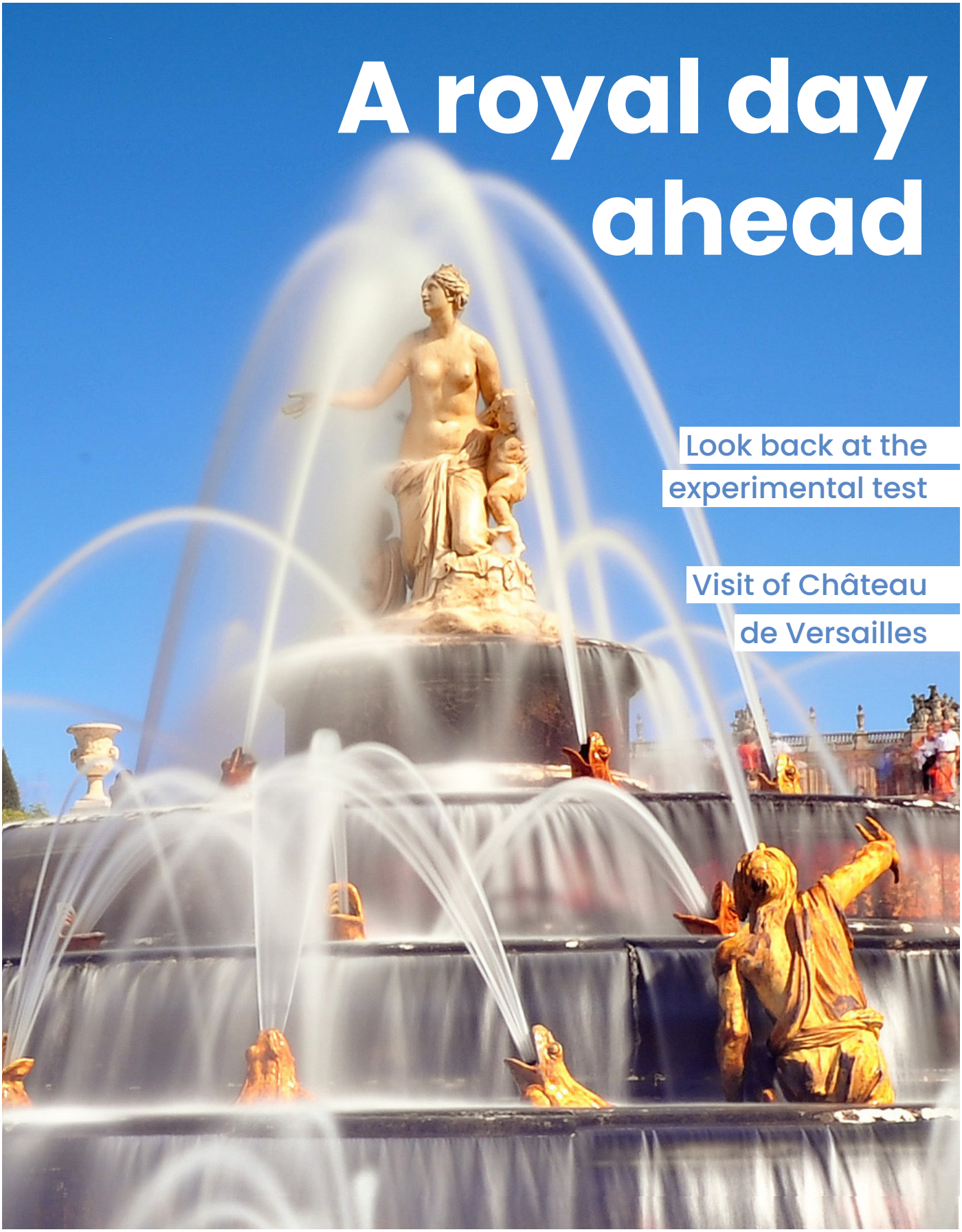
N°3
Sunday, July 20TH

# —PHYSICS—
## BEYOND FRONTIERS

International Physics Olympiad
FRANCE 2025



# A royal day ahead

Look back at the experimental test

Visit of Château de Versailles

# EDITO

The International Physics Olympiads (IPhO 2025) is taking place in France this year, under the auspices of the «Société Française de Physique», the «Ministère de l'Éducation Nationale, de l'Enseignement Supérieur et de la Recherche», the «Institut Polytechnique de Paris» and the «École polytechnique».

This prestigious competition gathers talented secondary school students from the entire world and is a magnificent way to promote excellency in physics, offering an opportunity to demonstrate competence, critical thinking and knowledge.

