.m.

Trajal Harrell and Perle Palombe, *The Conspiracy of Performance*
Reading (30 min.)

Performers Trajal Harrell and Perle Palombe use this project, created in New York in September 2011, to initiate a discussion on the state of performance today.

+

Laurent Goldring, *Terre Battue*
Video (18 min.)

With *Terre Battue*, a series of close-up shots of the ball boys filmed during the Roland-Garros tennis tournament, video-maker Laurent Goldring continues his explorations of bodily representation, focusing here on the relation between physical discipline and the discipline of the gaze.

Monday, December 12, 8.30 p.m.

The Third Eye Foundation
Concert

Ten years after *Little Lost Soul*, Matt Elliott returns to pursue the work of his Third Eye Foundation with a brilliant, spectral new album, *The Dark*. For this concert at the Fondation Cartier he is accompanied by Chris Cole (Manyfingers), Chris Adams (Bracken), and Louis Warynski (Chapelier fou).

Monday, January 9, 8.30 p.m.

Jonathan Burrows and Matteo Fargion, *Cheap Lecture & The Cow Piece*
Performance in English (60 min.)

Cheap Lecture is an adaptation by choreographer Jonathan Burrows and composer Matteo Fargion of John Cage's *Lecture on Nothing*, turning it into a comical, upbeat performance executed with great aplomb. The second of their two performances is an anarchic, entertaining meditation on dance, music, and death.

Tuesdays, January 24 and 31, February, 7 and 14, 7-10 p.m.

Fanny de Chaillé, *Living Library*

For *Mathematics: A Beautiful Elsewhere*, Fanny de Chaillé has created a version of her "living library" project. Visitors may borrow books, as in a normal library, except that in this case the books are human beings. These "living books" each take twenty minutes to tell the reader a story from their own lives on a topic related to mathematics.

Practical information

Information and reservations (essential), Tuesday-Sunday 11 a.m.-8 p.m.

Tel. +33 (0)1 42 18 56 72

Admission: 9.50 €

Reduced rate: 6.50 € (Students, under 25, "carte Senior" holders, unemployed, ICOM members, "Maison des Artistes.")

fondation.cartier.com/nomadicnights

L'Atelier Intérieur

Poetry, theater, performances, readings... Dedicated to the contemporary arts, the radio program *L'Atelier Intérieur* hosted by Aurélie Charon and produced by Thomas Dutter is broadcast live every Monday night from 11 p.m. to midnight on France Culture. Once a month, one of the Nomadic Nights artists joins *L'Atelier Intérieur* for a specially created artistic happening right in the studio.

The program is podcast and can be listened to on franceculture.fr



Practical information

The exhibition is open to the public every day except Monday from 11 a.m. to 8 p.m. Open Tuesday evenings until 10 p.m.

Admission: 9.50 €

Reduced rate: 6.50 € (students, under 25, "carte Senior" holders, unemployed, "Amis des Musées")

Free admission ("Laissez-passers" holders, children under 10, and ICOM members)

Free for visitors under 18 on Wednesdays from 2 p.m. to 6 p.m.

Ticket sales: Fnac stores, fnac.com

Group Visits

Guided tours: Tuesday to Friday, from 11 a.m. to 6 p.m. (min. 10 people).

Adults: 10 € per person

Students and "Carte Senior" holders: 5 € per person (free admission for group leaders)

Self-guided tours: Tuesday to Sunday, from 11 a.m. to 6 p.m. (min. 10 people).

Adults: 8 € per person

Students and "Carte Senior" holders: 4 € per person (free admission for group leaders)

Advance booking required

Visitor Services:

Tel. + 33 (0)1 42 18 56 67

info.reservation@fondation.cartier.com

The Laissez-passers pass

The Laissez-passers provides free and unlimited priority access to the Fondation Cartier, free admission for a guest accompanying the cardholder on Wednesdays, guided visits to the exhibitions, invitations to Nomadic Nights events, reduced prices for special events (limited number available, reservation only), a 5% discount at the bookstore, as well as privileges at many other cultural institutions in Paris (museums, theaters, etc.).

