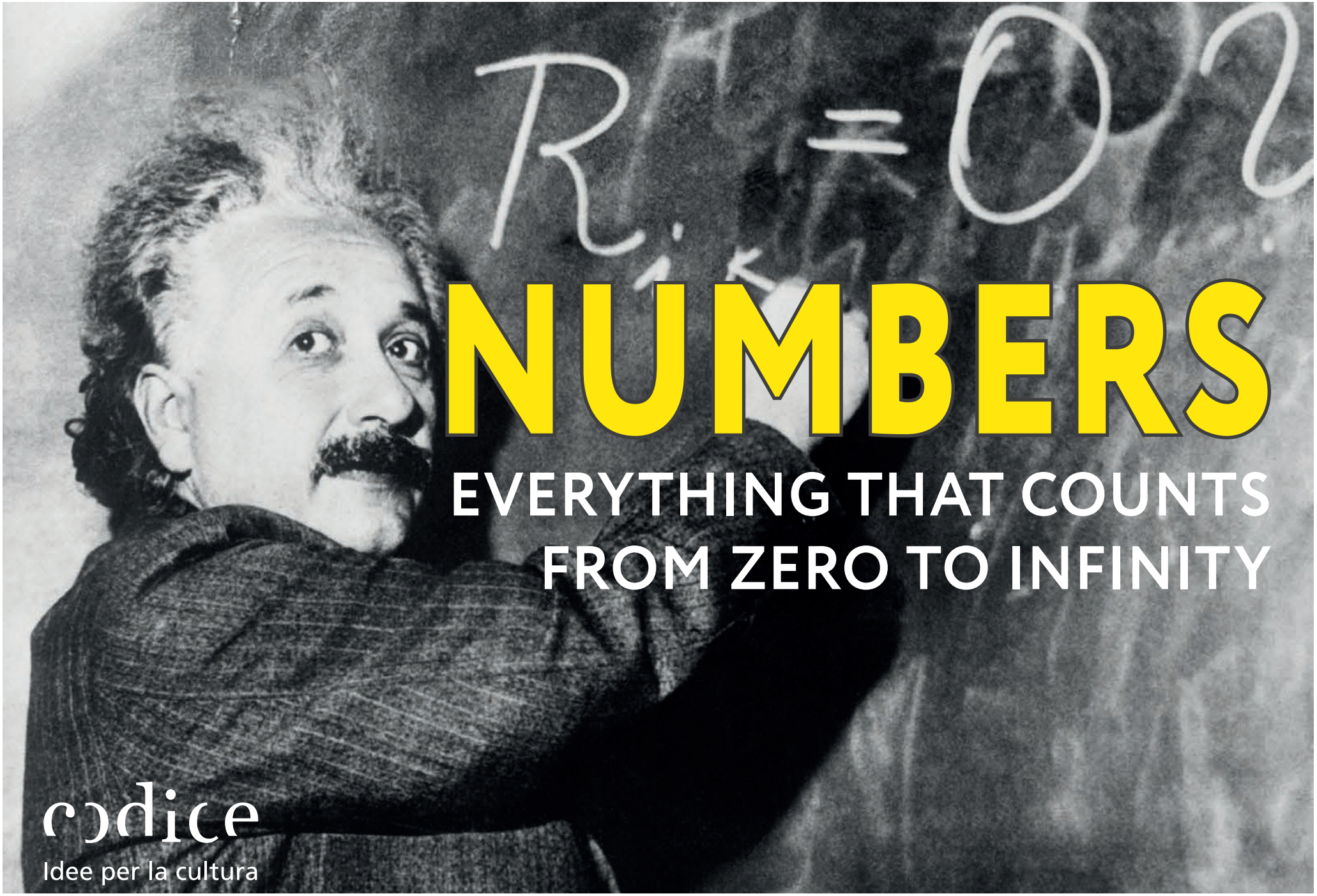


NUMBERS

EVERYTHING THAT COUNTS
FROM ZERO TO INFINITY

codice
Idee per la cultura

NUMBERS EVERYTHING THAT COUNTS FROM ZERO TO INFINITY

Numbers, calculations and measurements are part of the world that surrounds us. Although many people try to steer clear of them and have unpleasant memories of the subjects from their school days (or perhaps because of this), counting is an inevitable part of human culture, and the world of numbers seems to fascinate as never before. Books on mathematics are at the top of the charts, math games are highly popular, and the festivals and events dedicated to mathematics attract full houses.

This exhibition dedicated to numbers, in the broadest sense of the term, is designed for the general visitor, but it has **several levels of interpretation** that can also be appreciated by those in the know. The basic idea is simple: **show the dual, disconcerting, and fascinating essence of numbers**. On the one hand, they are **natural objects** that the human brain is designed to deal without problem, and they are **useful**, because society needs to quantify and measure; but they are also **man-made and social objects**, sophisticated mathematical and cultural constructions, multi-faceted and fascinating. Since ancient times and in many different cultures, numbers contain beauty and mystery within them, and are the mirror which enigmatically reflects the harmony of the cosmos. Not only do they **provide the basic language of all scientific discourse** that aims to explore and understand natural phenomena, but they exert a deep yet subtle charm on **philosophical and theological thought, art, architecture, and music.**

The narrative of the exhibition follows this logic with a **linear path**. After a moment in the entrance, that playfully presents the “mystery” of numbers in an attractive and charming set up, the path of **discovery starts with the brain**, as we show that it is naturally equipped to deal with numbers and quantities. But not all individuals and all cultures do so in the same way: analysing the differences will be very instructive, as well as realizing our limitations (such as the inability to treat large numbers).

After having grasped the idea of number and quantity, **the next step is to give a name to things and write them down**. We will show in parallel the two aspects of the **counting** (including the use of fingers and gestures) and the **writing** of numbers in its linguistic and cultural implications, in various societies of the past and present.

