CosmoCaixa Barcelona

From 12 April 2019 to 26 January 2020

Press release

”la Caixa” presents the exhibition *Mirrors: Inside and Outside Reality* at CosmoCaixa

- **Conceived and produced by ”la Caixa” Foundation, *Mirrors: Inside and Outside Reality* is an imaginative exhibition, full of surprises, which uses the potential and applications of the fascinating objects that are mirrors to show that reality can be observed from different viewpoints.**

- **Part of the originality of this show revolves around the fact that a single element, mirrors, are used to create an attractive route around the museum, enabling visitors to experiment interactively with their effects and peculiarities and to understand different phenomena related to them.**

- **Through the manipulation of these polished surfaces in which light is reflected, *Mirrors: Inside and Outside Reality* also explores physics and maths and encourages us to discover the laws that govern them.**

- **The exhibition begins by inviting visitors to literally cross through a looking glass, just like Alice in Wonderland. The exhibition route then firstly examines the properties of mirrors from a more accessible point of view, exploring flat and curved mirrors, kaleidoscopes and so on, before introducing mathematical aspects and asking what, exactly, mirrors reflect.**

- **A human-sized kaleidoscope will invite visitors to pass to the other side of the mirror, the second section of the exhibition, in which light is the protagonist. The interaction of light with mirrors enables us to go to the Moon, to use a sextant to navigate, to see the first light after the Big Bang and so on.**

- **Consultancy services for the exhibition were provided by the Museum of Mathematics of Catalonia and the Institute of Photonic Sciences, while outstanding contributions were also made by such partners as**

the Virgo project, which loaned a priceless mirror from its Gravitational Wave Observatory in Pisa.

Barcelona, 12 April de 2019. Elisa Durán, Deputy General Director of ”la Caixa” Banking Foundation, Jordi Portabella, Director of ”la Caixa” Banking Foundation’s Scientific Dissemination Department, and Lluís Noguera, Director of CosmoCaixa, today presented the exhibition *Mirrors: Inside and Outside Reality*. The new show invites visitors to experiment with and discover the properties of mirrors and their numerous applications throughout history.

Mirrors are objects that are so present in our everyday life that we usually take them for granted. We look into them and see the images they reflect, but we are often not really aware of their presence, their existence as objects. Although we use them daily, we rarely stop to think about how they work, their properties.

However, when we speak of mirrors, more than the object itself we are really speaking about the laws of reflection and refraction of light, about planes of symmetry and about the mathematical relationships that intervene.

In fact, mirrors have been used for scientific purposes since ancient times, and have enabled many discoveries to be made that have given us knowledge about the cosmos and the origin of the universe. Over time, this research that has led to advances for humanity and has enabled us to understand the world we live in a little better with every passing day.

Mirrors: Inside and Outside Reality takes visitors on a fascinating route that enables them to experiment in fully interactive ways with the effects and peculiarities of mirrors. In the two large sections in which the exhibition is divided, we will discover various phenomena related to physics and mathematics. The first section illustrates how the laws of reflection work, while second is devoted to mirrors and their interaction with light.

01. Inside the mirror. Experiments with planed and curved mirrors and kaleidoscopes

In the first section, like Lewis Carroll's character Alice, we are invited to cross through a looking glass to discover the secrets that lie on the other side. Welcoming us to the exhibition, the first module includes an installation of distorting mirrors that invites us to question whether what we see really coincides with reality. This illustrates the importance of doubt and the relativity of the observer's perception and point of view as a way of stimulating scientific thought. Next, the exhibition route enables us to interactively explore the properties of different types of mirrors and to discover the basic concepts that characterise the phenomenon of reflection and its relations to mathematics.

To speak of mirrors is to speak of the law of reflection. The simplest type of mirror is the **plane mirror**, which reflects a virtual image that presents a lateral inversion of the original model. However, if, instead of a single mirror, we combine two, arranged at different angles, the results and the images we perceive are greatly changed. A series of modules enables us to discover the relationship between the angles of aperture and the distances of the mirrors with mathematical proportions. It also shows us, in an entertaining and surprising way, that what our eyes see appears at times to contradict our perception, deceiving our brain.

Geometry occupies a prominent position among the mathematical disciplines. By arranging mirrors at certain angles, we construct relationships between lines, planes and angles, which divide the space into a series of specular, opposing and equidistant images. These mirrors form what we call "axes of symmetry" in which, depending on the way they are arranged, their images are multiplied and reversed. By opening or closing the book of full-body mirrors included in the exhibition in different positions, we multiply the number of virtual mirrors. Consequently, the number of virtual images generated is also multiplied. The modules in this section illustrate such basic concepts as multiplication or division, as well as enabling us to predict the result of each example by applying mathematical procedures.