Annual membership: 30 €

Discount ("carte Senior" and "carte famille nombreuse" holders): 25 €

Youth rate (under 25): 18 €

Contact: Visitor Services

Tel. +33 (0)1 42 18 56 67

info.laissezpasser@fondation.cartier.com

Access

261, boulevard Raspail F-75014 Paris

Tél. +33 (0)1 42 18 56 50

Fax +33 (0)1 42 18 56 52

Metro Raspail or Denfert-Rochereau

(lines 4 & 6) / Bus 38, 68, 88, 91

RER Denfert-Rochereau (line B)

Vélib' 2, rue Victor Schoelcher

Disabled parking at 2, rue Victor Schoelcher

Exhibition

Chief Curators

Hervé Chandès, Jean-Pierre Bourguignon and Michel Cassé

Curators

Thomas Delamarre and Giancarlo Lucchini

Production

Camille Chenet
assisted by Daphné Panacakis

Installation Coordinator

Christophe Morizot
assisted by Frédéric Ray

Audiovisual Design

Gérard Chiron
assisted by Cyril Chiron

Lighting

Nicolas Tauveron

Registrar

Corinne Bocquet and Alanna Minta Jordan
assisted by Yves Bauray

Installation

Gilles Gioan



UNESCO

The French Commission for UNESCO is comprised of 60 prominent representatives from France's scientific and intellectual communities, as well as participating government ministries. Its mission is to monitor and identify exemplary actions by promoting the development of partnerships with national and international institutions and civil society in order to enable France and UNESCO to benefit from the expertise of its members, to enlighten public policy in the areas of education, science, culture and communication, and thus to help strengthen the influence of France on the work of this institution.

Chaired by Jean Audouze, the French Commission for UNESCO is organizing a symposium entitled "Mathematics for Everyone?" at UNESCO on January 30-31, 2012 as part of the exhibition. unesco.fr

The exhibition *Mathematics: A Beautiful Elsewhere* was realized with the participation of the Institut Henri Poincaré (IHP), the Institut d'Astrophysique de Paris (IAP), the European Laboratory for Particle Physics (CERN), the Institut National de Recherche en Informatique et en Automatique (INRIA) and the European Space Agency (ESA).



IAP

The Institut d'Astrophysique de Paris is a laboratory specifically dedicated to theoretical studies of the universe and its components. Such studies require researchers to use complex mathematical methods that are the only medium for describing things that are beyond our standard models. In order to further develop this connection between astrophysics, physics and mathematics, several laboratories at UPMC and CNRS have teamed up with IAP to create the Institut Lagrange de Paris. This exhibition directly interests IAP in that it shows another side of mathematics. iap.fr



IHP

Since 1928, the Institut Henri Poincaré (IHP) has been involved in all of the disciplinary fields in which mathematics plays an essential vital role. Einstein came to teach general relativity here, Volterra introduced France to mathematical biology here; this is also where the first French computer project was initiated.

Cédric Villani (Université de Lyon), succeeded by Jorge Kurchan (ESPCI), has headed this institute for national and international scientific exchanges since 2009, with the support of CNRS and UPMC.

The collaboration between IHP and the Fondation Cartier corresponds to society's increasing demand for greater contact with scientists. At the same time, it belongs to an old tradition of interaction between mathematics and the arts, which is attested to by the photographs at IHP that were taken eighty years ago by Man Ray. ihp.fr

Institutions

The exhibition *Mathematics: A Beautiful Elsewhere* was developed in association with the Institut des Hautes Études Scientifiques (IHÉS) and is presented under the patronage of UNESCO, with the support of the French National Commission for UNESCO.



