Matematica, Cultura e Società

SYLVIE BENZONI

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SYLVIE BENZONI

Institut Poincaré e Université Claude Bernard Lyon 1

E-mail: benzoni@math.univ-lyon1.fr

Sommario: *L'Institut Henri Poincaré ha sviluppato un museo della matematica chiamato Maison Poincaré. Questo progetto decennale è stato completato nel 2023. Forniamo un resoconto delle motivazioni principali dietro il progetto, di come si è evoluto nel tempo, e offriamo uno sguardo sul risultato finale.*

Abstract: *The Institut Henri Poincaré has developed a mathematics museum named Maison Poincaré. This decade-long project was completed in 2023. We provide an account of the primary motivations behind the project, how it evolved over time, and offer a glimpse of the final outcome.*

Introduction

A decade ago, or so, the then director of the Institut Henri Poincaré (IHP) Cédric Villani launched the project of designing and hosting a maths museum at IHP, as part of an even more ambitious expansion project to the opposite building. Hosting the 'laboratoire de chimie physique' as it is written on its pediment, that building had been inaugurated by the physicist Jean Perrin (1870-1942) in the late 1920s, just two years before the historical IHP one by his friend mathematician Émile Borel (1871-1956).

This explains why, at the inception of the project, the museum was called after both Jean Perrin, the founder of the premises, and Henri Poincaré (1854-1912) to keep the link with the name of the institute. It was eventually inaugurated in 2023 under the shorter and more welcoming name 'Maison Poincaré' ([1]).

Save for the names and logos, the covers shown on Figures 1 and 2 look a bit similar to each other. However, a lot happened in between. The main purpose here is to give a glimpse of how the project evolved and came to reality. I will start by addressing a few questions about the motivations behind the project.

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([1]) For those who might wonder about the word 'maison', it means both home and house in French, like 'casa' in Italian.
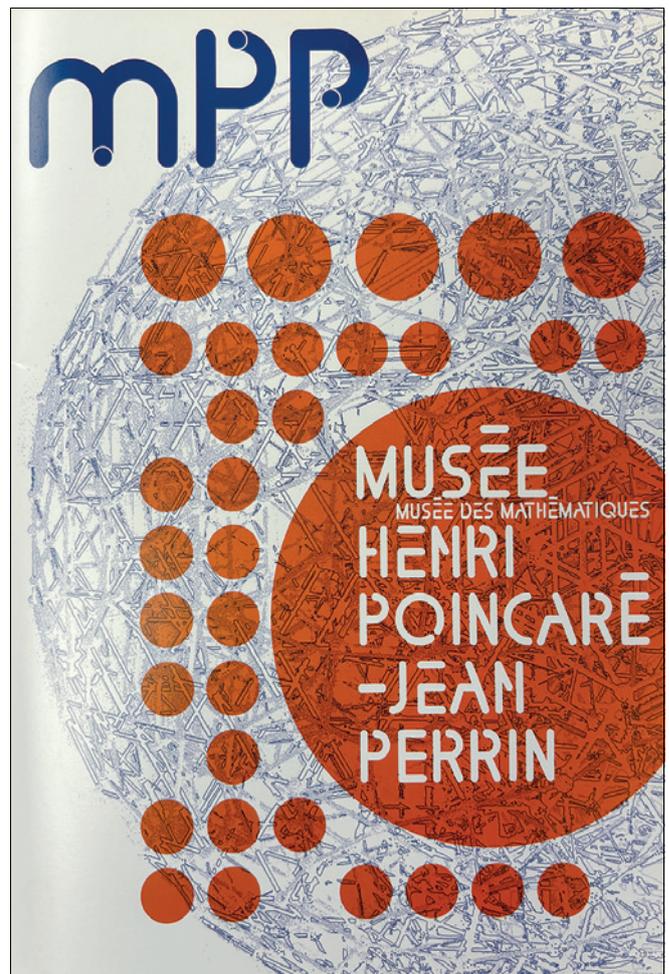

FIGURA 1 – Cover of a tentative museum project (2013). (© Institut Henri Poincaré)

FIGURA 2 – Cover of the very first catalogue of the Maison Poincaré (2023). (© Institut Henri Poincaré)

Motivations

In the first place, what is a museum?

