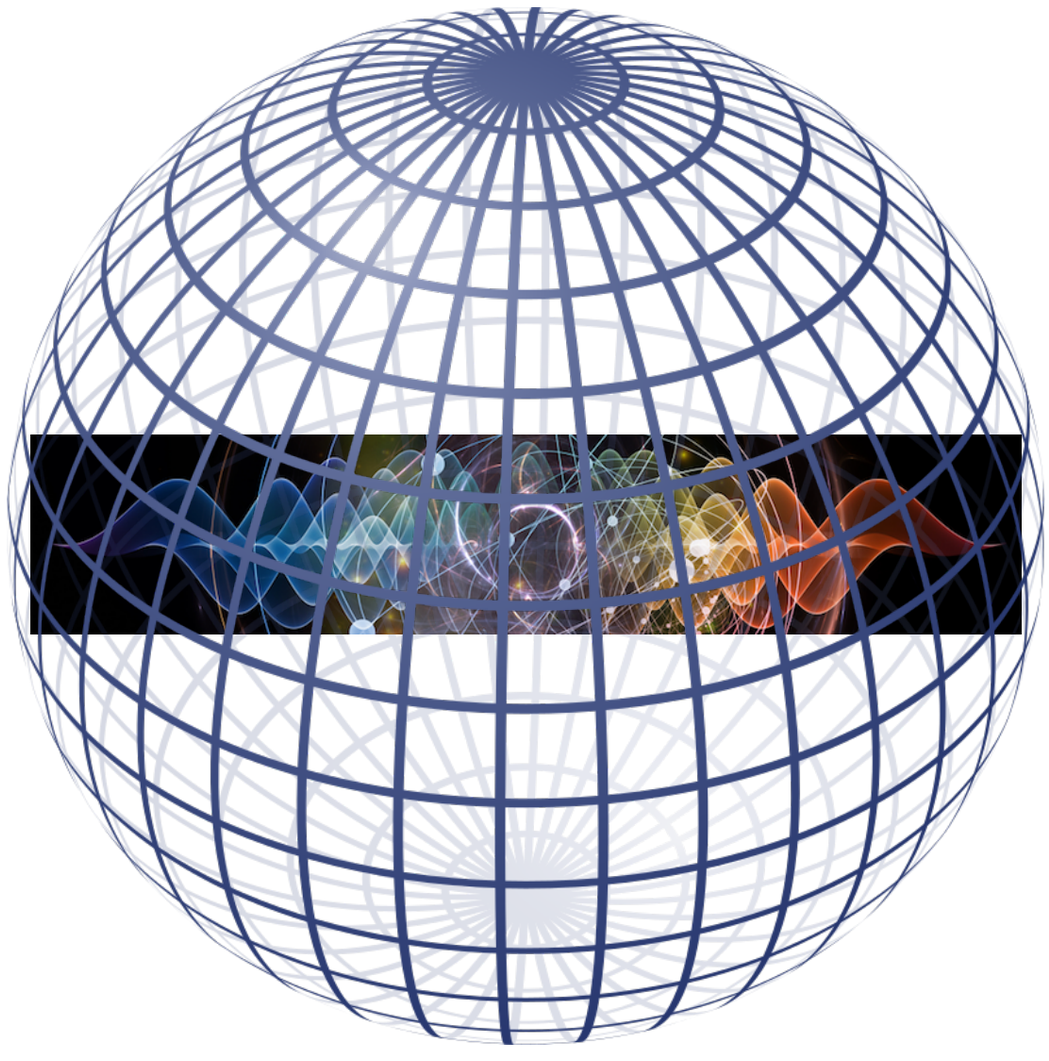
Theoretical Physics

A combination of Mathematics, Physics, and Philosophy

$$a^2 + b^2 + c^2 = d^2$$



$$E = mc^2$$

$$e^{i\theta} = \cos(\theta) + i\sin(\theta)$$

Hosted by Dr. Pierros Ntelis and IBS

Speakers: Prof. Thierry Martin and Dr. Aiofe Bharucha

Dr. Pierros Ntelis

2008-2013, Bachelor of Applied Mathematics and Physics
at National Technical University of Athens, Greece
2013-2014, Master in Astrophysics & Cosmology
at University of Paris, France
2014-2017, PhD in Fundamental Physics & Cosmology
at University of Paris, France
2018-2020, PostDoc in Observational Cosmology
at Aix-University, CPPM, France
Since 2022, Teacher of Math and Physics at IBS

