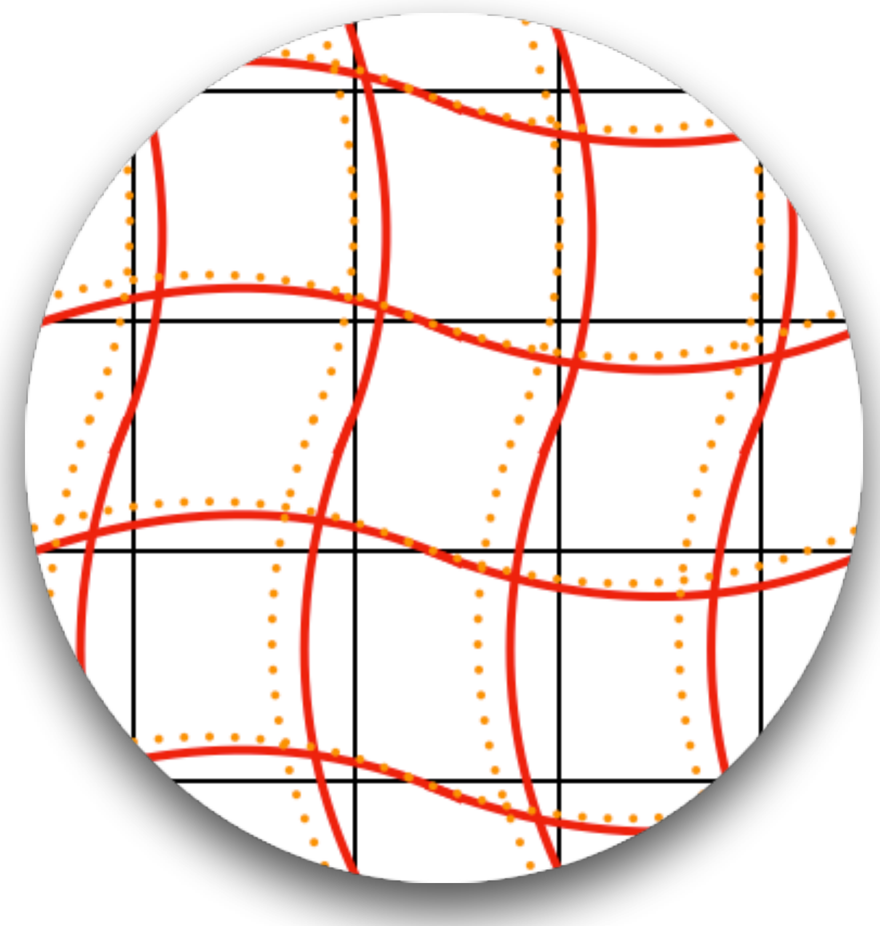
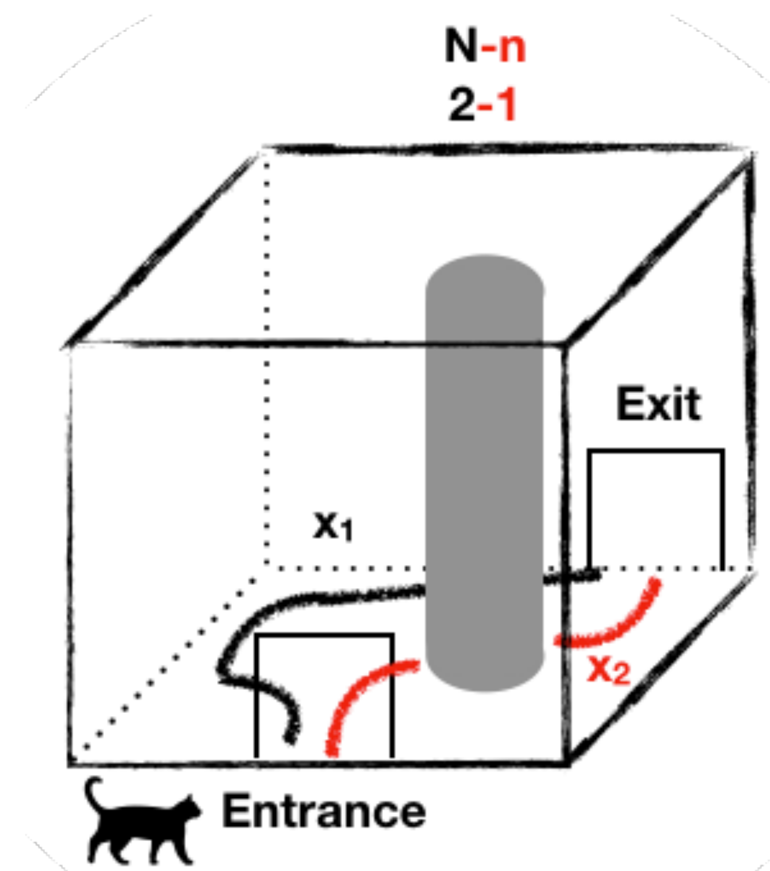
A probabilistic expanding universe under functors of actions theories





