Physics on the Infinity Canvas

A new tool for popularization and pedagogy

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On behalf of

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https://infinity-canvas.in2p3.fr/en/

The project and the tool

- The tool is based on **sets of printed cards** with texts and illustrations.
  - The **Science** set: Theoretical and experimental discoveries across centuries (70 cards in 7 thematic packs).
  - Other sets: Open questions (6 cards), Scientists (41 cards), Technologies (26 cards), Scientific instruments (27 cards), and Sci-fi "technologies" (5 cards).

- The tool can be used to explore **major physics discoveries** and **connections** between them.
  - The cards cover physics from ancient Greece to modern times along a time dimension.
  - The cards cover physics from the infinitely small to the infinitely large along a scale dimension.
  - The connections can highlight explanations, confirmations, refutations, unifications…
  - The text on each card suggests (quite clearly) these connections.

- **Inclusive approach**: Scientist cards actively highlight women's contributions to physics. (15 cards for women out of 41)
  With the help of *Petit dictionnaire illustré des femmes scientifiques*, by Adeline Crépieux (CPT), 2023.

Who did it?

- Created by a **collective of scientists and communicators** from **CPPM** and **CPT**.
  (CPPM = Centre de Physique des Particules de Marseille; CPT = Centre de Physique Théorique)

- **Current Team Members:**
  - Jérôme Charles (CNRS researcher, CPT)
  - William Gillard (AMU teacher-researcher, CPPM)
  - Yohann Lebouazda (AMU PhD student, CPT)
  - Thierry Masson (CNRS researcher, CPT; Project Coordinator)
  - Elisabeth Petit (CNRS researcher, CPPM; Gender Parity Referent)
  - Simon Rouvet (AMU PhD student, CPT)
  - Magali Damoiseaux (CNRS engineer, CPPM; Project Coordinator)
  - Paola Bertelli (CNRS engineer, CPPM; International Relations)

- **Graphic design:**
  - Camille Combes (Agence Ouvreboîte)

Some cards: Science set

1933 | 21 → 23

The First Clues of Dark Matter

Fernando Pena, CC BY 2.0, via Wikimedia Commons

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6 – THE INFINITELY LARGE

1933 | 21 → 23

OBSERVATION

In 1933, Fritz Zwicky observed gravitational anomalies in a cluster of galaxies. These anomalies were inexplicable by the presence of visible matter alone within the framework of General Relativity. To explain these observations, he proposed the existence of invisible matter, thus anticipating the concept of *Dark Matter*.

Later, other clues of Dark Matter would be observed in the rotation speeds of galaxies.

The gravitational anomaly detected by Zwicky concerns the velocity dispersion of 7 galaxies in the Coma cluster. This dispersion depends on the mass distribution according to a law similar to the 3rd law of Kepler.

from 1930 to 1950 | -18 → -10

Quantum Electrodynamics

Phys. Rev. Lett. 109, 171807

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5 – THE INFINITELY SMALL

from 1930 to 1950 | -18 → -10

THEORY

***Quantum Electrodynamics* describes how light and matter interact together. Developed in the 1940s, it combines a quantum version of Maxwell's Electromagnetic Theory and the Relativistic Wave Equation of Dirac. This theory describes electromagnetic interactions with great precision.**

Quantum electrodynamics is now integrated into the Standard Model of Elementary Particles.

In 2007, Quantum Electrodynamics agreed with the measurement of the anomalous magnetic moment of the electron to within 10^{-8}.

- Time (dates) and Scales (lengths in meters in powers of 10) are provided on cards.
- = Main text = Supporting link information (Optional) = Further details (Optional).

Some cards: Other sets

1928 – 2016

Vera Rubin (*née* Cooper)

AIP Emilio Segrè Visual Archives, Rubin Collection

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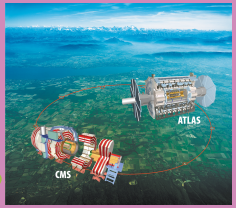
SCIENTIST

2008

The ATLAS and CMS Detectors



2009-2021 CERN

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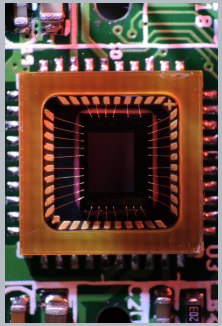
SCIENTIFIC INSTRUMENT

1969

The CCD camera



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TECHNOLOGY

Antimatter Engine

StarTrek Franchise

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SCIENCE FICTION

- Different colors for sets.
- No “time” information for sci-fi cards

We hold the cards, now what?