IHÉS

The Institut des Hautes Études Scientifiques (IHÉS) is an international center for fundamental research in mathematics and theoretical physics, at the interface between biology and mathematics. Founded in 1958, it soon became one of the top-ranking institutions worldwide and has been recognized many times, with one Abel Prize and seven Fields Medal winners on its roster. Located in Bures-sur-Yvette (91), IHÉS is a private foundation that has been recognized as a public-interest facility since 1981. It hosts 250 researchers each year. ihes.fr



CERN

Science underpins just about every aspect of modern life, and mathematics underpins science. That's why the world's leading laboratory for basic research in particle physics, CERN, is participating in the Cartier Foundation's exhibition, *Mathematics, A Beautiful Elsewhere*. In a science-based age, it is vital for science to engage with culture in the broadest sense. cern.ch



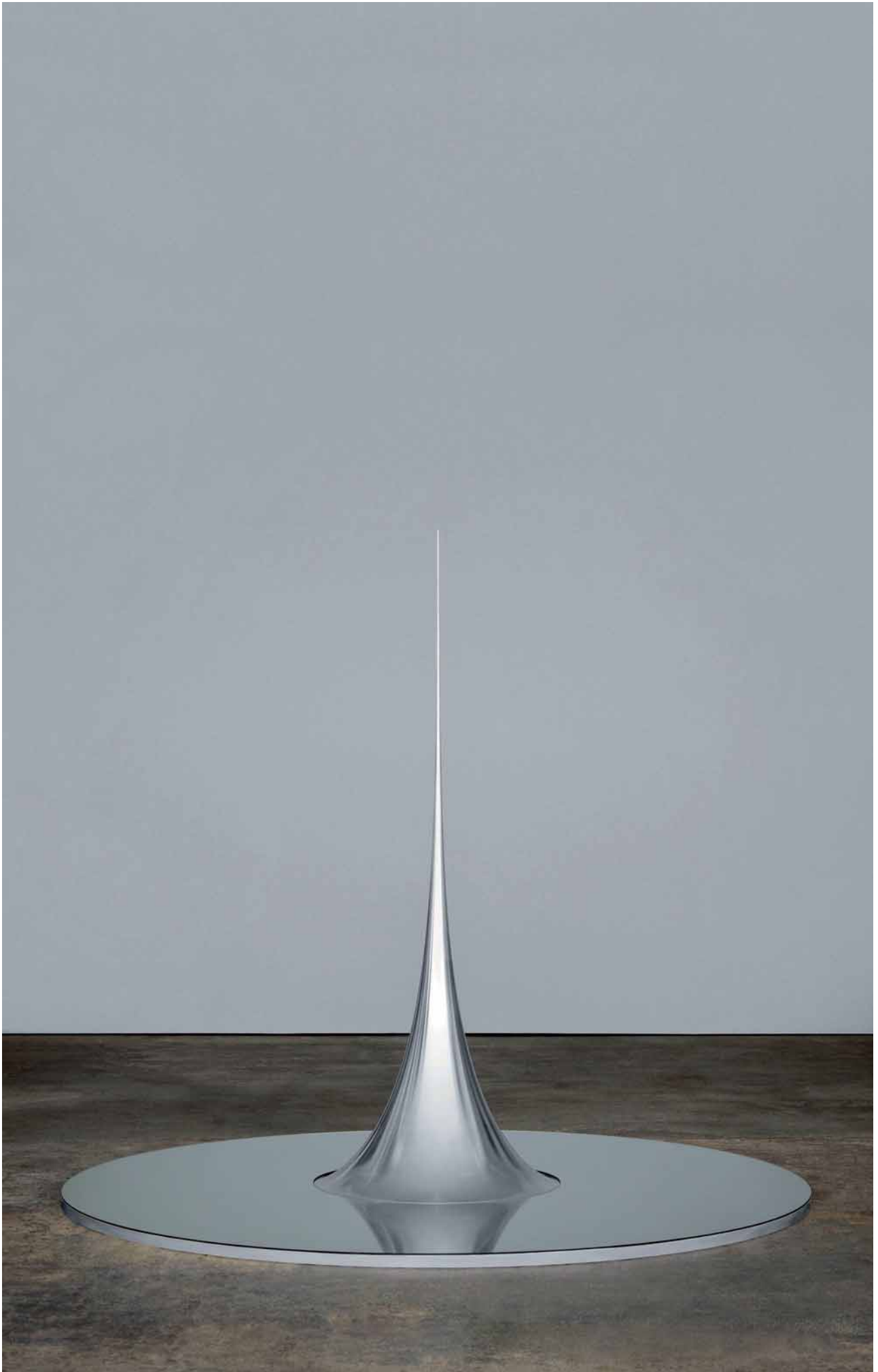
ESA

The European Space Agency (ESA), established in 1975, is an intergovernmental organization whose mission is to oversee the development of a European space capability. ESA is able to undertake wide-ranging programs by pooling the resources and capabilities of its 18 Member States. Today, thanks to ESA, Europe has its own launchers and it launches satellites for astronomical purposes, Earth observation,



INRIA

Our society is becoming increasingly reliant on digital technologies for communication, healthcare, travel or even for entertainment. Working on the interface between computer science and mathematics, involved in fundamental research, technological development or industrial technology transfer, researchers at INRIA, a public research institute, are inventing the digital technologies of the future. inria.fr



Media Partners



France Inter

France Inter promotes culture all year long through its radio programming, featuring a combination of cultural excellence and informative programs. The mysteries of science are explored in shows such as “La tête au carré,” “Sur les épaules de Darwin” and “Les Savanturiers.” France Inter is partnering with the Fondation Cartier in order to give these mental realms greater visibility and help certain listeners make peace with their nemesis. A fascinating journey into the mathematical world in order to see and listen to math in a different way. franceinter.com



Télérama