One feature of the competition is that the examination combines an experimental part and a theoretical one. This is a very important trait as it reflects the existence of two pillars in the physical science: theory and experiment, both having a constant interplay. Experimental physicists need the theorist's input to interpret their data, and theoretical physicists need experimental data to guide them. Theory and experiment progress hand by hand with common aim to understand Nature. Sometimes an experimentalist observes a phenomenon, and a theoretician is the one to explain it. And some other times, it goes the other way around. A theorist predicts a phenomenon, and the experimentalist is the ones who confirms its occurrence.

Another important aspect of the International Physics Olympiad is emulation beyond frontiers. It was initiated in Europe but gained impetus over the years and is now gathering teams from all continents. The international nature of the event is indeed one of its fundamental features, as this is the essence of science: it does not recognise borders. Science is a universal language allowing people from different cultural, political, and socio-economic backgrounds to communicate and collaborate towards common targets. Science has the power to unite people knocking down all boundaries.

As a side effect the laureates gain a worldwide recognition. IPhO is recognised as a talent detector, and this will help them if they choose to embark in a scientific career.

For all these reasons, the European Physical Society -- a federation of national societies aiming on advancing scientific excellence and influencing science policy -- strongly encourages IPhO and heartfully welcomes the participants to this 55$^{th}$ edition, wishing them success in that wonderful enterprise.

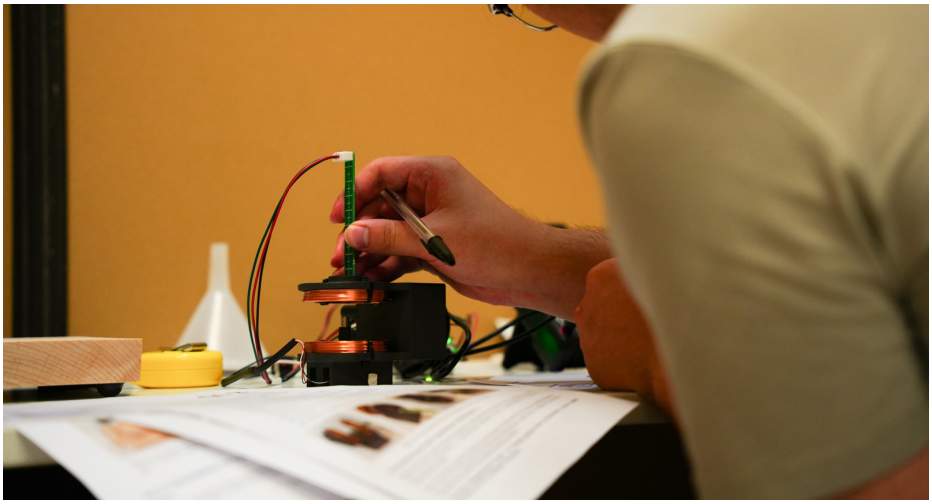
**Mairi Sakellariadou**

President of the European Physical Society (EPS)

Professor of Theoretical Physics, King's College London

# YESTERDAY'S HIGHLIGHTS

## Look back at the experimental test



### The Gouy balance

Louis Georges Gouy (1854-1926) was a French physicist born in Vals-les-Bains, in the Ardèche department of France. He is best known for the Gouy phase, which is the gradual phase shift acquired by a beam of light around its waist, a phenomenon used in particular to describe Gaussian beams. Gouy also invented the Gouy balance.

The Gouy balance is based on the principle that when a sample is placed in a non-uniform magnetic field, it experiences a force proportional to its magnetic susceptibility. This force causes an apparent weight change that can be measured with a precision balance. In the classic setup, a cylindrical sample is suspended vertically, with one end immersed in an intense magnetic field and the other end not. The sample may be in solid or liquid form. A paramagnetic material is attracted to the stronger field region, while a diamagnetic material is repelled.

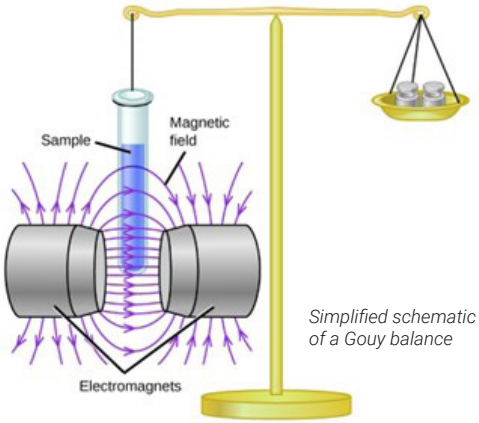
The magnetic force exerted is related to the volumetric magnetic susceptibility through a relationship involving the magnetic field gradient. By measuring this force, one can determine the volumetric magnetic susceptibility of the material being studied.