Human beings soon realized that they were not able to take full advantage of numbers, to record large figures, and to keep accounts with only natural means, so then they tried to overcome their inherent limitations. The next logical step, in fact, since prehistoric times, was the construction of **tools to help in calculation** - from pebbles to abacuses, from slide rules to mechanical calculators.

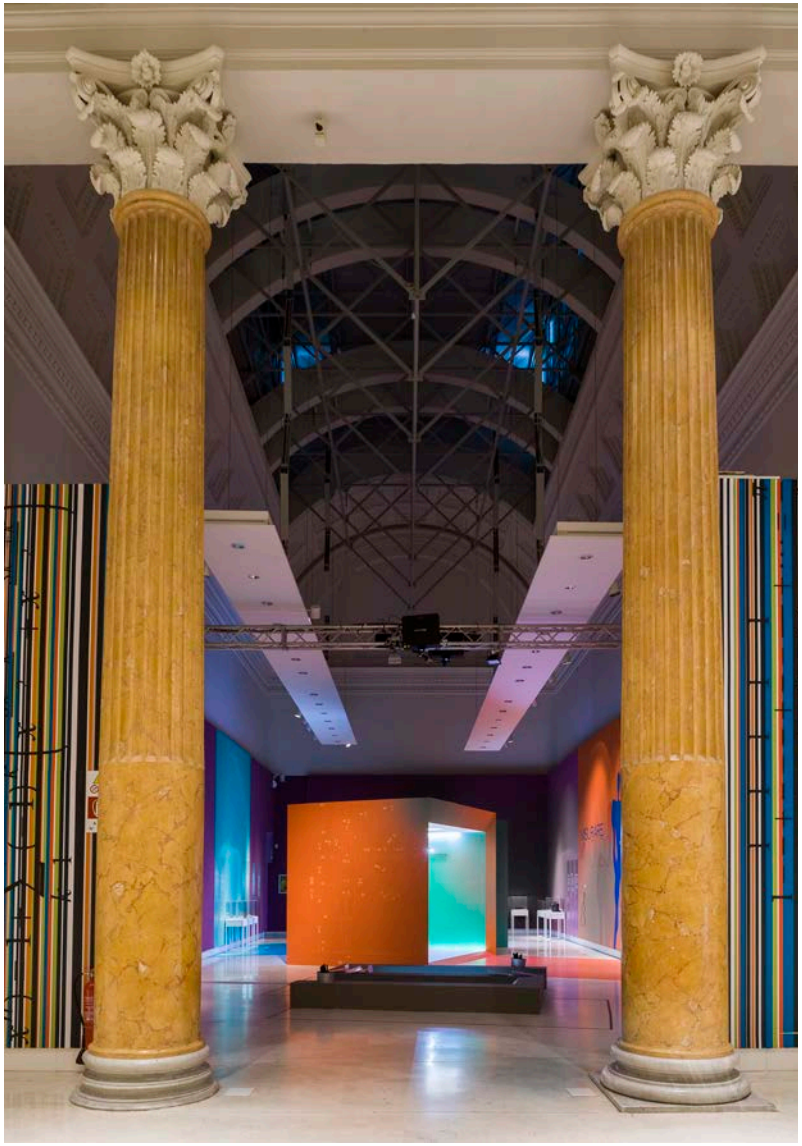
At this point, the exhibition leaps from “pure” to “applied” numbers, namely those which are necessary for **measuring**. We start with the **units of measurement** (“I am a size 10”, “I have 20/20 vision”, “the stock index went up 2 points” – what are those numbers referring to?), and arrive at the fundamental constants of the universe. We will also show areas such as **economics** and **statistics** where numbers are fundamental but their measurements are not always a source of certainty.

Finally, we will see the other nature of numbers, which is abstract and less bound to everyday experience. We will show how **mankind has meditated on numbers since ancient times**, coming to manipulate them with a high degree of abstraction – but also with considerable **practical consequences** (e.g. using certain of their properties to invent impregnable secret codes).

EXHIBITION OVERVIEW

With a potentially difficult topic like this, the **communication model** is essential. We have tried to avoid frustrating the visitor with the feeling of "I need to understand this at all costs", and at the same time we rejected the paternalistic view that "math is fun and easy". Depending on their level of preparation – and the mood of the moment – **visitors will take home different bits of knowledge, curiosity, new awareness, doubts, maybe even the desire to learn more, and will have enjoyed the exhibits that are lighter and more fun**.

The exhibition is divided into **11 modules** (plus two special entrance and exit modules). Some of them tackle **general issues** regarding numbers and counting, while other **focus on significant numbers**. Each number is associated to emblematic figures of **great mathematician**s, and offers an opportunity to explore the **intertwining** between mathematics and other areas of culture, from art to music, literature, and mystical thought.