Télérama is delighted to be associated with the exhibitions at the Fondation Cartier, a preeminent Parisian venue for the contemporary arts. For a magazine whose aim is to make all of the different cultures, and thus the creators of culture, accessible to everyone, the visual arts are an imperative. Olivier Céna has devoted his column to the visual arts for many years, while design and architecture are approached as part of the three pages dedicated to “Arts et Formes.” telerama.fr

Le Monde

Le Monde

Le Monde is delighted to be a partner in the exhibition *Mathematics, A Beautiful Elsewhere* at the Fondation Cartier. This event, on the borderline between art and science, resonates well with the multifaceted approach that is a feature of *Le Monde Week-end* in its new sections “Sciences & Techno” and “Culture & Idées.” lemonde.fr



Sciences et Avenir

Science and technology are transforming our societies at an unprecedented rate, revolutionizing the present and opening up new vistas for the future. With a loyal following of 2.5 million readers, *Sciences et Avenir*, founded in 1947, deciphers these astounding advances in every domain, from mathematics to fundamental biology, from ecology to cosmology... For involved citizens who want to understand what's going on. sciencesetavenir.fr



euronews

The channel is proud to partner with the Fondation Cartier and confirms its commitment to all cultures. euronews produces weekly magazines dedicated to art, cinema, science and education.

euronews, the No. 1 international news channel in Europe*, covers current events around the clock, everywhere in the world. With 11 language editions**, euronews is a unique organisation in its approach to analysing and presenting the news.

euronews.net

*source: euronews/Telmar Peaktime©, evaluation based on media response meters, 2nd quarter 2010.

**Arabic, English, French, German, Italian, Persian, Portuguese, Russian, Spanish, Turkish and Ukrainian.

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p. 12-13: © Jean-Michel Alberola / Adagp, Paris, 2011

p. 21: Hiroshi Sugimoto, *Conceptual Form 011*, 2008. Surface of Revolution with Constant Negative Curvature. Aluminum, mirror, 3 × 0.7 m. © Hiroshi Sugimoto, courtesy of Gallery Koyanagi

p. 23: Excerpt from the animated film by David Lynch, *Universe Coming From Zero*. © David Lynch

p. 24: Bird Flight (Bernoulli's principle) image from the film by Beatriz Milhazes and BUF, *Mathematical paradises*, 2011. Artwork BUF