presented @

Extended session 12 Dec 2024

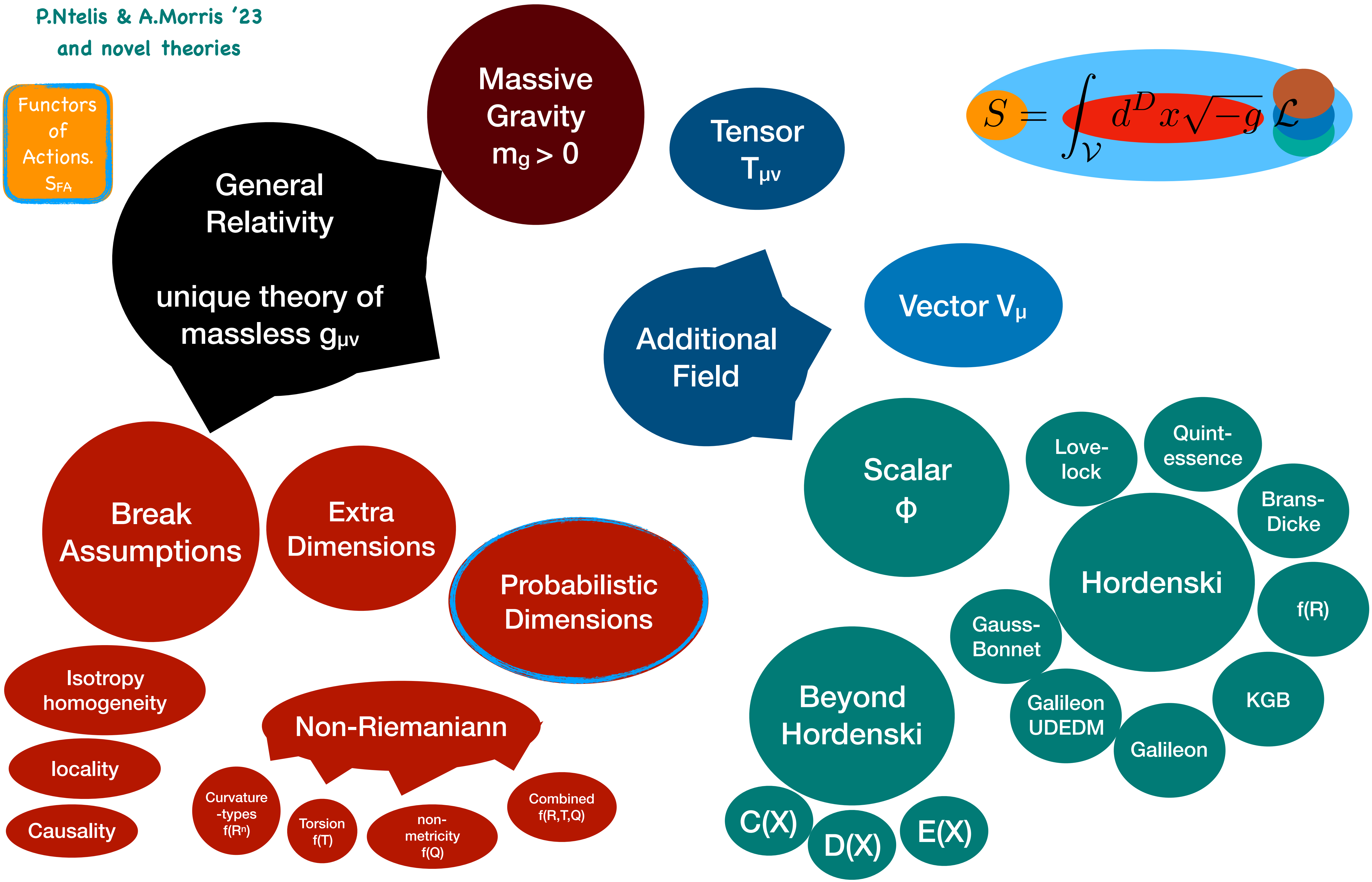
Pierros Ntelis
Postdoc researcher

Dec 2024

Outline

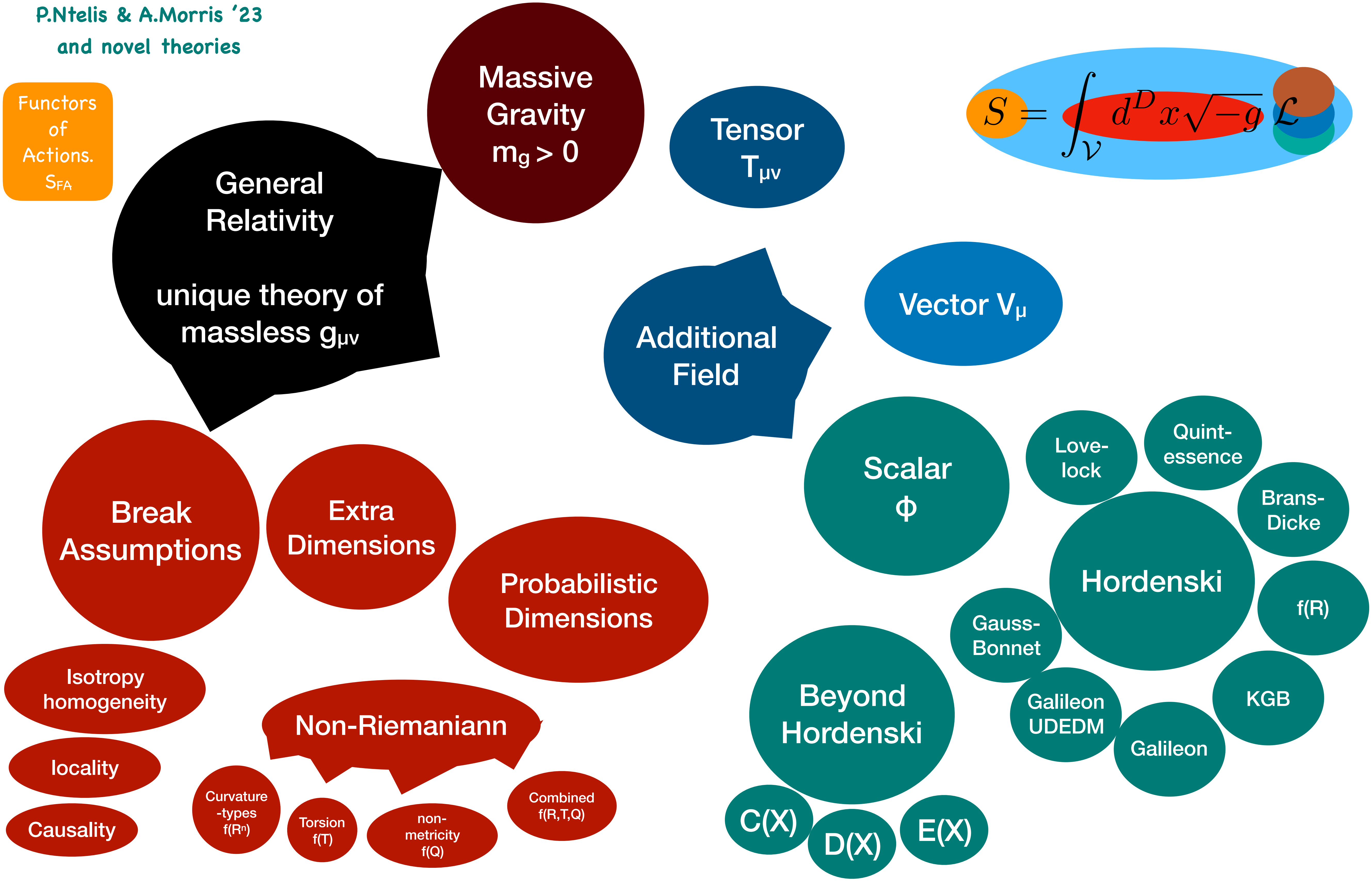
Cosmological Gravitology

Diagram remodified from
P.Ntelis & A.Morris '23
and novel theories



Cosmological Gravitology

Diagram remodified from
P.Ntelis & A.Morris '23
and novel theories



Outline

Aix*Marseille université

Functor of actions (S_{FA}) theories

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 predict the existence of actionic fluctuations and field-particles which is an analogue of the energetic/topological fluctuations/field-particles in nature.