Remarkably enough, the question is not set in stone. In March 2022, the International Council of Museums (ICOM) revised the definition as follows. "A museum is a not-for-profit, permanent institution in the service of society that researches, collects, conserves, interprets and exhibits tangible and intangible heritage. Open to the public, accessible and inclusive, museums foster diversity and sustainability. They operate and communicate ethically, professionally and with the participation of communities, offering varied experiences for education, enjoyment, reflection and knowledge sharing." (^{2}) This is quite engaging (see Figure 3).

In the beginning, the primary feature of IHP that supported the idea of starting a museum was its

(^{2}) https://icom-europe.mini.icom.museum/museum-definition-icom-europe-option/

FIGURA 3 – Word cloud for museum. (© ICOM)

substantial collection of mathematical objects. When we say substantial, it means hundreds of objects, not more, but with a true heritage value. Independently of the museum itself, they are now comprehensively showcased on the website https://patrimoine.ihp.fr/. We also refer to a collective book (Institut Henri Poincaré, 2017) and a documentary film (Lazzarotto, 2019) produced by IHP (see its poster on Figure 4).

FIGURA 4 – Poster of film Man Ray and the skakespearian equations. (© Institut Henri Poincaré)

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At the national level there exists a 'musée de France' label ([3]) that is quite restrictive. This explains why during the preliminary work about the IHP museum the stakeholders were refraining from speaking of a museum. Instead, they would call it an 'exhibition space' or, in more details in French, 'la maison des mathématiques, espace d'expositions et d'échanges'. At the end, we are happy with calling it a museum, even though its brand name 'Maison Poincaré' does not contain the word museum. As we say, the Maison Poincaré is the museum where maths comes to life ([4]).

What is the purpose of a maths museum, and who is it for?

From the outset, the stated ambition was to create a unique and exemplary space for interactions between mathematics and society, welcoming two main categories of audiences: half middle and high schoolers and teachers and, for the other part, a spontaneous audience of curious people, tourists, families, enthusiasts and amateurs. These categories could of course apply to any science centre.

Regarding maths, there is the additional challenge to attract people who are a priori reluctant, and make them change their perception of the field. Not that they would suddenly like maths if they did not prior to their visit, but at least they would become more aware about what maths actually is and willing to increase their mathematical culture. This is sometimes called "raising public awareness" ([5]) and "mathematical enculturation" ([6]). Recently, we have seen excellent books debunking maths myths, e.g. (Bessis, 2024) (Cheng, 2023), which are in the same spirit ([7]).

([3]) https://www.culture.gouv.fr/Aides-demarches/ Protections-labels-et-appellations/Appellation-Musee-de-France

([4]) "La Maison Poincaré, le musée où les maths prennent vie."

([5]) This was the former name of the EMS Mathematics Outreach and Engagement committee.

([6]) As in the title of a book by Alan J. Bishop (1937-2023): Mathematical Enculturation: a cultural perspective on Mathematics Education, Kluwer Academic Press 1989.

([7]) Bessis' book was originally published in French (Bessis, 2022), and has been translated to Italian (Bessis, 2023).

Why a maths museum at the Institut Henri Poincaré?

The Institut Henri Poincaré has been an international research centre for almost a century. It is nowadays supported by the Centre national de la recherche scientifique (CNRS) and Sorbonne Université (SU), its supervisory institutions – SU being in addition the owner of the buildings (see Figures 5 and 6), and an endowment fund. Back in 2014 they all agreed with the project, together with the City of Paris, the Île de France region and the French government. It was clear to all stakeholders that IHP should play a crucial role in bringing together researchers and the general public, including first of all the youth.

FIGURA 5 – The IHP historical – Borel – building. (© Institut Henri Poincaré)

FIGURA 6 – The IHP Perrin building. (© Institut Henri Poincaré)

Once most of the financial support was secured from those public institutions, and hoped for from the IHP endowment fund, it remained to make the roadmap more precise. This is where I stepped in, early 2018, when I got appointed director of IHP. The main, daunting task was to design a permanent exhibition that would indeed achieve the project's ambition of showcasing contemporary mathematics in all its diversity.