EXHIBITION OVERVIEW

0 THE NUMBER GALLERY

1 NUMBER SENSE

2 FIRST STEPS: 1, 2, 3 ...

3 COUNTING GESTURES AND FIGURES

4 A FASCINATION WITH THE IRRATIONAL: $\sqrt{2}$ E Φ

5 CALCULATION TOOLS AND MACHINES

6 THE SECRET OF THE CIRCLE: π

7 MEASURING THE WORLD

8 A NEW BASIS: *e*

9 IMAGINARY NUMBERS: *i*

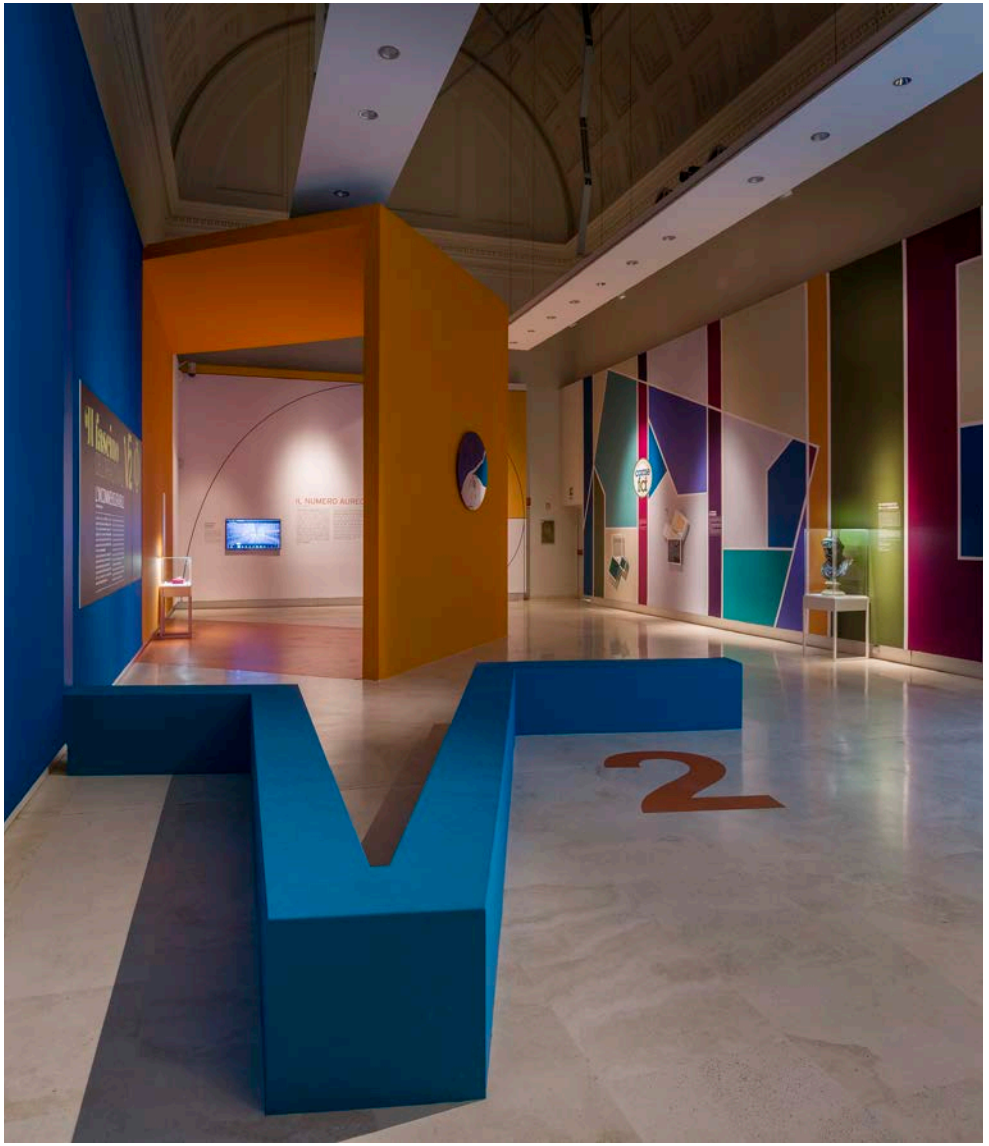
10 FROM ZERO TO INFINITY

11 THE ENIGMAS OF PRIME NUMBERS

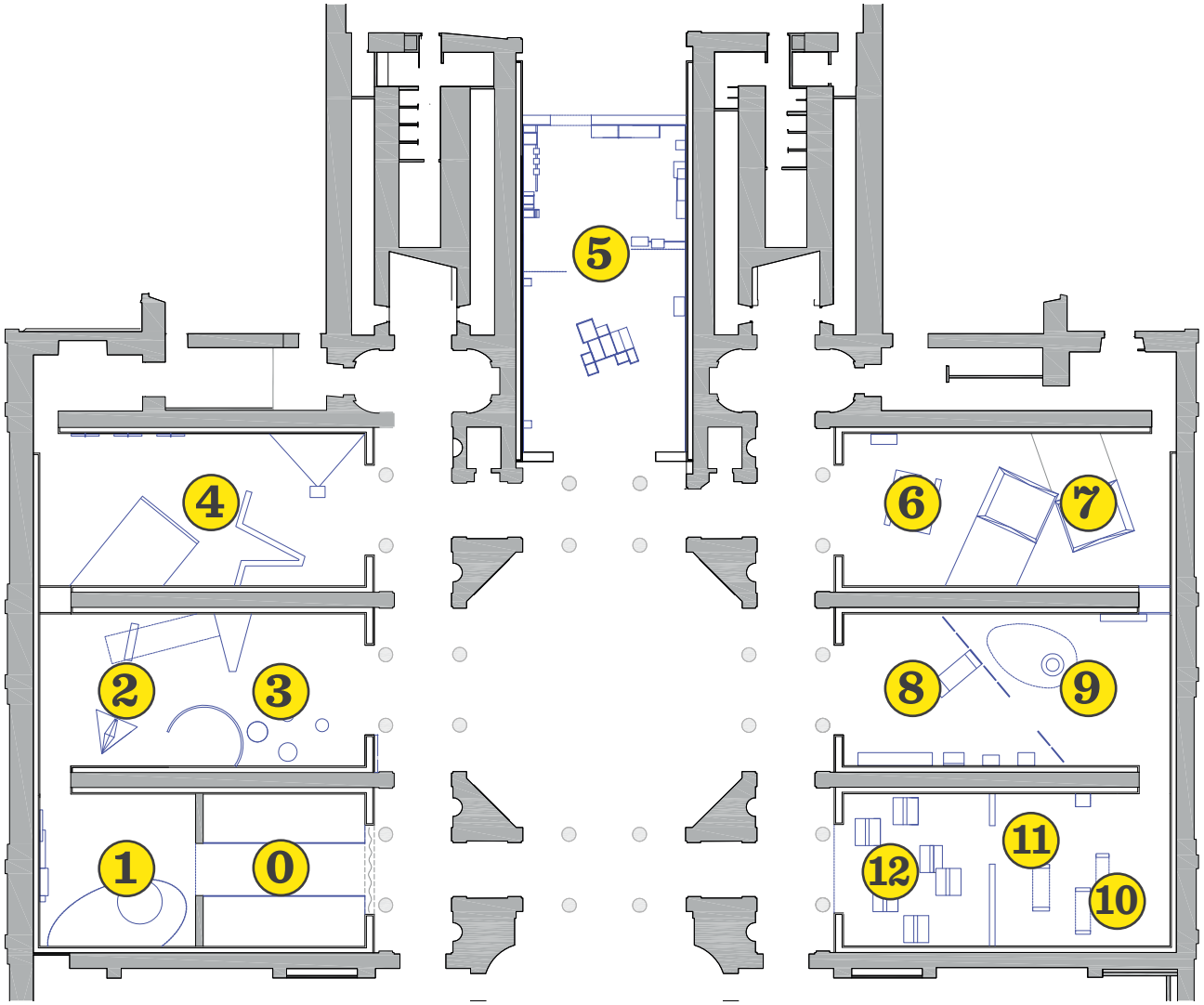
12 OUR PLANET IN NUMBERS

EXHIBITION OVERVIEW

As well as **information panels** in each module, we show **artifacts** of various kinds, **installations**, and **virtual and hands-on interactive exhibits**. We also tell stories of mathematics and mathematicians in twelve **brief podcasts**.