$$\mathcal{S}_{\rm FA} \supset \int_{\Omega_{\rm S}} dS' \supset \mathcal{S}_{\rm EFT} \supset \int_{\Omega_S} dS' S' \longleftarrow S = \int_{\mathcal{V}} d^D x \sqrt{-g}\, \mathcal{L}$$

Aix*Marseille université

Functors of actions

Prediction of Modification of Einstein Field Equations

$$S_{\mathrm{FA}}^{\mathrm{simple}} = \beta S_{\mathrm{R}} + S_{\mathrm{m}} + \boxed{S_3}$$

Prediction of Actionic fields (similar to energy fields)

$$0 = \delta S_{\mathrm{EFT}}^{\mathrm{Simplified,2,GR,2}}$$

$$0 = \int d^4x \sqrt{-g}\delta g^{\mu\nu} \left(\beta^{(S_R)} \frac{c^4}{16\pi G_{\mathrm{N}}} \left(R_{\mu\nu} - \frac{1}{2} R g_{\mu\nu} + \Lambda g_{\mu\nu}\right) - T_{\mu\nu}/2\right) \boxed{+ \delta S_3'}$$

$$R_{\mu\nu} - \frac{1}{2} R g_{\mu\nu} + \Lambda g_{\mu\nu} = \frac{1}{\beta^{(S_R)}} \frac{8\pi G_{\mathrm{N}}}{c^4} \left(T_{\mu\nu} + \boxed{\delta \left[\mathcal{L}_3\right]_{\mu\nu}}\right)$$

Functors of actions

Constraints and Prediction of Modification of EFE

$$R_{\mu\nu} - \frac{1}{2} R g_{\mu\nu} + \Lambda g_{\mu\nu} = \frac{1}{\beta^{(S_R)}} \frac{8\pi G_{\rm N}}{c^4} \left(T_{\mu\nu} + \delta \left[\mathcal{L}_3 \right]_{\mu\nu} \right)$$

Prediction of Actionic fields,

by choosing a special Lagrangian fluctuation

$$\delta \left[\mathcal{L}_3 \right]_{\mu\nu} \rightarrow \delta \mathcal{L}_3 \begin{pmatrix} \rho & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{pmatrix}$$

$$T^{(2)}_{\mu\nu} = \begin{pmatrix} \rho(1+\delta\mathcal{L}_3) & 0 & 0 & 0 \\ 0 & -P & 0 & 0 \\ 0 & 0 & -P & 0 \\ 0 & 0 & 0 & -P \end{pmatrix}$$