Evolution

The project team

Of course, I was not alone in the project management. The passing of the baton from the former director and deputy director Cédric Villani and Jean-Philippe Uzan took place in January 2018. The three of us had a very long night meeting with the museum designer, Rémi Dumas (Du&Ma), who had been chosen along with the architect (Atelier Novembre). This is when I started to work with him and Marion Liewig, who had been appointed by the CNRS as a project manager for IHP two years ago, on the permanent exhibition.

At that time, there were two key ideas. This idea of showcasing mathematical objects, which had to do with 'tangible heritage'. Plus, the idea due to Cédric Villani of a most innovative experience called Holo-Math, using mixed reality to communicate intangible concepts like the Brownian motion in an interactive manner (see Figure 7). Rémi Dumas was

FIGURA 7 – Cédric Villani featuring the Holo-Math project. (© Hololight)

enthusiast about the former, and reluctant about the latter. Nevertheless, we thought that it would be a key attraction for the youth. The Holo-Math project was eventually managed by Adrien Rossille, a science communicator whom we hired in 2019 (see (Rossille, 2021)).

Even though exciting, two ideas clearly do not make a museum. We needed to embark people with a wide range of skills, but also someone able to manage the content design by interacting with the scientific experts and the museum designer. This central figure is called a 'museographer' while the museum designer is called a 'scenographer' (at least in France). We found a museographer originally trained as a physicist and then as a heritage curator. She is called Céline Nadal (MuseoScience), and joined the project team soon enough in June 2018.

Four mathematicians were strongly involved as scientific advisors. Besides myself, these were Antoine Chambert-Loir (Université Paris Cité), Olivier Druet (CNRS), and Clotilde Fermanian Kammerer (Université Paris Est Créteil). Of course, many other researchers were consulted, and teachers and science communicators as well.

On the operational side, the IHP librarian Henri Duvillard was a key player in retrieving all the iconography and the associated rights of use. Finally, early 2022 Élodie Christophe succeeded Marion Liewig as head of the Maison Poincaré department at IHP. She managed in particular the highly successful opening of the Maison Poincaré as a museum.

On the way, the project team became more gender balanced than at the beginning. We even ended up running 100% female steering meetings, Élodie Christophe, Clotilde Fermanian Kammerer, Céline Nadal and I.

The entrance hall

A notable evolution in the content and layout concerns the entrance hall. From the outset, it was envisioned as a place where museum visitors and researchers participating in scientific programmes on the upper storeys would have opportunities to interact.

FIGURA 8 – Hall project. (© Atelier Novembre, Du&Ma 2017)

We can see two versions of the project on Figures 8 and 9. The former was showcasing the 'founding fathers', namely Henri Poincaré (1854-1912, actually not a founder of the institute bearing his name) and Émile Borel plus a plaster bust of Jean Perrin at the back, and the sponsors John D. Rockefeller (1839-1937) and Edmond de Rothschild (1845-1934) on the left side. The working group in charge of the hall soon agreed that this was not a good way of welcoming the people.

FIGURA 9 – Hall project. (© Atelier Novembre, Du&Ma 2020)

At the end, the welcoming is ensured by an optical theatre (in the black and white box on Figure 10)

FIGURA 10 – Actual entrance hall. (© Institut Henri Poincaré / Atelier Novembre, Du&Ma 2023)

FIGURA 11 – Glimpse of optical theatre. (© Pierrick Sorin, Rulpidon by Ulysse Lacoste)

showcasing a 'Rulpidon', a sculpture by Ulysse Lacoste which in the meanwhile became the symbol of the Maison Poincaré. The scene designed by Pierrick Sorin involves two playful characters who subtly allude to the museum content, see Figure 11.

Outcome

Details about the conception of the permanent exhibition are provided elsewhere, see (Benzoni-Gavage, 2024) (Benzoni-Gavage & Fermanian Kammerer, 2023) (Benzoni-Gavage & Nadal, 2022) (Benzoni-Gavage & Liewig, 2022). Here, I would like to focus on the overall philosophy of the museum tour and highlight a few unique exhibits.