The more acute the angle of aperture of the mirrors, the more axes of symmetry and the more images we obtain. And if we observe a motif through a combination of three mirrors arranged in the form of a tetrahedral pattern, for example, we will obtain a cascade of images like those typically found in kaleidoscopes.

Mirrors: Inside and Outside Reality invites the visitor to experiment with different types of motifs and increasingly complex combinations of mirrors in order to learn how kaleidoscopes work, as well as to enjoy the images generated. Each new axis of symmetry that we add generates new images until the point of infinite reflection is reached, at which point the light gradually attenuates. The show features several extraordinary installations, even introducing us to kaleidoscopes that create the illusion that we are inside or below a large sphere. Kaleidoscopes also play with our perceptions of what we see, but with the peculiarity, in this case, that the object of the exercise is not to observe reality from outside mirrors through their reflection, but to explore the mirror images that form before our eyes for themselves, as they are often surprising and impressive.

Curved mirrors contribute new properties to the laws that govern the formation of images and which are vital in the field of optics and lens making. These mirrors have a centre of curvature and a focus in which reflected rays – or their fictitious extensions – converge, and which can be concave or convex. Whether concave or convex, the virtual images obtained differ in size from the originals, and their peculiar characteristics can be useful in many practical applications, both in everyday life and in the manufacture of scientific research instruments. Several installations in the exhibition illustrate how these mirrors work.

Another type of reflected images are those produced by the **curvature of a cylindrical mirror**. And one of the most surprising applications is anamorphosis, in which distorted figures are created that only appear normal when viewed from a particular point. As in the case of kaleidoscopes, the real image that we want to observe is the one we see reflected, and not the original, which is distorted. In the show, a module demonstrates how this type of images is created and is used in art, from painting to film. By extension, we can also find many examples of paintings, sculptures and architectures that were deliberately distorted and are only seen normally and in their correct proportions from a single point of view: that of the person who observes them.

02. Mirrors and light. Scientific and technological applications

On the other side of the mirror is light. Without light, we could not see the reality around us, and mirrors would have no sense. Light is formed by photons, which behave simultaneously as both waves and particles when they interact with matter. Light is, therefore, a physical object that is propagated in the form of an electromagnetic wave and transports energy and information. This light energy enables us to see the world and everything around us. And thanks to mirrors we can “tame” light and use it in numerous functions, such as for heating, lighting, measuring, navigating and travelling through time and space. The modules in this space focus on various scientific and technological

applications that use mirrors as “tamers” of light. One of the applications uses the properties of mirrors to channel light and take it wherever we want. For instance, it seems that the builders of the Egyptian pyramids did just that, using a large system of mirrors to illuminate the interior of those huge construction. Moreover, we can emulate the sun and bring light to villages located in dark valleys where it does not reach during the winter months. In the exhibition, interactive modules enable us to experiment with different types of reflections.

Mirrors and the Moon landing

Another application in which mirrors are used to direct light are retroreflectors, mirror systems that have reflect the light they receive exactly back to the source of origin, along the same path but in the opposite direction. The modules in this space invite us to measure the distance from the Earth to the Moon, and provide several examples, including those of the astronauts on the Apollo XI, XIV and XV missions, who installed retroreflectors on the Moon in order to measure the distance from Earth and detect any variations in their relative positions.
The truth is that humanity has always tried to design and build all kinds of instruments to calculate our position on Earth and explore the universe. And many of these devices are made possible thanks to mirrors and their properties. The sextant is a good example, guiding us as we navigate through sea and space. Among many other applications, the sextant was also key in the Apollo VIII manned expedition, as the astronauts used it to guide themselves when the ship flew behind the Moon and communications with Earth were interrupted.

Hunters of light: telescopes

The exhibition also includes a space devoted to the telescope, an instrument designed to explore both space and time. The capacity to capture light depends on the size of the

objective, which may be a lens or a mirror. Nowadays, large telescopes, like the Hubble, are capable of capturing very weak light emissions from stars located at enormous distances from the Earth. As the speed of light is finite, when we observe a very distant object it is the equivalent to seeing it as it was at a very remote time in the past. As we see, then, telescopes enable us, not only to explore the depths of space, but also to go back in time, almost to the origins of the universe. Today, work continues on several major projects, such as the James Webb Space Telescope (JWST), the largest ever sent into space. The exhibition also includes information about the JWST.