Equation of state

$$w = -\left(1 + \delta\mathcal{L}_3\right)^{-1}$$

for **w ~ -1.1**

=>

δL_3 ~ -0.1

=>

$\delta S_3 \sim \int d^Dx(-g)^{1/2}\, \delta L_3 \sim -0.1 V_D$

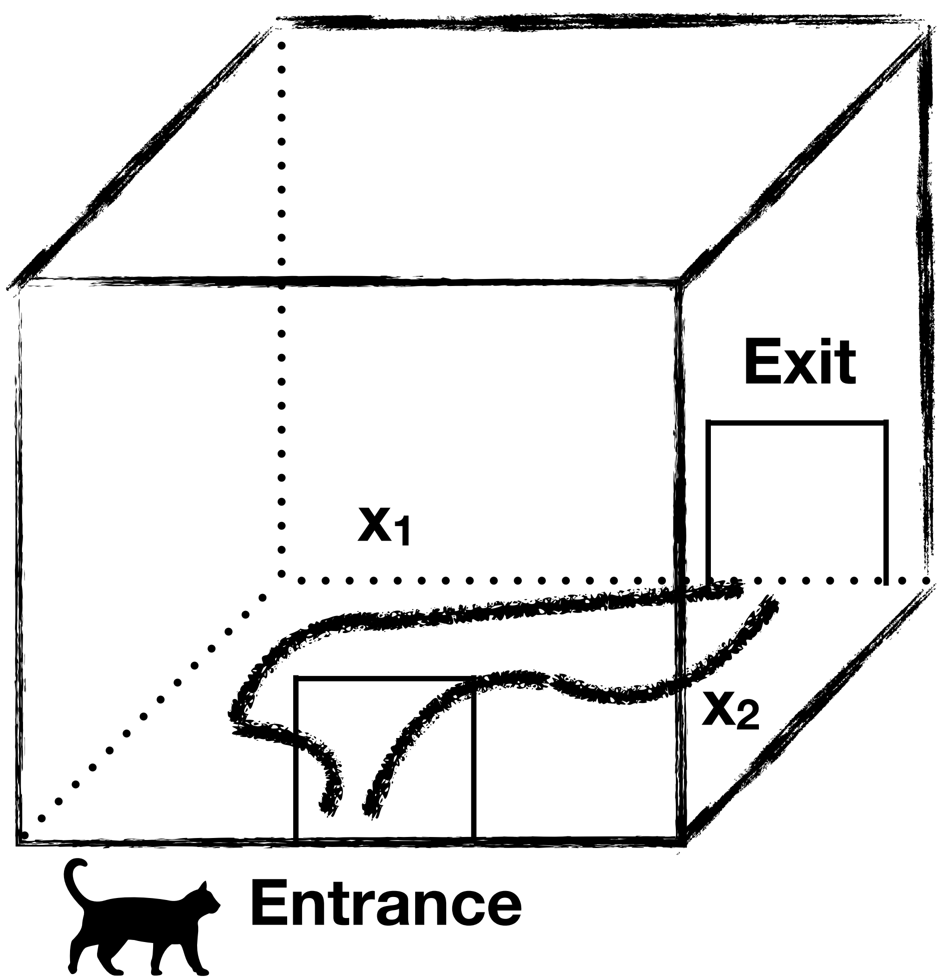
<u>Under these assumptions simple actionions are 1/10th of the observed volume</u>

Actionic field interpretation

Action answers to the question :