Each physical space is defined by a verb that characterises its content. These verbs are displayed as large capital letter signs hanging prominently in the middle of the space. We have the following, the first half being of modern layout, the second half being refurbished spaces:

- Connecting (CONNECTER) in the atrium
- Modelling (MODÉLISER) in the gallery
- Visualising (VISUALISER) in Alice's room
- Becoming (DEVENIR) in Perrin's former office
- Discovering (INVENTER) in the lecture hall
- Sharing (PARTAGER) in the tearoom

There are also numerous virtual doors through which to access the content. I will elaborate a bit on art, technology, games, everyday objects, and human experiences.

Games

A door that engages youth is through games. We offer a variety of games, both digital and low-tech. Among the digital ones is a large tablet where visitors can experiment with improving crowd evacuation in counter-intuitive ways. This game is part of the Modelling space. It was coded by Sylvain Faure, a researcher working in the field of crowd modelling. On Figure 12 we can see the French Minister of Higher Education and Research playing with it on the inauguration day.

FIGURA 12 – Crowd game. (© Institut Henri Poincaré / Atelier Novembre, Du&Ma, Laurent Ardhuin)

An example of a low-tech game is a sphere that visitors are invited to tile with various leather pieces, including those from a traditional soccer ball and the six identical pieces of the Brazuca. Figure 13 shows an invitee of the inauguration playing with it. This picture also shows another game that contains a low-tech part, the aim being to fit 11 cubes in a square box that seems too small. Actually, the cubes have a value written on them, they are weighted, and the box is also a scale. So, a variant of the game is the knapsack problem of optimizing the total value of cubes without exceeding a certain weight threshold. The invitees we can see trying it on the picture are actually the architects from Atelier Novembre.

Everyday objects

The soccer ball and a knapsack or a suitcase are obviously objects that everybody knows. These are part of a list of everyday objects chosen to draw connections with a variety of mathematical domains that are represented on a large 'mathematical metro' map in the Connecting space, see Figure 14. We can also spot a Rubik's cube, a buoy, a satellite, a saddle, a romanesco cabbage (a white, 3D printed version of it somehow hard to see on the picture) plus drawings of a smartphone, a pendulum clock, a rope, a cycle wheel, an actual metro map, a roulette and a credit card. Our science communicator team has stories to tell about each of them. Personally, I like very much the seven-colour buoy.

Our mathematical metro has six lines – algebra, analysis, arithmetic, computer science, geometry, logic, probability – navigating through six neighbourhoods – change, foundations, numbers, random, shapes, structures. Most visitors are unaware of the

FIGURA 13 – Hands-on. (© Institut Henri Poincaré / Atelier Novembre, Du&Ma, Laurent Ardhuin)

FIGURA 14 – Connecting. (© Institut Henri Poincaré / Atelier Novembre, Du&Ma – Pentagon – Aveam, Thibaut Voisin)

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variety of maths involved here, and are not even supposed to know the words on this map. Nevertheless, if not following a guided tour they can enter the map through the description of each of the 14 objects.

Technology

Another door to access maths is through technology, starting with a device that almost everyone carries in their pocket nowadays: their smartphone. Going back to Modelling, we have several exhibits dealing with technologies embedded in smartphones – and more generally in our digital world, see Figure 15. In particular we can see on this picture a set of blue or red balls on the left, and a desk with a sort of open book on the right.

FIGURA 15 – Modelling. (© Atelier Novembre, Du&Ma, Thibaut Voisin)

The balls are displayed here to show in our 3D space the basic principle of data separation by hyperplanes, see close-up from another angle on Figure 16. In addition, there is a conundrum about the white ball: should it be blue or red? In other words, this is a low-tech exhibit to explain the modern technology of machine learning.