Press Information

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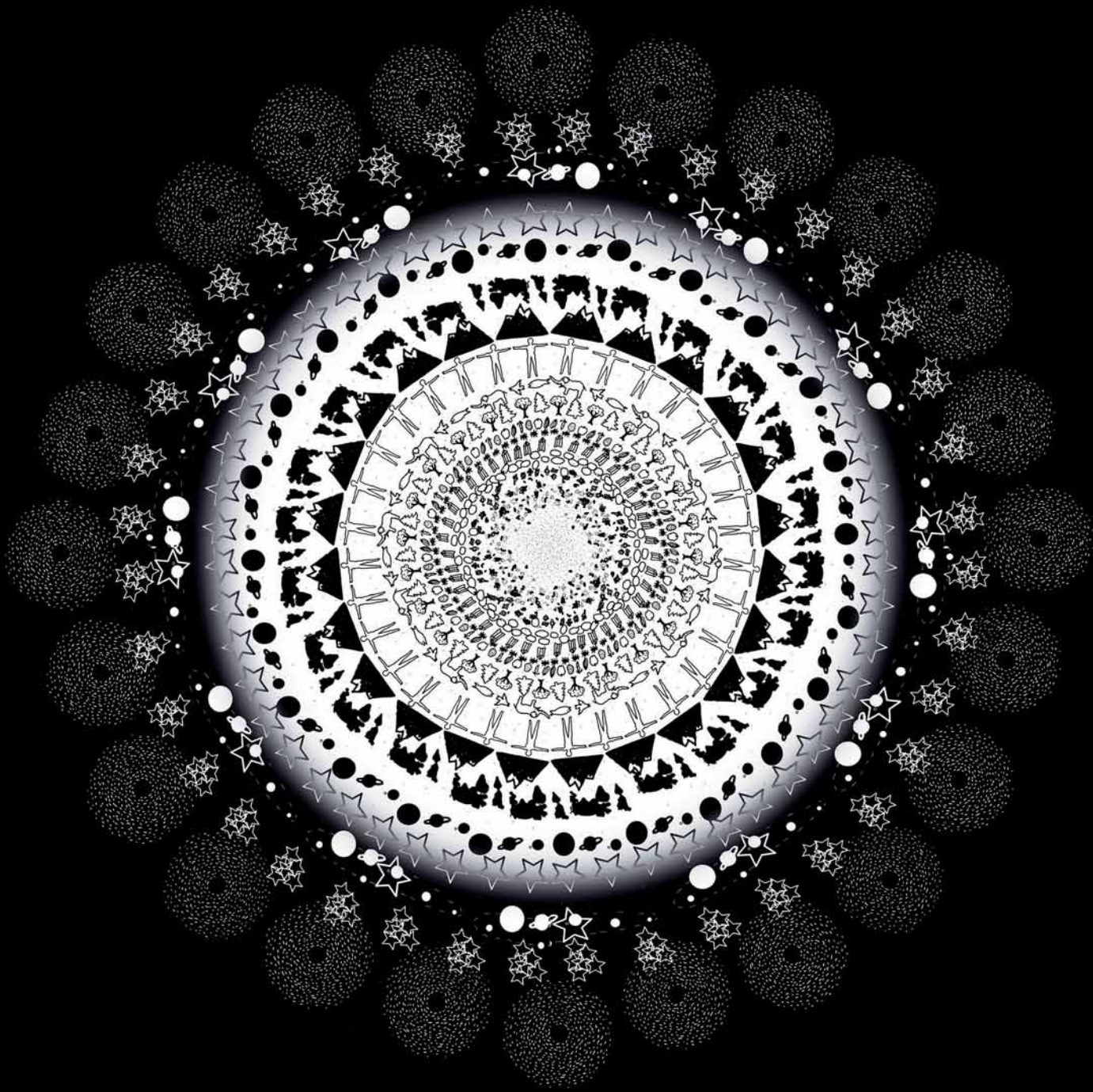
jammes@ihes.fr