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

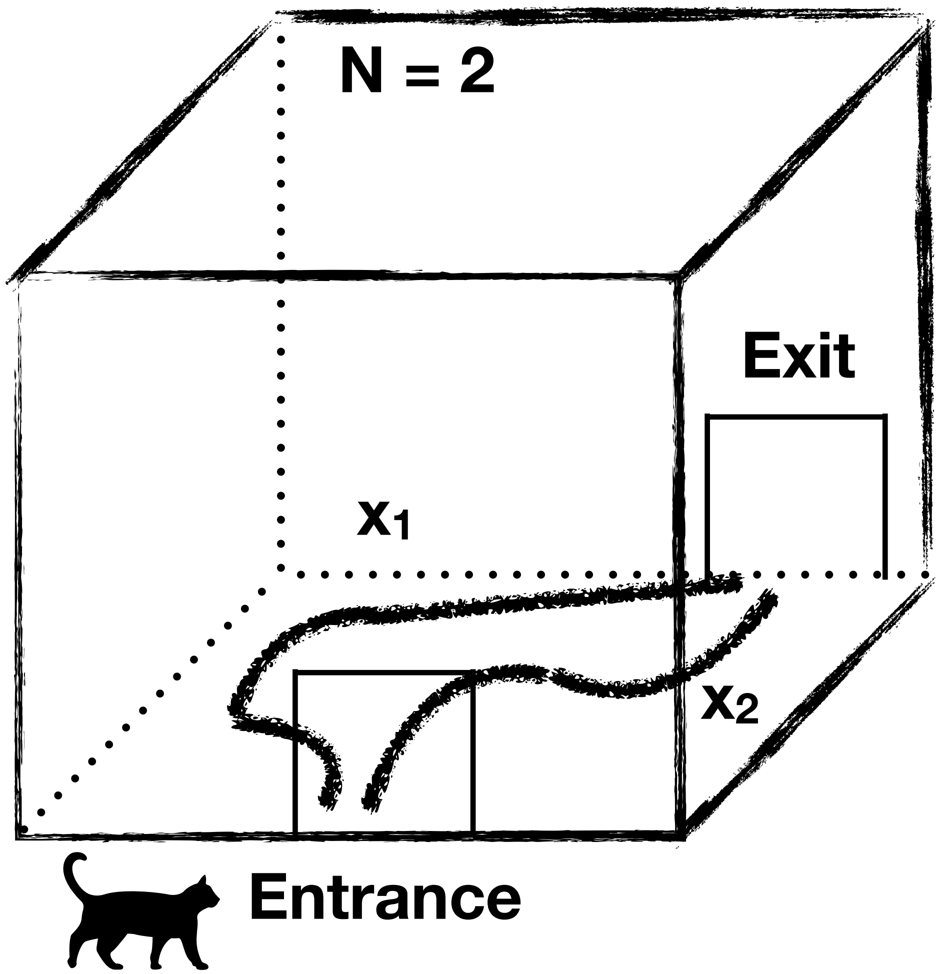
Actionic field interpretation

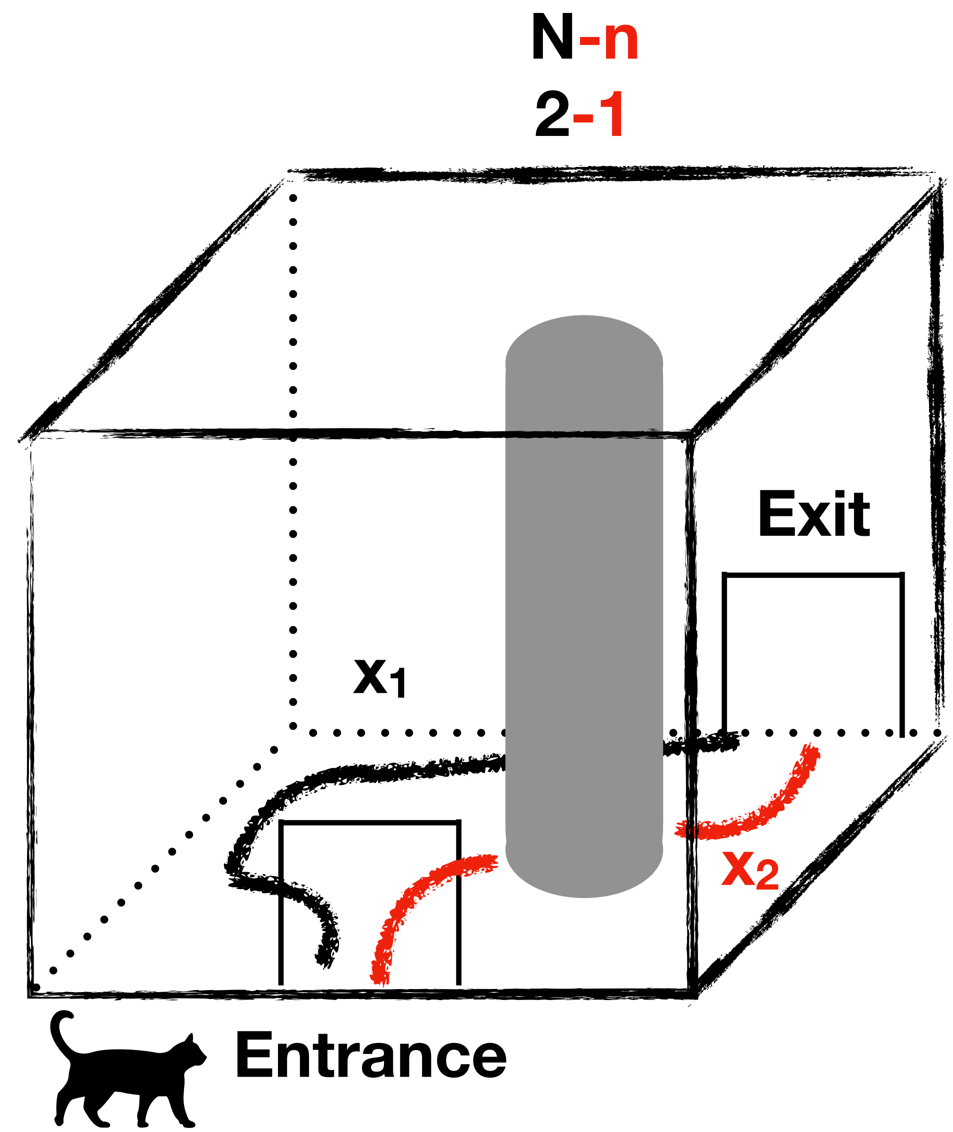
Action answers to the question :