The desk with the open 'book' is actually an exhibit about image processing designed with the researcher Gabriel Peyré. The aim is to give an idea of two highly used methods for compressing digital images, namely the usual Fourier transform and wavelets, see Figures 17 and 18. In practice, visitors can experiment both methods on their own picture taken through the exhibit.
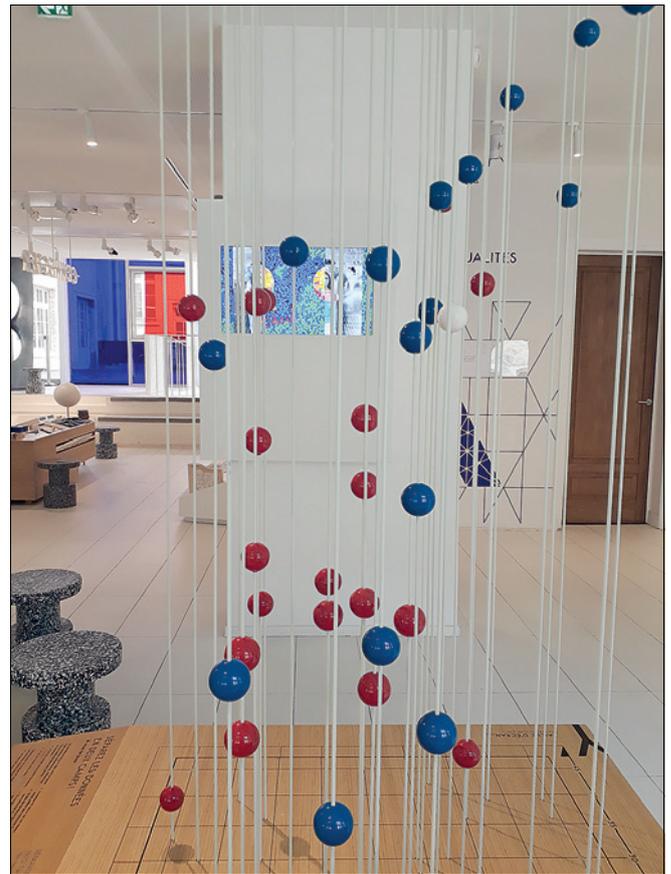

FIGURA 16 – Data separation. (© Institut Henri Poincaré / Atelier Novembre, Du&Ma – Aveam)
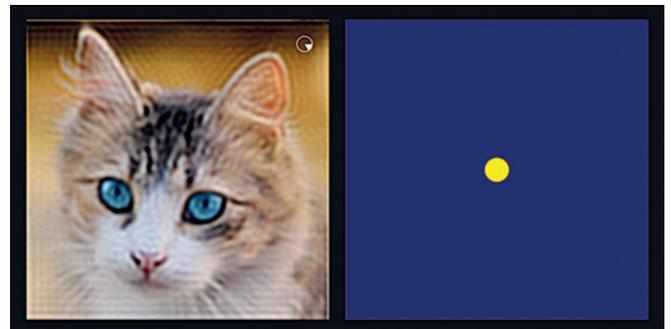

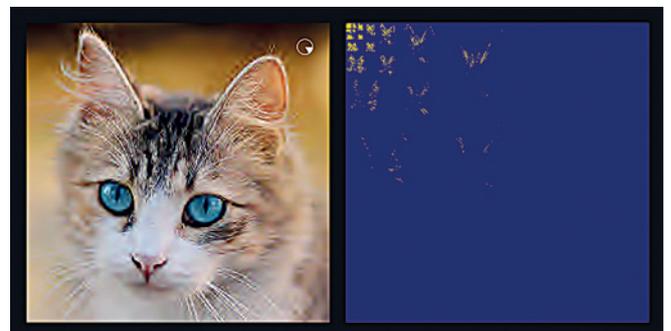FIGURA 17 – Fourier transform. (© Opixido, Gabriel Peyré)

FIGURA 18 – Wavelet transform. (© Opixido, Gabriel Peyré)

TABLE 1 – Screenshots of the film 'A sense of creativity'. (© Institut Henri Poincaré, Thierry Czajko and Quentin Lazzarotto)

Despite being enjoyable, this exhibit has proven challenging to comprehend, posing difficulties for our science communicator team in providing explanations.

An easier exhibit is about sound effects where we can hear an effect and watch at the same time the corresponding spectrogram. This is fun and rather easy to grasp. On Figure 19 we can see Gaël Richard, the researcher who coded the filters and produced sound samples and spectrograms, together with another Maison Poincaré ambassador ([8]), Susanna Zimmermann, whom we can meet in a documentary film screened in the lecture hall.