Specialised in
- Astrophysics
- Cosmology
- Teaching Math and Physics

Dr. Bharucha Aoife

2002-2006 Bachelor/Master: University of Oxford, UK
2006-2010 PhD: Institute of Particle Physics Phenomenology
Durham University, UK
2010-2014 Postdocs: Hamburg University
Technical University Munich Allemagne
2015-Present Chargé de recherche,
Centre Physique Théorique, Marseille

Specialised in
- particle physics,
- interactions between quarks (flavour physics)
- dark matter.

Prof. Thierry Martin

Born 26/10/1962
Bachelor at Ecole Polytechnique Fédérale de Lausanne
Master and PhD of physics at University of California Los Angeles
Postdoc 1: IBM T. J. Watson Research Center, New York
Postdoc 2: Los Alamos National Laboratory
Postdoc 3: Institut Laue Langevin, Grenoble
since 1996: Professeur des Universités (2ème classe, 1ère classe, puis classe exceptionnelle)

Specialised in
- theoretical condensed matter physics,
- mesoscopic physics/quantum nanophysics
- electronic transport in nanostructures

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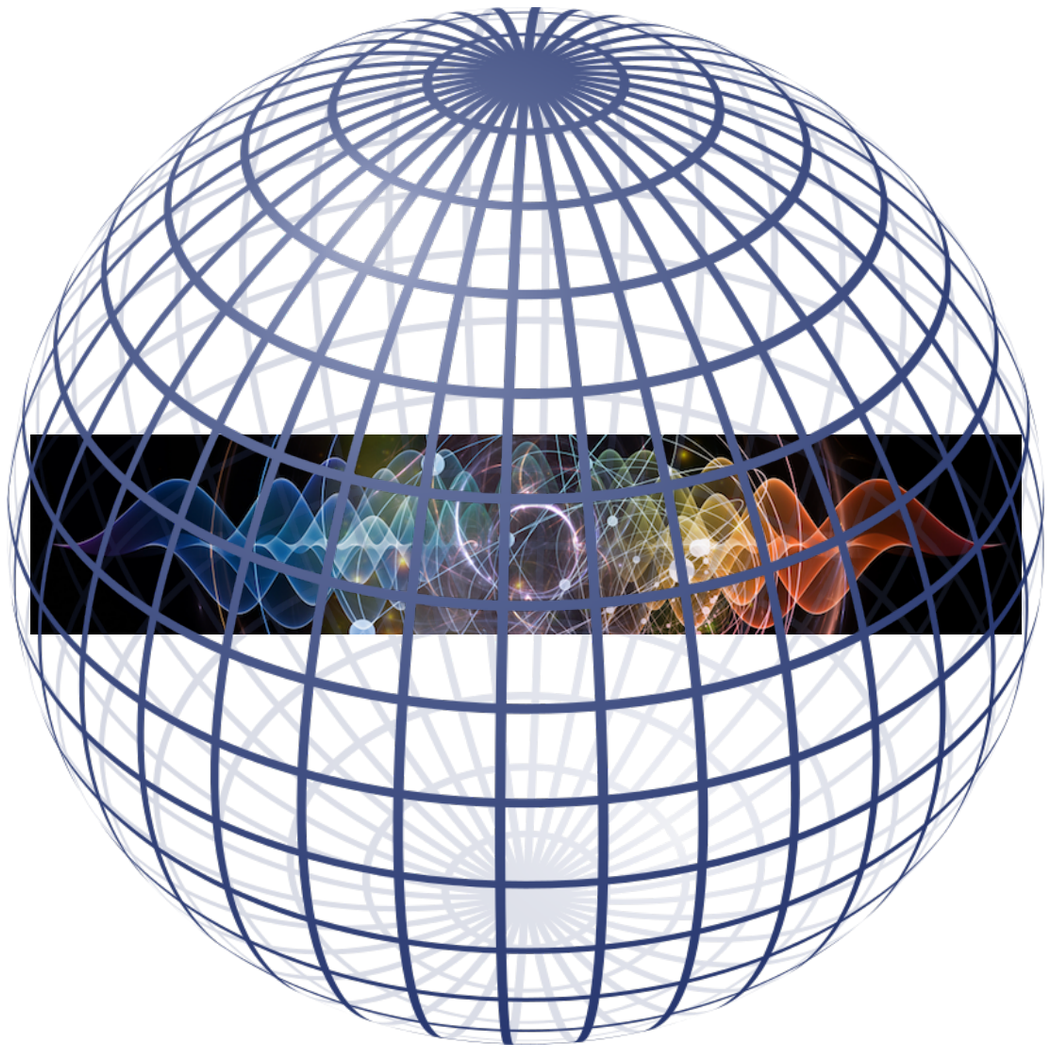