The objects and the installations are instrumental in supporting the path of knowledge, but in some cases they strike a more aesthetic chord and aim to inspire **a sense of wonder** in the visitor.
The aim of the exhibition, on one hand, is to leave the feeling of awe intact, and on the other, **to make visitors aware of how much intelligence and complexity sometimes underlie simple and intuitive ideas.**



EXHIBITION OVERVIEW

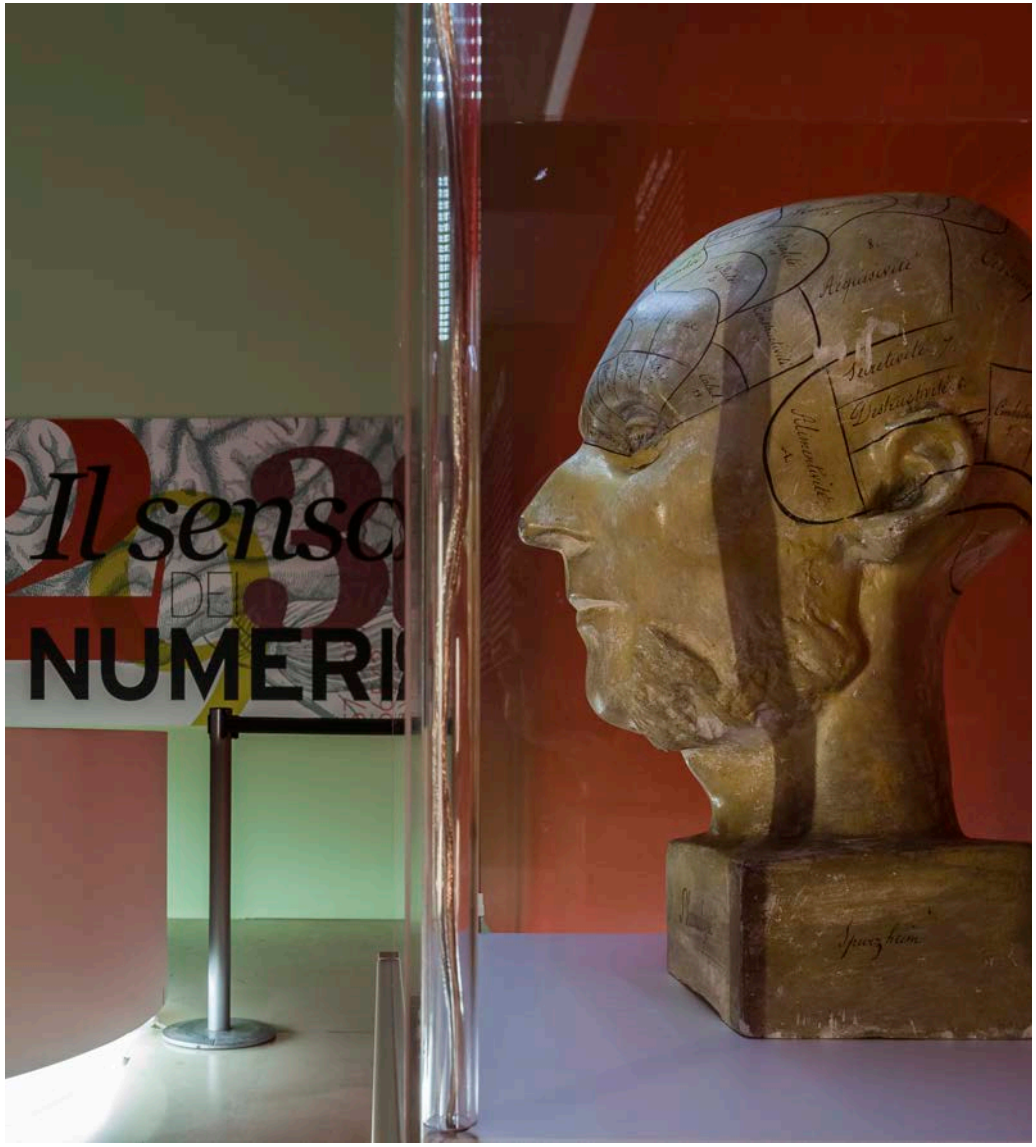


THE NUMBER GALLERY

The entrance provides a “gentle” welcome, to stimulate a sense of wonder and curiosity. Swarms of numbers projected on an interactive video wall follow visitors as they make their way through the entrance tunnel.