FIGURA 19 – Sound effects. (© Institut Henri Poincaré / Atelier Novembre, Du&Ma, Thibaut Voisin)

Human experiences

On the theme of discovering (INVENTER in French), the film 'A sense of creativity' ('Sensations d'invention' in French) explores what it feels like to pursue mathematics as a profession. We have chosen eight living mathematicians with diverse profiles. Some of them may be known to the public because they have received awards and garnered media attention. Others not. Screenshots of them in this film are shown on TABLE 1. Can the reader recognize them all?

Other portraits of contemporary personalities engaged in mathematics are shown in the office (see Figures 20 and 21) along with large pictures of the two main figures of the premises, the physicists Jean Perrin and Yvette Cauchois. The latter is less famous than the former. Nevertheless, she was the director of the laboratory for a quarter century, just like him.

FIGURA 20 – Becoming. (© Institut Henri Poincaré / Atelier Novembre, Du&Ma, Thibaut Voisin)

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FIGURA 21 – Becoming. (© Institut Henri Poincaré / Atelier Novembre, Du&Ma)

We have ensured a gender-balanced and diverse representation in the photographic portraits, with half of the subjects being international. This was quite tricky in Covid times but our French photographer, Camille Cier, managed to be in touch with local photographers who aligned with her point of view. These portraits are distributed harmoniously in this heritage room with two mirrors which reflect one in the other. This literally opens many perspectives of storytelling.

Another place where the voice is given to human experiences is the tearoom on the theme of Sharing (PARTAGER). There is an illustrated sound book featuring short stories inspired by researchers' testimonies, see Figures 22 and 23. While visitors turn the pages, an RFID chip selects the appropriate short story and plays it in the sound dome above them – insightful readers will notice that this dome is designed as a part of a dodecahedron, like the

FIGURA 23 – Cover of the book. (© Institut Henri Poincaré / Julie Machart & Gaël Octavia)

sound effects one on Figure 19. We have unfortunately experienced technical problems implying that this 'Story time!' (or 'Laissez-vous conter' in French) exhibit is not appreciated as it should be.

Human experiences of course leave traces of all kinds, in time and space. This underlies an interactive exhibit entitled 'Circulation of knowledge'. It consists of a beamer projection behind the mobile chalkboard in the tearoom that is controlled through an interactive screen. The latter is visible on the tablet on Figure 24 – lower left

FIGURA 22 – Sharing. (© Institut Henri Poincaré / Atelier Novembre, Du&Ma, Thibaut Voisin)

FIGURA 24 – Sharing. (© Institut Henri Poincaré / Atelier Novembre, Du&Ma, Thibaut Voisin)

FIGURA 25 – Circulation of knowledge. (© Institut Henri Poincaré / Atelier Novembre, Du&Ma – Pentagon, Opixido)
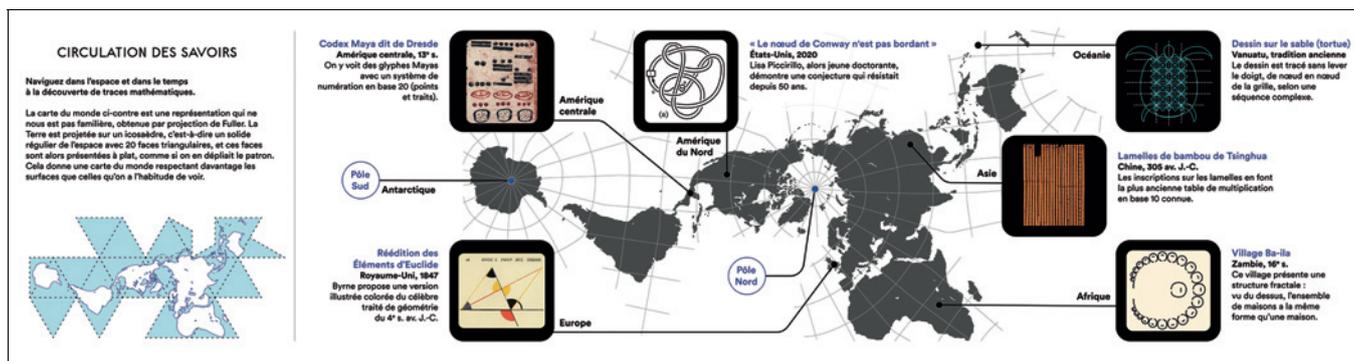

FIGURA 26 – Circulation of knowledge. (© Institut Henri Poincaré / Atelier Novembre, Du&Ma - Pentagon, Atelier 3 points)

corner – while a screenshot of a projection is in Figure 25.