In practical experimental devices, the balance and magnet assembly are enclosed in a glass box to prevent air currents from affecting the weight measurement. The sample can also be enclosed in a thermostat to enable temperature-dependent measurements.

Though mainly used today for educational purposes, the Gouy balance remains a simple method for quickly determining the paramagnetic or diamagnetic properties of a sample.

### Exploring Mars in the lab

NASA's Spirit rover landed on a crater of Mars in 2004, explored its environment for a few years, and finally got stuck in sand. The second experimental problem for the 2025 IPhO raises two related questions on the physics of granular media: i) What is the size of an impact crater? ii) What is the mechanism for friction in sand? The "mystery box" provided to the candidates contains fine sand from the nearby Fontainebleau region and a series of steel balls to answer these challenges experimentally.




*Simplified schematic of a Gouy balance*

*Figure: Drop small objects in sugar and invite Mars in your kitchen!*

By dropping balls of various sizes from different heights, the candidates formed craters in the sand. The crater diameter increases with the energy of the impact in a way that reflects the physical mechanism at play: upon impact, the volume of sand put in motion is elevated by about one crater diameter.

Friction is investigated by letting balls roll on a carefully prepared bed of sand. The IPhO candidates showed experimentally that the stopping distance of a ball is proportional to the initial kinetic energy. The kinetic energy of the ball is dissipated by an analogous of the solid-like friction mechanism first clearly formulated by Coulomb, a French physicist and engineer.

The IPhO candidates discovered that minimal table top experiments may be as challenging as they seem simple! Reducing a complex and remote system to its essential physical components, one may perceive the universal in it. Throughout the experimental part of the competition, the students learned another universal fact: one is never too old to play in a sandbox!

# Science lectures at the IPhO: big challenges ahead

After a well-earned break, all the IPhO participants gathered in the stunning Poincaré amphitheatre at École polytechnique for four awesome lectures. The atmosphere was a mixture of joy, excitement and exhaustion after the morning exams.

First up was Vincent Brion from ONERA, the French aerospace lab. He explained how humans have struggled for centuries to master flight. Today, aircrafts are very efficient- almost as good as birds! But unlike birds, they leave behind contrails (those artificial clouds behind planes), which are actually a threat to climate. Figuring out how to reduce or eliminating that is a big research challenge.

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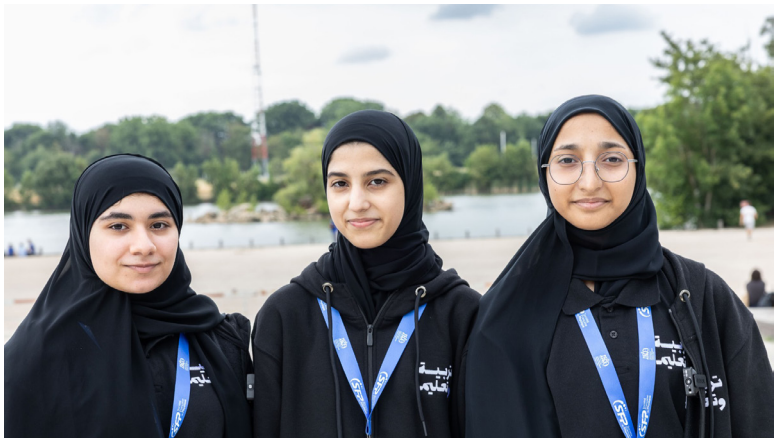
Next, Sylvie Richard from EDF talked about nuclear energy and how it can help fight climate change. She introduced new types of reactors—like microreactors and molten salt reactors—that could change the game, even if they're still in development.

Then came Pierre-Olivier Lagage, who spent 25 years working on the James Webb Space Telescope. After detecting exoplanets, scientists starting wondering:  is there an atmosphere surrounding the exoplanets? Answering these question is one of the objectives of JWST mission. Mr. Lagage wowed everyone with infrared camera demos.

Last but not least, Emmanuelle Gouillart from Saint-Gobain made us enter the wonderful world of glass. She introduced innovative technologies developed at her company - inspired by igloo and cotton candy - to reduce $CO_2$ emissions of glass manufacturing and of buildings.