1. NUMBER SENSE

This module is dedicated to numbers as “natural objects”, that is, to the “innate” aspect of computing. We discuss topics such as: how our brain elaborates numerical information; can animals count?; the anthropology and linguistics of numbers; limitations of the human mind in dealing with very large numbers, and the resulting difficulty in making quantitative estimates; and human computers, individuals with incredible mental calculation abilities.



2. FIRST STEPS: 1, 2, 3 ...

Numbers that mathematicians define natural are, just like the name suggests, entities that we use “naturally” for counting. The reasons of interest and fields of application are limitless.

Opening: **The mystique of numbers**
Natural numbers have been associated with symbolic meanings since ancient times. Among other things, we will deal with the Pythagoreans, the Hebrew gematria, alchemical numerology, and magic squares.

3. COUNTING GESTURES AND FIGURES

As we have seen, counting is a natural and "innate" activity. The representation of numerical quantities and their elaboration, though, is translated in different ways in space and in time, according to very different conventions.

In this module, we illustrate the numbering systems in various cultures nowadays and in the past. We address in parallel the counting and the writing of numbers. We also tackle the issue of **calendars** – in close connection with its own numbering system, every civilization develops different ways to count the days. From a mathematical point of view, developing a calendar means mostly solving an arithmetic problem.

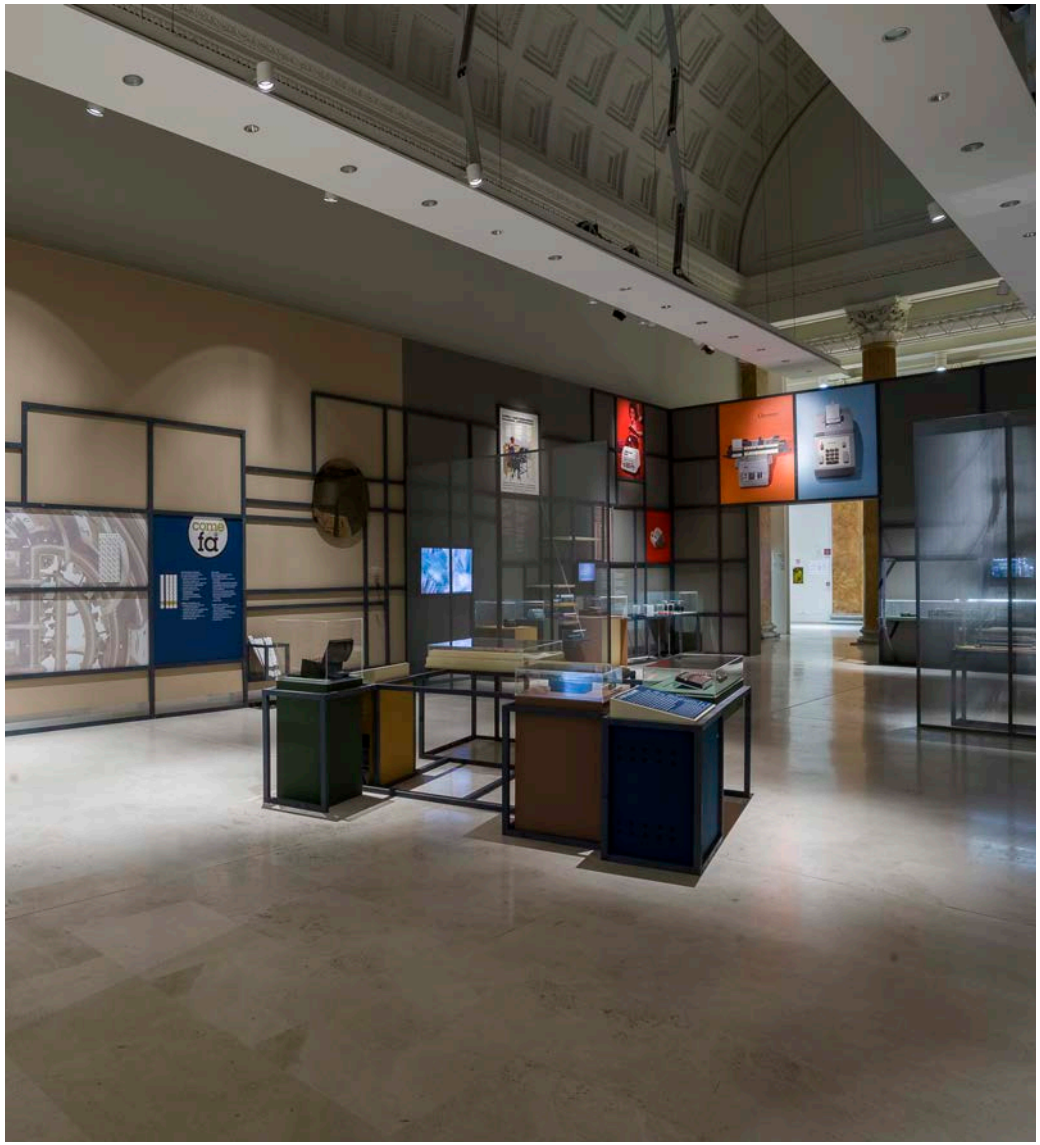
4. A FASCINATION WITH THE IRRATIONAL: √2 E Φ

Ancient mathematicians discovered that some numbers, like the square root of 2 and the golden number Φ, are irrational, that is they cannot be expressed as a fraction (i.e. the ratio of two integers) in any way. This had a profound impact, especially on the idea of measurement.

Opening: **“Divine proportion” in art history.** The golden number Φ has always been linked to the idea of the “perfect” proportion.