The content of this exhibit was carefully chosen with Céline Nadal and an intern, Noëlle Krajcman – now working at the Palais de la Découverte in Paris – to represent humanity as a whole. Even the map is special to avoid the usual distortion of the southern hemisphere – on Mercator maps for instance. This Fuller projection – based on an icosa-hedron – was suggested by the graphic designers (Pentagon). Regarding the content, we are indebted to the Mathematical Association of America (MAA) initiative called 'Mathematical treasures' [9]. The current editor of the MAA Journal Convergence, Amy Ackerberg-Hastings, and their 'chief treasure hunter' Franz Swetz (1937-2023) [10] generously accepted that we feed our exhibit with those treasures.

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[9] https://www.maa.org/press/periodicals/convergence/index-to-mathematical-treasures.

[10] https://obits.pennlive.com/us/obituaries/pennlive/name/ frank-swetz-obituary?id=52304700.
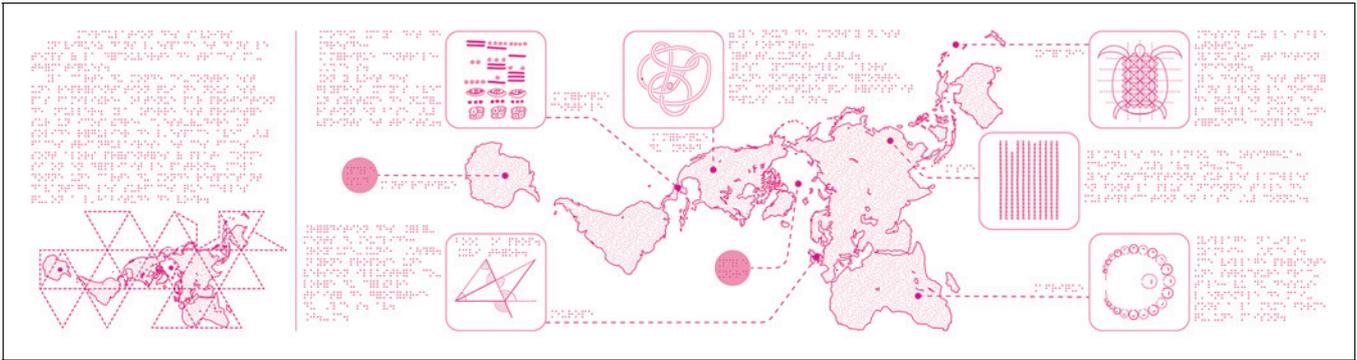
FIGURA 27 – Circulation of knowledge. (© Institut Henri Poincaré / Atelier Novembre, Du&Ma – Pentagon, Atelier 3 points)

To conclude about this remarkable exhibit, I would like to highlight that we offer an excerpt accessible to visually impaired people. It is located on the already mentioned tablet and looks visually as we can see on Figure 26 while the tactile version (in Braille and embossed) is shown on Figure 27.

Incidentally, the small company Atelier 3 points who made all the tactile content of the Maison Poincaré is also the one who had made the tactile model of the 'Pi room' that we can spot under the screen on the right on Figure 21. It was donated to us by Universcience – Palais de la Découverte (which was founded by Jean Perrin) before their refurbishment work that started in the early 2020s.

Art

I will conclude this overview by exploring the door of art, which is wide open for both connoisseurs and enthusiasts of all kinds. This includes adults and young people engaged in art studies, possibly starting as early as secondary school.

Of course, there are these mathematical objects that attracted the attention of the surrealists Salvador Dalí, Max Ernst, and above all Man Ray. We showcase most of the objects that were photographed by Man Ray in the 1930s – meaning all those that have not been lost since then – in the tearoom, see examples on Figures 28 and 29.