Each speaker wrapped up by encouraging students to join the adventure in their field. The future of physics is wide open!

# TODAY'S PREVIEW

## Visit of Versailles and Jane street evening

### Physics meets history

Louis XIV understood early on that knowledge was a tool of power. In 1666, he founded the Royal Academy of Sciences, followed by the Paris Observatory in 1667. These institutions established a contract with scientists: with an income and the freedom to pursue their research, they were required to serve the State in order to meet the kingdom's pragmatic objectives. These included astronomy for navigation, geometry and chemistry for artillery, geodesy and cartography for cadastral and tax purposes, medicine and apothecary for public health, botany and agronomy to combat famine, and of course physics for its technical applications.

The French Academy of Sciences still exists within the Institut de France. It encourages and protects the spirit of research and contributes to the progress of science and its applications.

Versailles is then much more than a place to live. King Louis XIV wanted to make it a showcase for French artistic, scientific and technical knowledge. The aim was to amaze visitors, especially foreigners, with innovations that enhanced the buildings and gardens, but also to provoke astonishment with experimental demonstrations conceived as shows. Astronomy, queen of the sciences, is present everywhere in the decor of the Palais.

During your visit, try to notice all these small and large testimonies to science at Versailles!

## #Recap : scientific experiments at Versailles

### Under king Louis XIV (1643-1715)

**1666:** King establishes the Royal Academy of Sciences

**1667:** King establishes the Paris Observatory

**1670:** Fiery mirror experiment: with a mirror approximately one meter in diameter and a candle at the mirror's focus, the king saw the entire small gallery illuminated, as well as the possibility of melting metals at the focus of a mirror facing the sun.

**1681:** The construction of the Marly machine began. It was to bring water from the Seine (10 km away) over a 150 meters drop (15 bars of excess pressure required) to supply all the park's fountains and water jets. The 14 (number of Louis XIV!) submerged paddlewheels drove the pumps. This hydraulic engineering made it possible to achieve the feat of the 'Grandes eaux' (Great Waters).

**Between 1645 and 1715,** it was the Little Ice Age, partly due to low solar activity (Maunder Minimum): winter ice was kept covered with straw in wells to make sorbets in summer (in the absence of ice cream makers!).

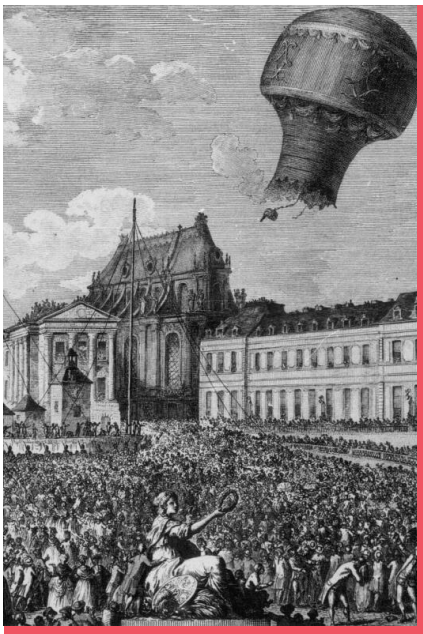
## Louis XV (1715-1774): watching the solar eclipse in the gardens

**May 22, 1724:** The court gathered around the young King Louis XV in the gardens of the Grand Trianon to observe a total solar eclipse. Astronomers, including Jacques Cassini, director of the Paris Observatory, were able to measure a 2 degree drop in temperature during the 4-minute totality phase. Meanwhile, the king and his courtiers were able to marvel at this fascinating spectacle of Nature.

One lady of the court, very concerned about her appearance, took so long to get ready that she arrived late and missed the event. Very disappointed, she asked if the event could be repeated. Alas for her, the next total eclipse visible at Versailles will take place in 2081!

**1743:** To save a lady from staircase fatigue, a 'flying chair', the first elevator, was built, operated by a cable connected to a system of pulleys and counterweights. Scientific shows were all the rage at the Court, in particular the electricity experiments of Abbé Nollet in the mid-18th century and, later, automatons, the forerunners of robots.

**1746:** 1st experiment with electricity in the Hall of Mirrors: 140 people and Abbé Nollet join hands to feel the electric concussion.