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Philosophy originates from the greek word, ***φιλοσοφία***
Which is a compound word, composed by
The word ***φιλο-, friendly,*** *and word,* ***-σοφία, wisdom.***
Ergo, philosophy means being ***friends with wisdo*****m**

Look at :
- Theory of Knowledge (TOK)
- Global perspectives (GP) courses

Officially, modern Philosophy is the study of general and fundamental questions:

abstraction, existence, reason, knowledge, values, mind, and language.

Such questions are often posed as problems to be studied or resolved.

Mathematics

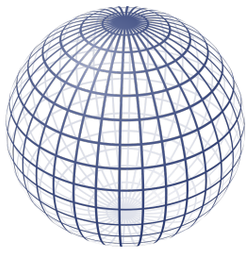
Mathematics (μαθηματικά) originates from the greek word, μάθημα, which means learning.

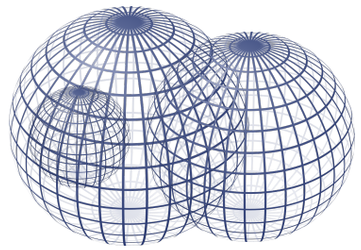
Axioms . / $1 \in \mathbb{N}, \pi \simeq 3.14 \in \mathbb{Q}', e^{\pi} \in \mathbb{R}, e^{i\pi} \in \mathbb{C}$ Numbers

$(a \pm b)^2 = a^2 \pm 2ab + b^2$ Algebra

Functions $f(x) : \mathbb{R} \to \mathbb{R}^+$

$f'(x) = \frac{\partial f}{\partial x}$





Geometry

Derivatives $f''(x) = \frac{\partial^2 f}{\partial x^2}$

$\ldots = \ldots$

$f^{(n)}(x) = \frac{\partial^n f}{\partial x^n}$

Sets

$f'(x) = \lim_{h \to 0} \frac{f(x+h) - f(x)}{h}$ Limits

Integrals $F(x) = \int_0^x f(s)ds$

$P(x; \mu, \sigma) \propto e^{-\frac{1}{2}\left(\frac{x-\mu}{\sigma}\right)^2}$ Probabilities

Statistics $\lim_{s \to +\infty} \int_{-s}^{+s} dx P(x) = 1$

$a^2 + b^2 + c^2 = d^2$ Theorems

with proofs !

Physics

Physics (φυσική) originates from the greek word, φύση,
and it means the study of nature.