5. CALCULATION TOOLS AND MACHINES

After seeing the difficulties that mankind faced in manipulating certain numbers, we now see how civilizations have tried to overcome the limitations of our species by developing tools to manipulate numbers faster and with fewer errors.
For various reasons, we have deliberately stopped on the threshold of the modern computer, focusing instead on the ingenious earlier inventions – ancient and fascinating instruments.



6. THE SECRET OF THE CIRCLE: π

The constant ratio between the length of any circumference and its diameter, π, is perhaps the best known mathematical quantity.
We will review its history from the Babylonians to the Indians, from Archimedes to modern times.

7. MEASURING THE WORLD

Numbers, basically, are used to measure and quantify – operations which we take for granted but which lend themselves to interesting observations.
It all has to do with the “unreasonable effectiveness of mathematics” and the omnipresence of the quantitative element in our lives. We address issues such as: the concept of units of measurement; the numbers of the universe and the fundamental constants; the numbers of our lives and statistics; the numbers of wealth and money.

8. A NEW BASIS: e

The number e is less known to the general public than π, yet it has great importance in theory and applications. This number fully performs its historical function to “simplify calculations”, and on the other hand it is essential for introducing abstract mathematical concepts.

9. IMAGINARY NUMBERS: *i*

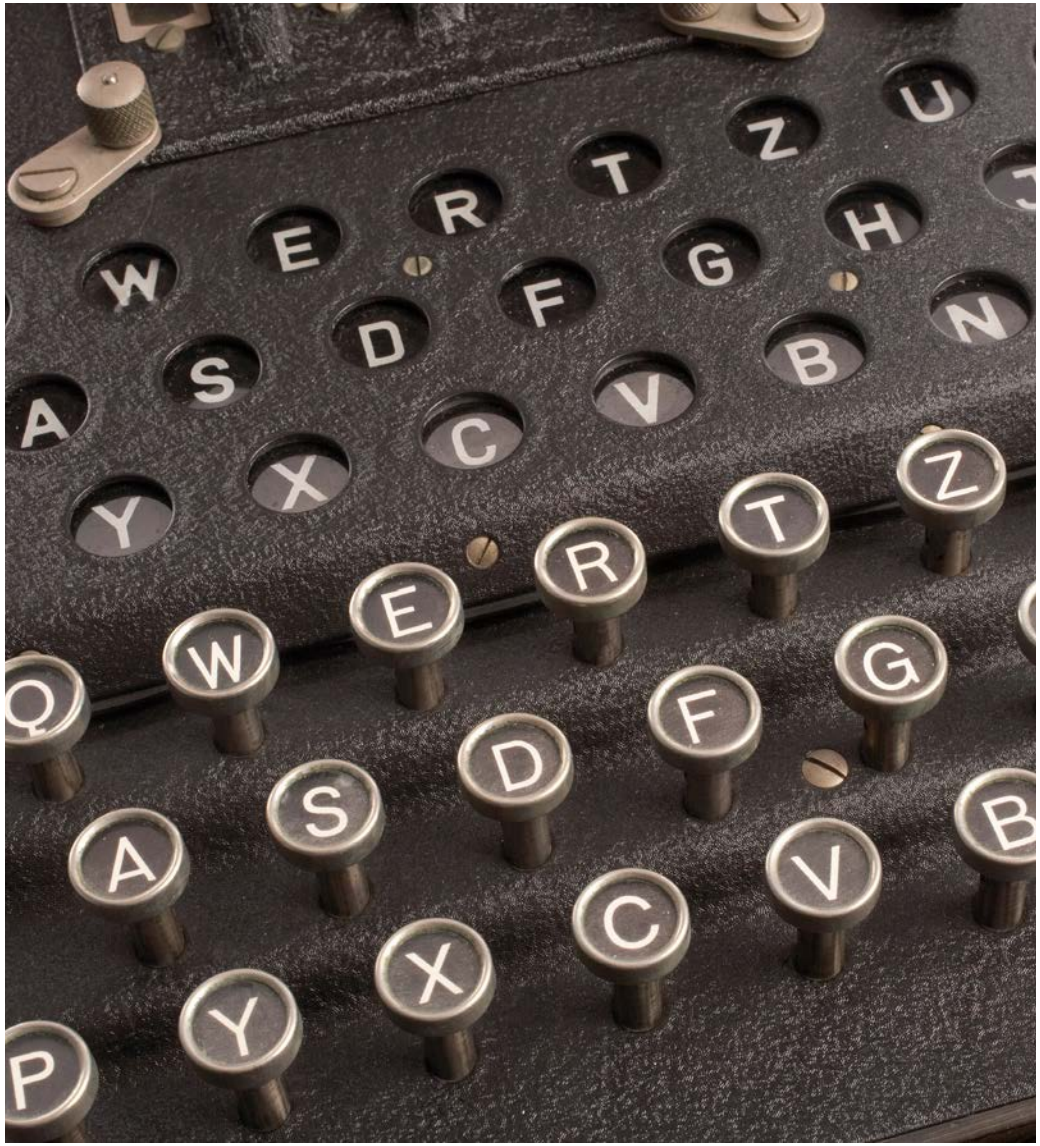
The letter *i* indicates the *imaginary unit,* i.e. that number which raised to the square equals the negative unity -1.
This apparent intellectual artifice, which clashes with what the majority of visitors have studied ("there are no square roots of negative numbers"), entered into mathematical practice with difficulty, but has proved to be an invaluable working tool, and has important applications.

10. FROM ZERO TO INFINITY

Zero and infinity, quantities that seem diametrically opposed, are here in the same room. Who first had the idea of using a special sign to indicate an absence? Why is zero so important? Infinity, on the other hand, is a concept that is hard for the human mind to fathom, and its consistent mathematical treatment occurred only in the 19th century. Today we distinguish various “types of infinity” and treat infinite quantities in the same way as numbers, although equipped with special rules.