## Louis XVI (1774-1792)

**September 19, 1783:** A great spectacle with the ascent, in 1783, of a hot-air balloon designed by the Montgolfier brothers. An eight-minute flight carried a sheep, a duck and a rooster to an altitude of 500 meters. The event was a complete success, especially as it was attended by foreign delegations who had come to sign the Treaty of Paris…

1784 : Presentation of the dulcimer player, forerunner of robots. The automaton was created by a German clockmaker, Peter Kinzing, and the Queen's cabinetmaker, David Roentgen. The automaton, about 45 centimeters high, stands in front of a wooden table on which a dulcimer rests. Its operation is based on a brass cylinder driven by a spring mechanism, concealed both in the musician's body and in the table. As it rotates, this cylinder sets in motion cams that control arm and head movements. The instrument is actually played: the mallets held by the figure strike the strings directly, producing the sound. Its manufacture mobilized some one hundred craftsmen from 26 different trades, illustrating the pinnacle of technical know-how at the time.

The automaton's hair is said to be the Queen's, and its dress is said to have been sewn from one of her gowns.

## The hole in the window

Louis XVI was staunch in science: chemistry, astronomy, mechanics, geography and so on. He loved making sophisticated mechanisms for locks and other mysterious boxes.

He had a telescope to observe the stars, but also to watch the equipages riding up the wide avenue leading to the Château.

In a window on the second floor, just to the right of the marble courtyard pediment, it was possible to see the circular hole that enabled him to position his optical instrument.

Unfortunately, in 2019 and 2020, all the windows of the Château were restored and the glass replaced. The observation hole has now disappeared. Let's hope the glass has been preserved somewhere.

# Animation by Jane Street

Jane Street

And the day will continue with a fun-filled evening hosted by Jane Street at Espace Charenton, Paris.


AUSTRIA

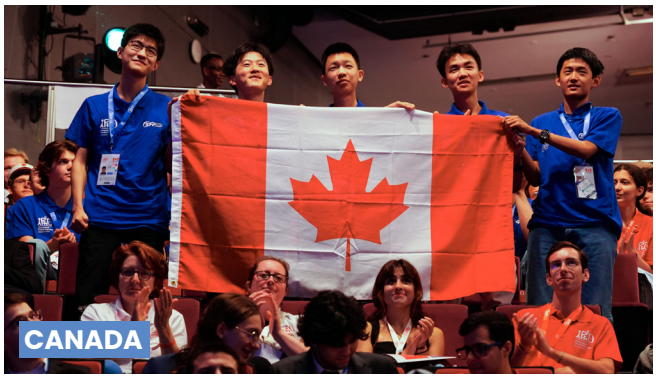

COLOMBIA


L'ABUS D'ALCOOL EST
HONG KONG


KUWAIT


MACAU


CZECHIA


CANADA


SWEDEN

# Physics on this day

## JULY 20, 1823

### Commissioning of the first Fresnel stepped lens in Cordouan lighthouse (Gironde, France).

Until the 19th century, lighthouses used large metal mirrors to focus the light beam, which, in addition to their mass, absorbed part of the radiation. In 1820, Augustin Fresnel (1788 -1827), a member of the lighthouse commission, proposed the use of a lens made of several annular parts, engraved in scale (to reduce the mass to be moved), a system already proposed in 1748 (creation of large lenses).

The first lighthouse to be equipped with this lens (80cm square and 92cm focal length) was Cordouan in the Gironde estuary.

# Schedule

## Sunday, July 20

### Students

**10:00AM – 3:00PM:** Cultural visit
Château de Versailles

**4:00PM – 8:00PM:** Jane Street activity
Espace Charenton, Paris

### Leaders & observators

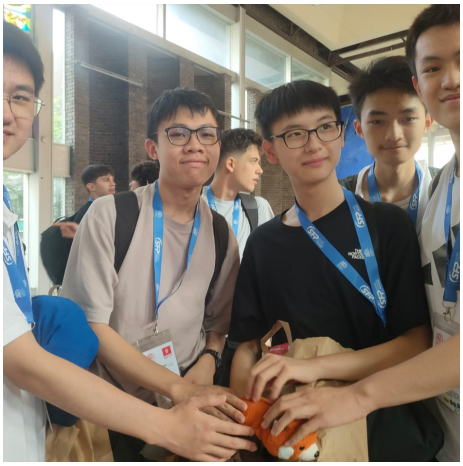
**9:00AM– 12:30PM:** Theoretical Exam Discussion
Ecole polytechnique BEM

**2:00PM – 7:30PM:** Theoretical Exam Discussion

**9:00PM – 5:00AM:** Theoretical Exam Discussion (continued)

# The quirky pic'

## of yesterday



Lucky blanket!

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Société Française de Physique

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