Newton 2nd Law of motion

$$F = ma$$

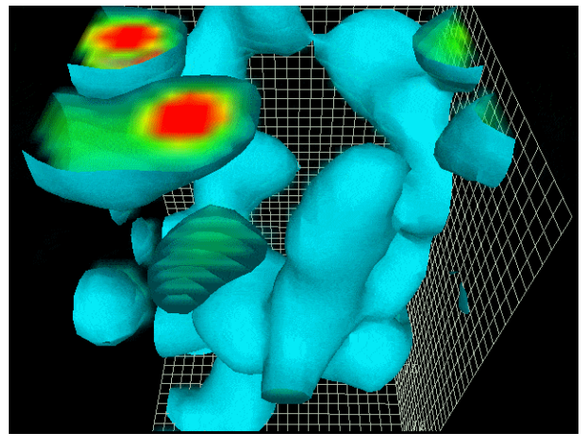
$$\frac{\partial p}{\partial t} = m\frac{\partial^2 x}{\partial t^2}$$

Quantum mechanics (Special Relativity)

Energy is a manifestation of **matter**

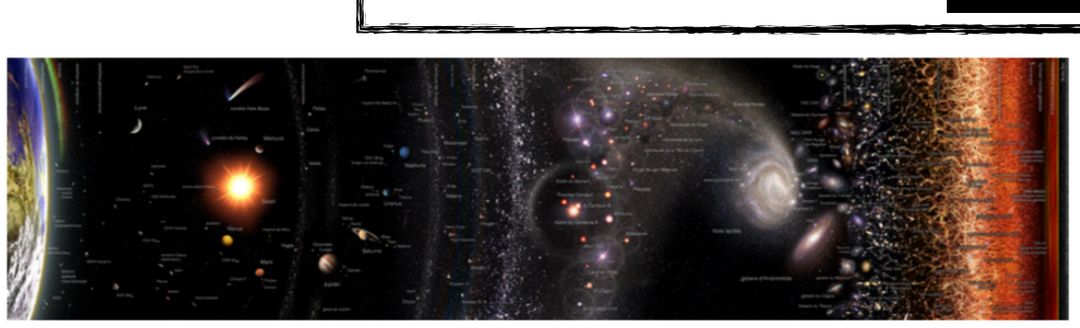
$$E = mc^2$$

Small world



Cosmology

is the study of the smallest to largest objects



Electric force

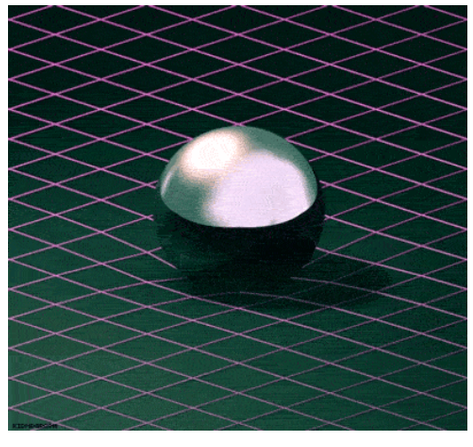
$$F_{12} = k_e \frac{q_1 Q_2}{r_{12}^2}$$

Gravity (General Relativity)

Geometry is a manifestation of **Energy**

$$G_{\mu\nu} \simeq E_{\mu\nu}$$

Large world



Physics; Cosmology

To describe and explain their positions, movement and properties, we use experimental and theoretical physics, including:

cosmology, condensed matter, and particle physics

Functor of actions (S_{FA}) for high school students

Functor (F) is the generalisation concept of functionals

Functionals is the generalisation concept of functions

Action (S) in physics is a quantity which is the product of energy with time.

Action is a quantity which tell us the amount of possible ways a particle can travel from one point to another within a certain region

Functor of actions (FA) predict the possible existence
of the **actionic fluctuations and field-particles**
which are analogues
of the **energetic fluctuations and field-particles,** in nature.

$$\mathcal{S}_{\mathrm{FA}} \supset \int_{\Omega_{\mathrm{S}}} dS' \supset \qquad S = \int dx \mathcal{L}$$