Invisible light

Not all light is visible. Part of the spectrum is infrared radiation, which transports thermal energy and is invisible to the eye. A module invites visitors to conduct an experiment to detect it. In it, a transparent sheet allows visible radiation to pass through, but not infrared radiation, to which it acts as a mirror. Countless scientific and technological applications harness the properties of these waves to manufacture instruments in areas as diverse as communications, physiotherapy and the consumer goods sector, among many others.

In 2015, the gravitational waves predicted in Einstein's general theory of relativity were observed for the first time in history. This discovery opened up new paths for observation and research in the exploration of the cosmos and the origin of the universe. Both the American LIGO programme and the European Virgo project work to detect new waves to help us understand the discovery of the universe. The modules in this area enable you to discover how these devices work, and there is also an exceptional piece here: an authentic interferometer mirror, loaned by the Virgo Observatory for the exhibition period.

Making the invisible visible

The Schlieren method makes the invisible visible. In this exhibition space, very small changes in the refractive index can be observed. The Schlieren effect is found in such well-known optical phenomena as mirages.

Mirrors teach us to question the reality of what we see. But we still need to answer the initial question: we recognise ourselves consistently in mirrors, but can we really say that the images reflected back at us are really us? The very existence of mirrors leads us to question our identity. “Who am I?” is one of the oldest and most difficult questions to answer.

Not even mirrors, which we believe reflect us as exactly we are, show us how others see us. Indeed, as this space suggests, we can see ourselves a sum of fragments, with the particularity that, at times, we can see some of these fragments only through the reflection provided by other people. This is becoming particularly apparent nowadays, with the advent of the social networks, in which one’s own identity becomes blurred, broken down into multiple fragments, each with its own small portion of reality.

ACTIVITIES PARALLEL TO THE EXHIBITION

The exhibition ecosystem: temporary exhibitions presented at CosmoCaixa are all linked a series of activities and workshops, both for the general public and for schools groups, which enable participants to obtain more transversal knowledge of the particular subject.

The activities organised during the exhibition a *Mirrors: Inside and Outside Reality* are as follows:

Season of lectures, Thursdays throughout May

The purpose of the lecture season ***Journey through symmetry (and more) in knowledge*** is to help participants explore the exhibition content in greater depth.
In the five lectures, mathematics speaks to museology and different artistic expressions – visual art, film, literature – generating imperfect symmetries and a complex, kaleidoscopic vision of culture and life.

- **The museum looks at itself in the mirror.** Speaker: Guillermo Fernández
- **Symmetry: art, architecture and mathematics.** Speaker: Capi Corrales
- **Mathematics in film.** Speaker: José María Sorando
- **Physical and symmetrical harmonies.** Speakers: Francina Turon and Joan Jareño
- **Through the looking-glass: a mathematical look at literature.** Speaker: Marta Macho

Guided tours of the exhibition

Weekends, public holidays and school holidays

Family workshops, from June 22

- **What is on the other side of the mirror?** In summer, from June 22 to September 11
- **Light boxes.** Weekends, public holidays and school holidays, from June 22 and until December 15

Special activities – International Museum Day and summer activities

International Museum Day weekend (Saturday and Sunday, May 18 and 19)

- Explore: **Kaleidoscopes**
- Show: ***No sap pas on***

CosmoNits de pel·lícula (CosmoNights at the Movies), Thursdays throughout July and August

- **Ready Player One.** Steven Spielberg, USA, 2018
- **Being John Malkovich.** Spike Jonze, USA, 1999
- **Your Name.** Makoto Shinkai, Japan, 2017
- **Inception.** Christopher Nolan, USA, 2010
- **Alice in Wonderland.** Walt Disney, USA, 1954
- **Matrix Reloaded.** Lilly and Lana Wachowski, USA, 2003

Activities for schools groups, throughout the academic year

- Research mornings (lectures for students): **What does a mirror reflect? From the remote universe to the interior of a cell**
- Workshops: **Touch the light; Light and colour; Between light and shade: experiments with light**

Activities for summer club, July 2-19

- Workshop: **The Other Side of the Mirror**

Mirrors: Inside and Outside Reality

From 12 April 2019 to 26 January 2020

Official opening: Friday, April 12, at 1 pm (by invitation)

CosmoCaixa (C. d'Isaac Newton, 26, Barcelona)

Times: Monday to Sunday, from 10 am to 8 pm

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