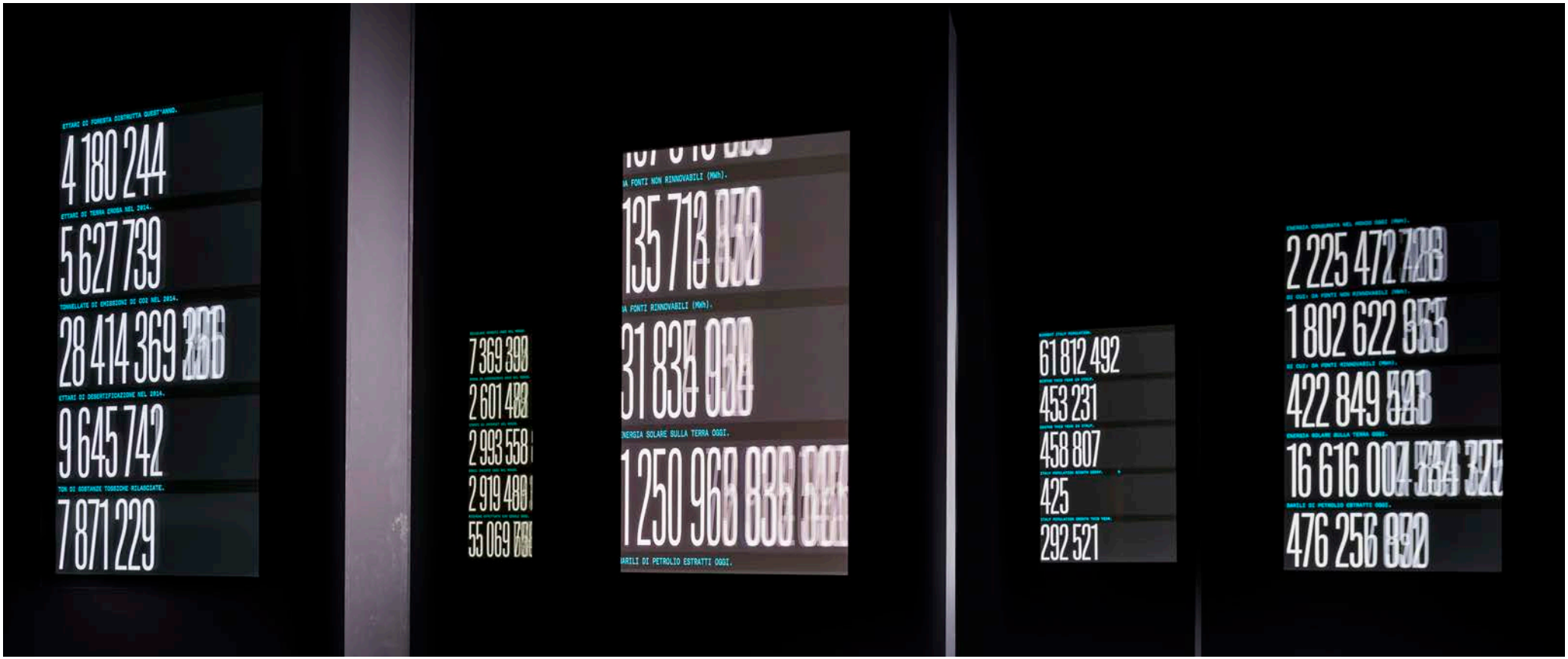
11. THE ENIGMAS OF PRIME NUMBERS

In mathematics, all numbers are not created equal. Some, such as prime numbers, are special in many ways, because we can consider them as the “bricks” which make up all natural numbers – similar in this respect to the elements of chemistry and the elementary particles of physics.
Prime numbers are the tools of the trade in number theory and have also important application, such as in cryptography.



OUR PLANET IN NUMBERS

We end our journey with a room full of panels showing some constantly updated data regarding human life on Earth.
Every second, someone is born, dies, marries, travels, buys goods, exploits natural resources.
Numbers are a snapshot of life on the planet – for good and for bad.



INTERACTIVE EXHIBITS

0 THE NUMBER GALLERY

1 NUMBER SENSE

- An animation showing which areas of the brain “light up” when we count.
- A game that challenges viewers to make estimates of large quantities.

2 FIRST STEPS: 1, 2, 3 ...

- An interactive model of Pascal’s triangle that reveals many secrets hidden in the sequence of natural numbers.

3 COUNTING GESTURES AND FIGURES

- An entire wall is occupied by an interactive map that shows the calendar systems of various civilizations in time and space.

4 A FASCINATION WITH THE IRRATIONAL: √2 E Φ

- A low tech apparatus for proving the Pythagorean theorem in a “mechanical” fashion.

INTERACTIVE EXHIBITS

5 CALCULATION TOOLS AND MACHINES

- The Napier rods, an ancient and low tech method for multiplying numbers
- A model in Meccano® of the Difference engine no. 1 by Charles Babbage.

6 THE SECRET OF THE CIRCLE: π

- A device for recreating the famous Buffon's Needle, a game that can be used as a statistical experiment to approximate the value of π.

7 MEASURING THE WORLD

- An apparatus for anthropometric measurement allows visitors to instantly obtain a wealth of data regarding their body size.

8 A NEW BASIS: *e*

- A device for composing musical sequences, playing with different scales and appreciating the difference between various temperaments.