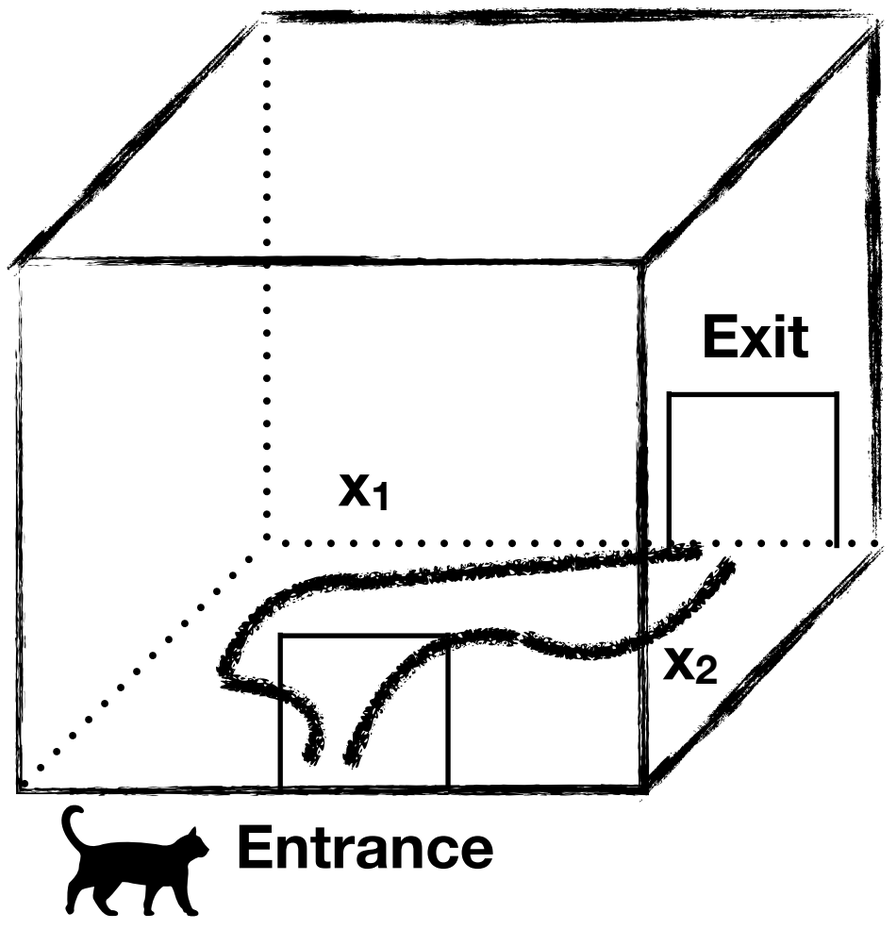
PN and A.Morris, Functors of Actions, Foundation of Physics Journal '23 (2010.06707)

Actionic field interpretation
Action answers to the question :

There is actually an actionic field everywhere

What is the number of all possible routes a cat can use to pass through each room ?