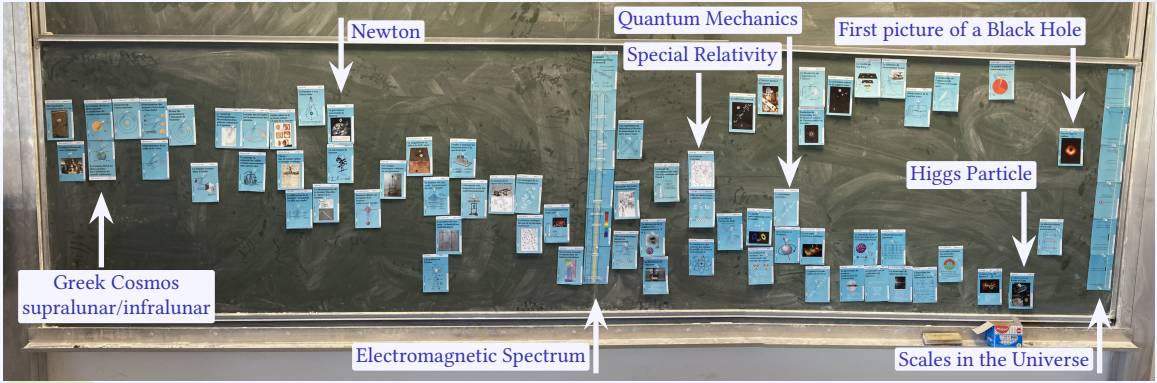
Animation of the “full game” version

- **A workshop lasting about 3 hours:**
  - Can be integrated into some outreach or educational program (e.g., summer camp, integration week).
  - A facilitator who is familiar with the physics in the cards (but not an expert).
  - A group of participants (between 5 and 10).
  - Divided into **two distinct phases**.

- **The mapping phase (1h30):** 💡
  - Participants collaboratively arrange the **Science** cards onto a **large “canvas”** (e.g., a blackboard with magnets).
    - Time along horizontal axis (from ancient Greece to modern times).
    - Scale along the vertical axis (from the infinitely small to the infinitely large).
    - The facilitator introduces thematic card packs one by one ➞ The canvas is built step by step by the group.
  - The mapping is driven by **group collective intelligence**: exchanges, discussions, decisions…
  - The facilitator acts as a guide to encourage collaborative learning but not as a lecturer.
    - Information provided in the card texts are sufficient to build the canvas.

- **The debriefing phase (1h30):** ✨
  - Use the canvas created as a support to spark an **interest in physics** or motive **activities in physics**.
  - The facilitator is **free to chose how to manage discussions**, using the thematic card sets or her own material. (e.g. Scientists, Technologies, Scientific instruments)

The mapping phase on a blackboard



- Links between cards are not drawn here (*mapping phase* not yet complete).
- Some cards assemble into a unique larger panel.
  Greek Cosmos (2 cards), Electromagnetic Spectrum (5+1 cards), Scales in the Universe (6 cards)

Animation of the “quiz game” version

- **Drop-in interactive session** for passing public (e.g., a science festival).
- Based on a smaller set of pre-arranged cards on a portable display.
- The facilitator interacts with the public to stimulate the discovery of relations between cards.

- Featured in the main hall of the conference, with animations on Tuesday and Wednesday (in French).

Our target audience

- **Initial Focus:** High school level and above.
  - We are in the process of establishing contacts with teachers to reach lower educational levels.
- **General Public:** Positive feedback from the quiz version at the 2024 *Fête de la science* in Marseille (literally "French Science Festival", pictures on previous slide).
- **Education:** Well-received by teachers in schools and universities.
  - **Secondary School Teachers**: Discussions are initiated with some pedagogical specialists.
  - **University Students**: Discussions are initiated with academic program directors (Bachelor's and Master's).
  - Need for a set of cards on "jobs in physics" (color already attributed, need only to write the cards…).

How is it produced?

https://infinity-canvas.in2p3.fr/en/

LaTeX (with TikZ) + Python

- Cards are written in LaTeX (TikZ's externalization library).
- Many illustrations are produced using TikZ (migration in progress for others illustrations).
- Python scripts automate the production of print-ready PDF files.
- **(Compile) Print (Cut) & Play!**

Open-source project

- Creative Commons License CC-BY-NC-ND.
- Git repository for collaborative work.
- Does not depend on proprietary software or resources (e.g., we use *Libertinus* fonts).
- The cards can be freely downloaded from the Git repo.

Translation process implemented

- Python script helps to get an *initial translation* from any Large Language Model (LLM, generative AI tool).
- English translation completed, German translation currently underway.
- Future languages to be developed (you are welcome).

How can you get involved?

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- **Become an Ambassador**: Promote the workshop within universities, schools, and outreach events.
- **Become a Facilitator**: Receive (short) training to lead workshops.
- **Become a Developer**: Contribute to the technical evolution of the tools (LaTeX, Python…).
- **Become a Content Creator**: Contribute to improving existing cards or creating new ones.
- **Become a Translator**: Help adapt the tool into new languages.

The future

- **Establish a Scientific Council**
  - It will ensure a quality control of the scientific and societal content.
  - It will include researchers, research support staff, and secondary school teachers.
  - It will be open to international collaborators for broader diffusion.
- **Develop the dedicated website**
  - Central hub for community contributions and exchange.
  - Multiple entries: large public, facilitators, teachers, and content creators.
  - Available in several languages.
  - Create complementary materials for the cards: wiki-style articles, video capsules…
- **Develop scientific content and scope**
  - Develop new animation methods.
  - Expand the content to include physics at intermediate scales.
  - Explore the adaptation of the tool for other scientific disciplines (e.g., Mathematicians already interested).

Thank you!


La Fresque des deux infinis
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(graphic designer)