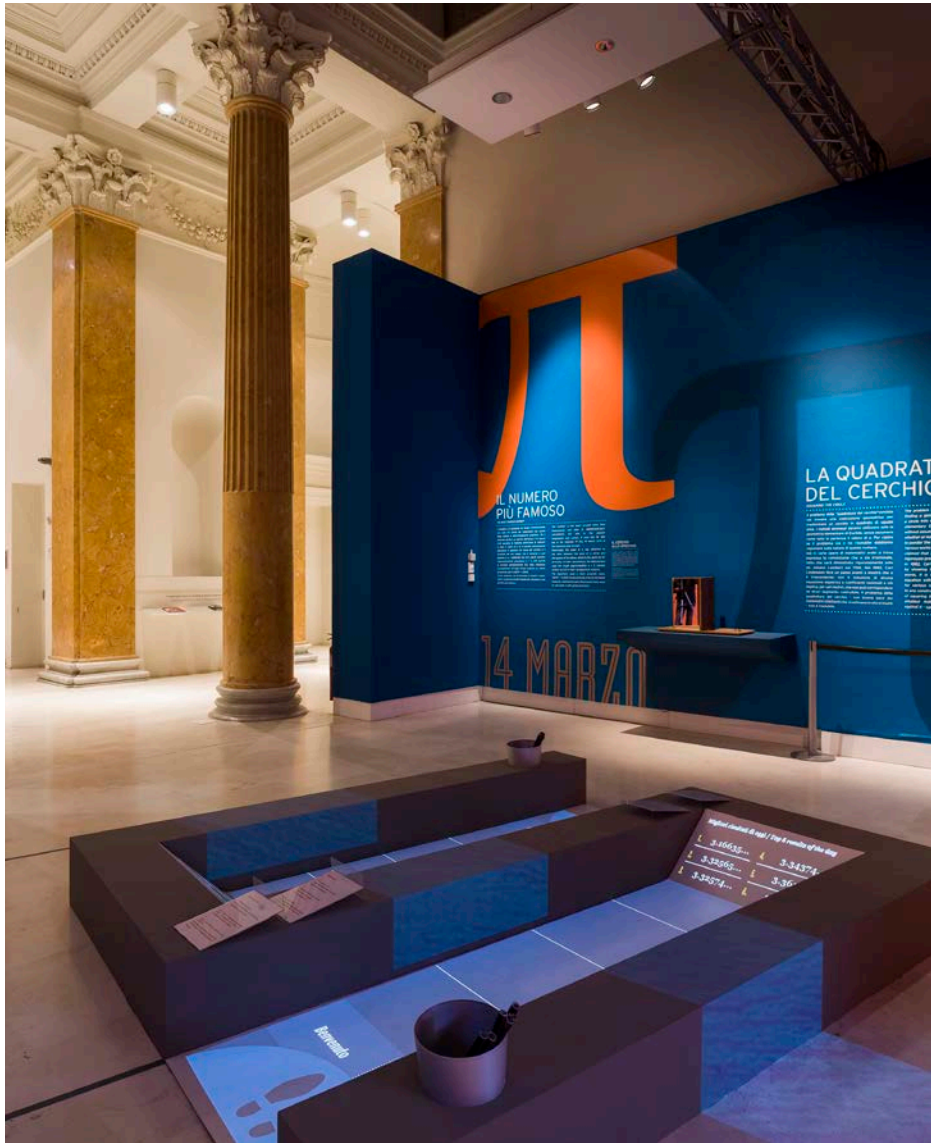
INTERACTIVE EXHIBITS

9 IMAGINARY NUMBERS: *i*
- A device for generating fractals from imaginary numbers.

10 FROM ZERO TO INFINITY

11 THE ENIGMAS OF PRIME NUMBERS

12 OUR PLANET IN NUMBERS



CURATORS

Claudio Bartocci (Ph.D. in Mathematics, University of Warwick, 1993) is Professor of Mathematical Physics and History of Mathematics at Genova University, Italy.
He held visiting professor posts at the State University of New York at Stony Brook (1994), Université de Paris VII (1996), University of Philadelphia (2001), École de Hautes Études en Sciences Sociales, Paris (2006, 2011 and 2013), Sissa Trieste (2007); in 2011 he held a fellowship from the Italian Academy at the Columbia University.
He authored over 40 papers in international peer-reviewed journals (mostly in mathematical physics and algebraic and differential geometry), 2 scholarly books and many essays on the history of mathematics and on topics at the crossroad of mathematics, literature and philosophy of science.

Among his latest works: Una piramide di problemi. Storie di geometria da Gauss a Hilbert (Raffaello Cortina 2012); New Trends in Geometry: Their Role in the Natural and Life Sciences (co-editor with L. Boi e C. Sinigaglia, Imperial College Press, London 2011); Fourier-Mukai and Nahm Transforms in Geometry and Mathematical Physics (with U. Bruzzo and D. Hernández Ruipérez, Birkhäuser, Boston 2009), Mathematical Lifes (co-editor with R. Betti, A. Guerraggio, R. Lucchetti, Springer, Berlin-Heidelberg 2010); Racconti matematici (Einaudi, Torino 2006). He is the general editor (with P. Odifreddi) of La matematica Einaudi (4 vols., 2007-2011). He writes for the daily Il Sole 24 Ore.

CURATORS

SCIENTIFIC COORDINATOR

Luigi Civalleri, born in 1967, studied Mathematics at Pisa University. After some years in research, he moved into the publishing and communication business. He worked as an editor for top Italian publishers, such as Bollati Boringhieri and Einaudi; then he became a freelance consultant, editor and translator. He translated into Italian bestsellers such as: Guns, Germs, and Steele, by Jared Diamond; The Elegant Universe, by Brian Greene; The Omnivore's Dilemma, by Michael Pollan; The Immortal Life of Henrietta Lacks, by Rebecca Skloot; The Disappearing Spoon, by Sam Kean; Spillover, by David Quammen.

He recently shifted his interests to science events. Among other projects, he was involved as programme coordinator in "ESOF – Euroscience Open Forum" a huge international conference with 4,500 participants, held in Torino, Italy, in 2010. Since 2002 he teaches at the Master in Science Communication at SISSA, Trieste, Italy.

CONTACTS

Codice. Idee per la cultura srl

Via Giuseppe Pomba, 17

10123 Torino

T +39.011.19700579/580

F+39.011.19700582

exhibitions@codicultura.it

www.codicecultura.it