N = 2



x_1 is possible for both rooms, x_2 is not possible for the 2nd room

space, x

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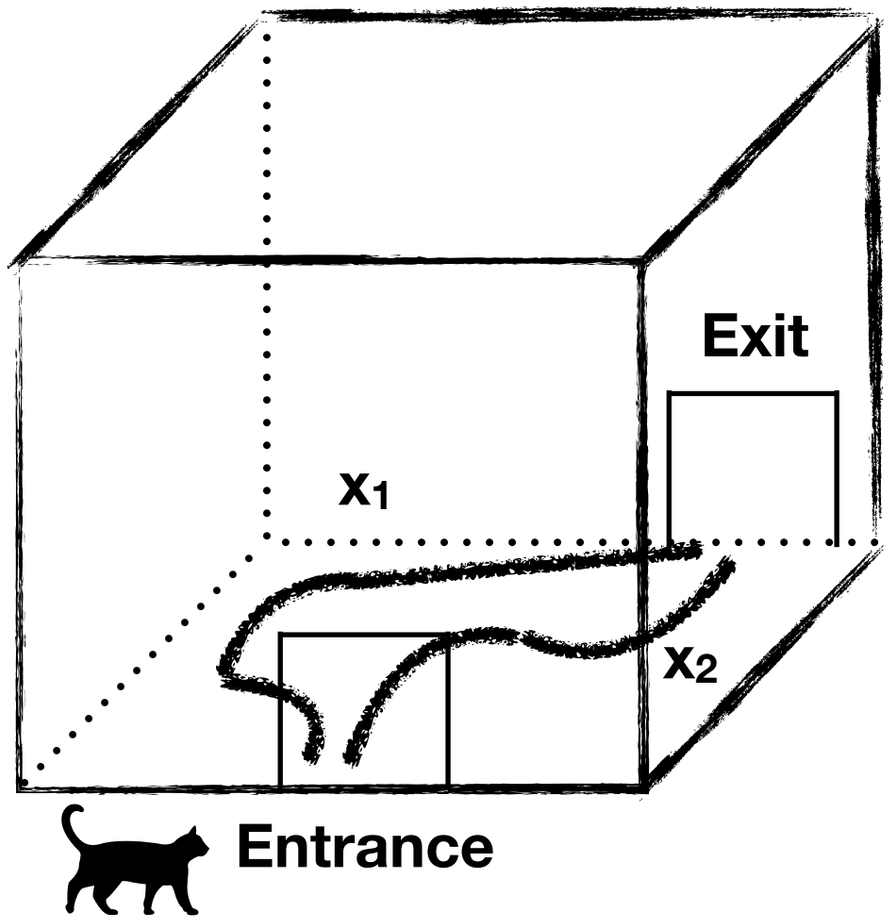
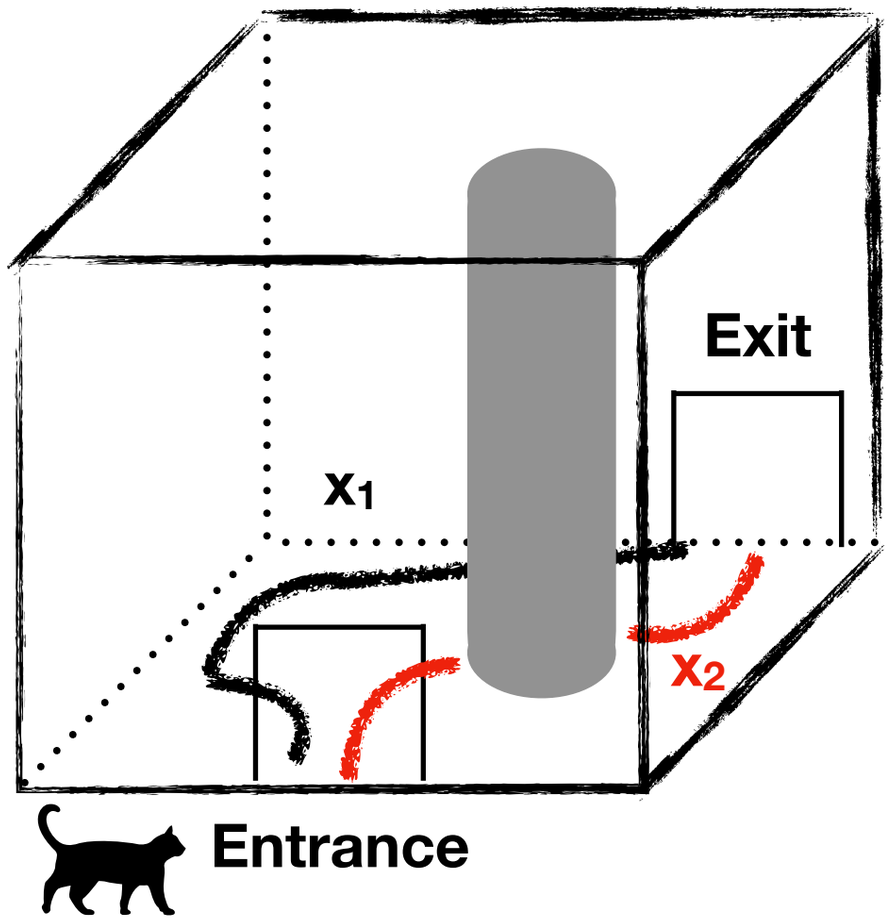