On Figure 29 we also see a panel in connection with art. Mathematically speaking, it represents all prime knots with 7 crossings or fewer, plus the Conway and the Kinoshita – Terasaka knots – experts will recognize them easily, in particular

FIGURA 28 – Mathematical objects. (© Institut Henri Poincaré / Atelier Novembre, Du&Ma)
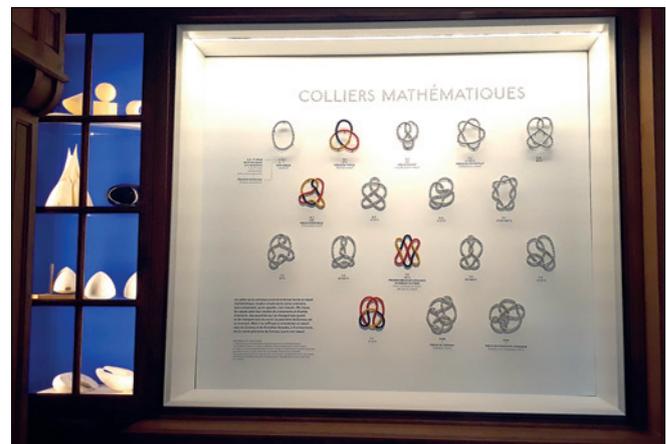

FIGURA 29 – Mathematical objects and knots. (© Institut Henri Poincaré / Atelier Novembre, Du&Ma – Aveam)

FIGURA 30 – Le théorème de Narcisse, Petit Palais, Paris 2021. (© Jean-Michel Othoniel)

FIGURA 31 – Rulpidon. (© Institut Henri Poincaré / Ulysse Lacoste)

FIGURA 32 – Mobile sculptures. (© Institut Henri Poincaré / Galerie Wagner & Ulysse Lacoste)

those which are tricolorable. This is a door to the field of topology, which most visitors do not know. However, the arrangement of these knots, resembling bead necklaces, is inspired by the work of French artist Jean-Michel Othoniel (Arroyo & Othoniel, 2017), of which an example is shown on Figure 30.

Finally, let me come back to the Rulpidon, this sculpture of Ulysse Lacoste that we have chosen to be the symbol of the Maison Poincaré. This was motivated by its shape that be seen both round and square, hence the pun point-carré for Poincaré in French that inspired the Maison Poincaré logo. More seriously, the Rulpidon also involves some interesting mathematics (Benzoni-Gavage, 2024). Thanks to the IHP endowment fund, we have a monumental version of it in the garden, see Figure 31. It is on purpose that it seems ready to roll. The artist indeed has a fondness for mobile sculptures. This one is fixed on the ground for obvious security reasons. A temporary exhibition in partnership with the art gallery Wagner in Spring 2024 includes truly mobile sculptures of Ulysse Lacoste. These can be seen in a showcase, along with the prints they would leave on the ground when moving, see Figure 32.

We often mention the beauty of maths to praise it. Except that it is very hard to see for people who are not acquainted with it. By showcasing many pieces of art, we aim to evoke an appreciation for their beauty among visitors, and consequently, an appreciation for mathematics.

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Ex studentessa dell'École Normale Supérieure di Saint-Cloud, Sylvie Benzoni ha conseguito un dottorato in matematica nel 1991 ed è stata assunta come ricercatrice presso il CNRS nel 1992. È professoressa presso l'Università Claude Bernard Lyon 1 dal 2003. È stata direttrice dell'Istituto Camille Jordan dal 2016 al 2017, dopo esserne stata vicedirettore per cinque anni. Dal 1 gennaio 2018 è direttrice dell'Instituto Henri Poincaré.

Gli studi di Sylvie Benzoni riguardano sistemi di equazioni differenziali alle derivate parziali relativi alla propagazione delle onde e alla modellazione di fluidi complessi, come quelli con transizioni di fase. Il suo lavoro si concentra in particolare sulla stabilità di alcune famiglie di onde. È molto impegnata nella trasmissione della matematica attraverso l'insegnamento e la mediazione scientifica.

Sylvie Benzoni