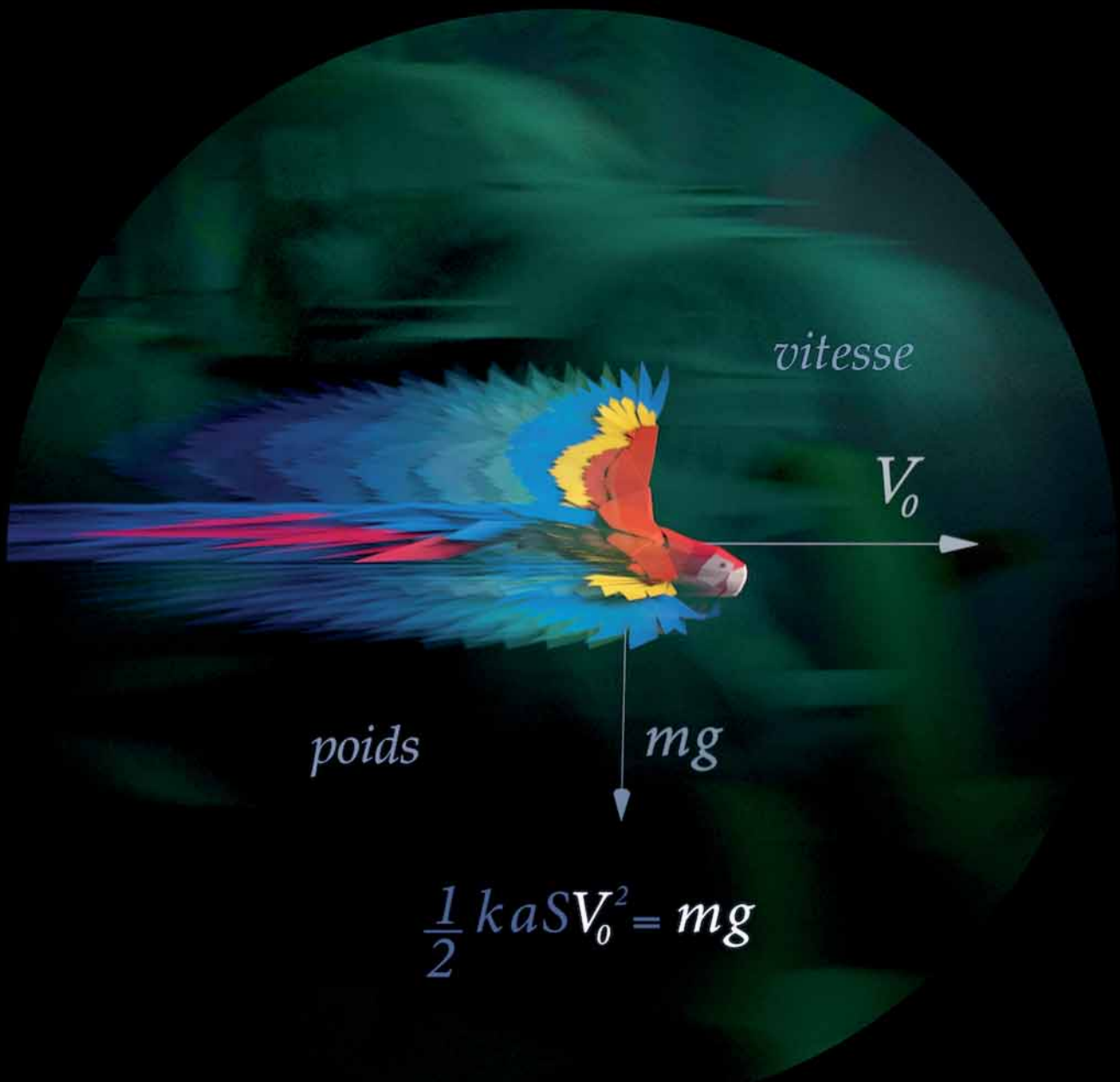
On the Internet

The Fondation Cartier has created a website specifically for media professionals. This new site gives journalists, picture editors and bloggers a comprehensive vision of all of the information relating to the Fondation Cartier's different activities and exhibitions in France as well as around the world.

Access to content (press kits and releases, visuals, archives, etc.) is simplified and the selected materials can be quickly downloaded.

Create an account online at: presse.fondation.cartier.com





vitesse

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