N-n
2-1



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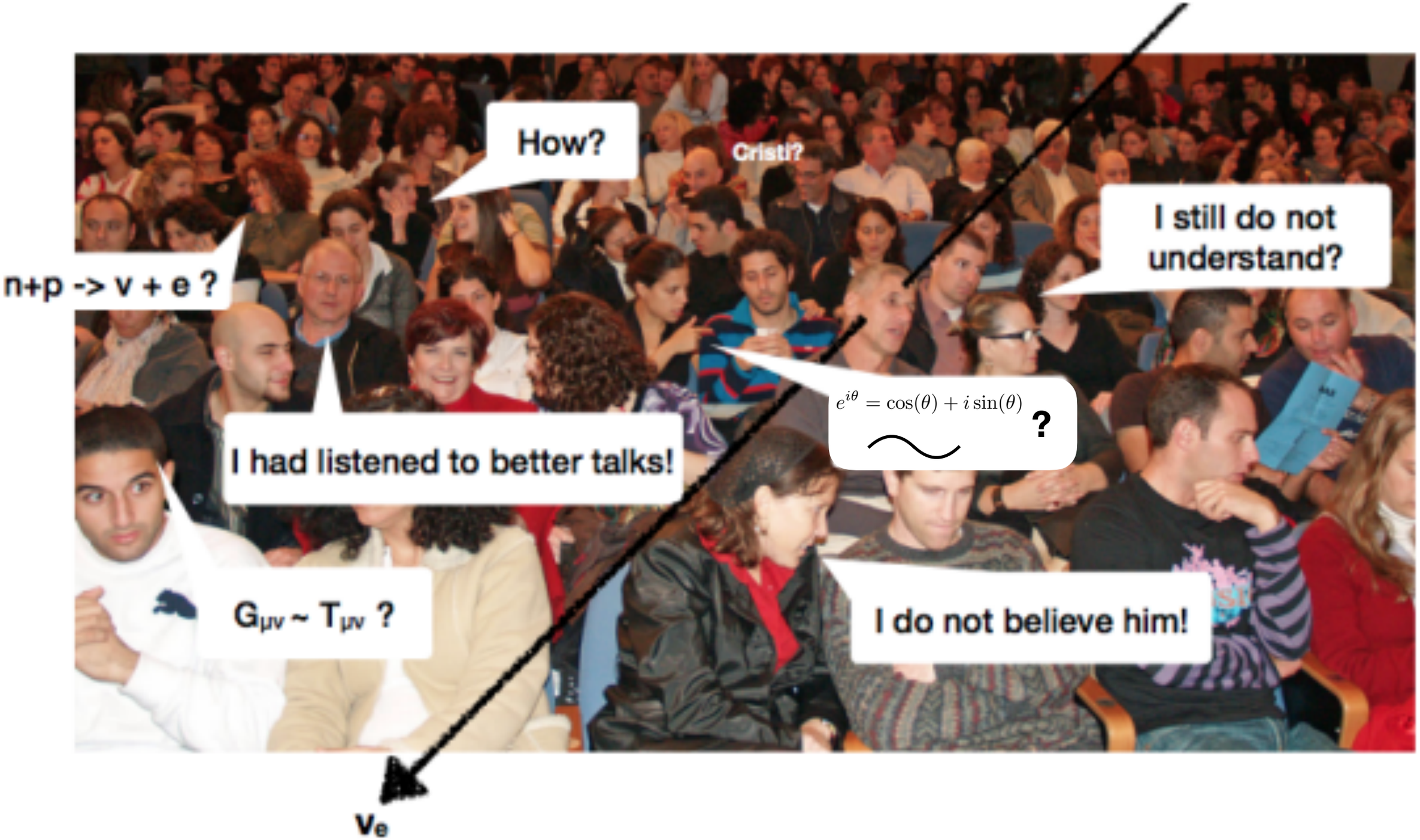
Thank you for your attention!



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S.Alam, …, **P.Ntelis**, … et al., Testing the theory of gravity with DESI, JCAP

A. Bharucha et al., Axion-like particles as mediators for dark matter, JHEP

B. Bertin-Johannet, …, **T. Martin**, … et al., States in quantum Hall arxiv

Short related quizzes

Kahoot: Theoretical Physics

Kahoot: Math and Physics (Cosmology)

Kahoot: Condense matter