An actionic field everywhere

QM <=> actionion field-particle

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





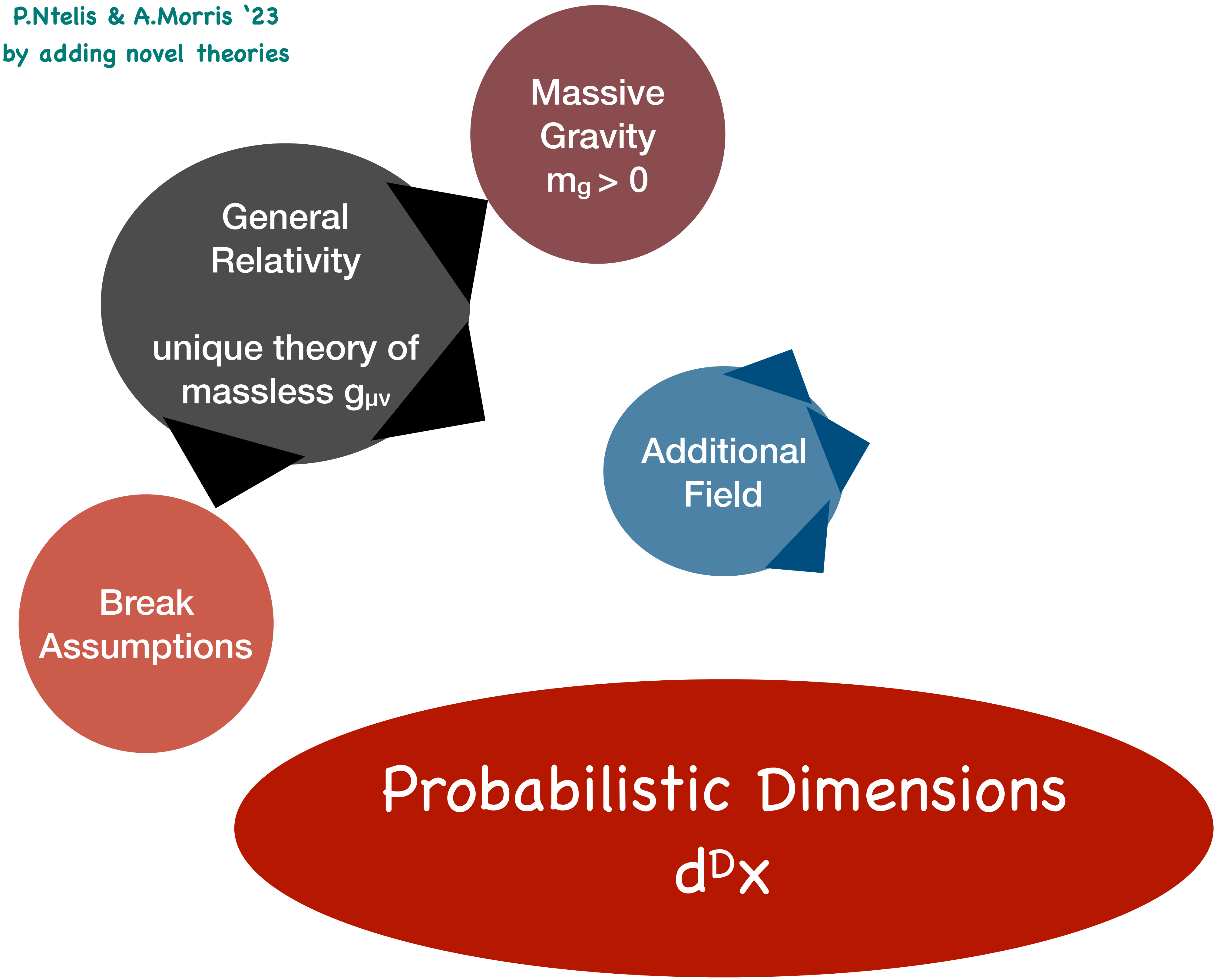
x_1 is possible for both rooms, x_2 is not possible for the 2nd room

space, x

Outline

Cosmological Gravitology

Diagram modified from
P.Ntelis & A.Morris '23
by adding novel theories



P.Ntelis 2024 under review

Motivation 1

In 1942, Menger have introduced the concepts of statistical metrics [1].

In 1977, Drossos introduced the stochastic Menger spaces [2].

In the framework of modifications of gravity,

string theories predict extra dimensions [3],
while
Loop quantum gravity theories predict the non-existence of metric [4].

→ Natural to introduce an idea of a manifold in between extra dimensional spacetime manifolds and non-metric manifolds

Motivation 2

Evidence for a semi analytical model is found to be

Dimensions = 4 ± 0.1

from gravitational wave estimates

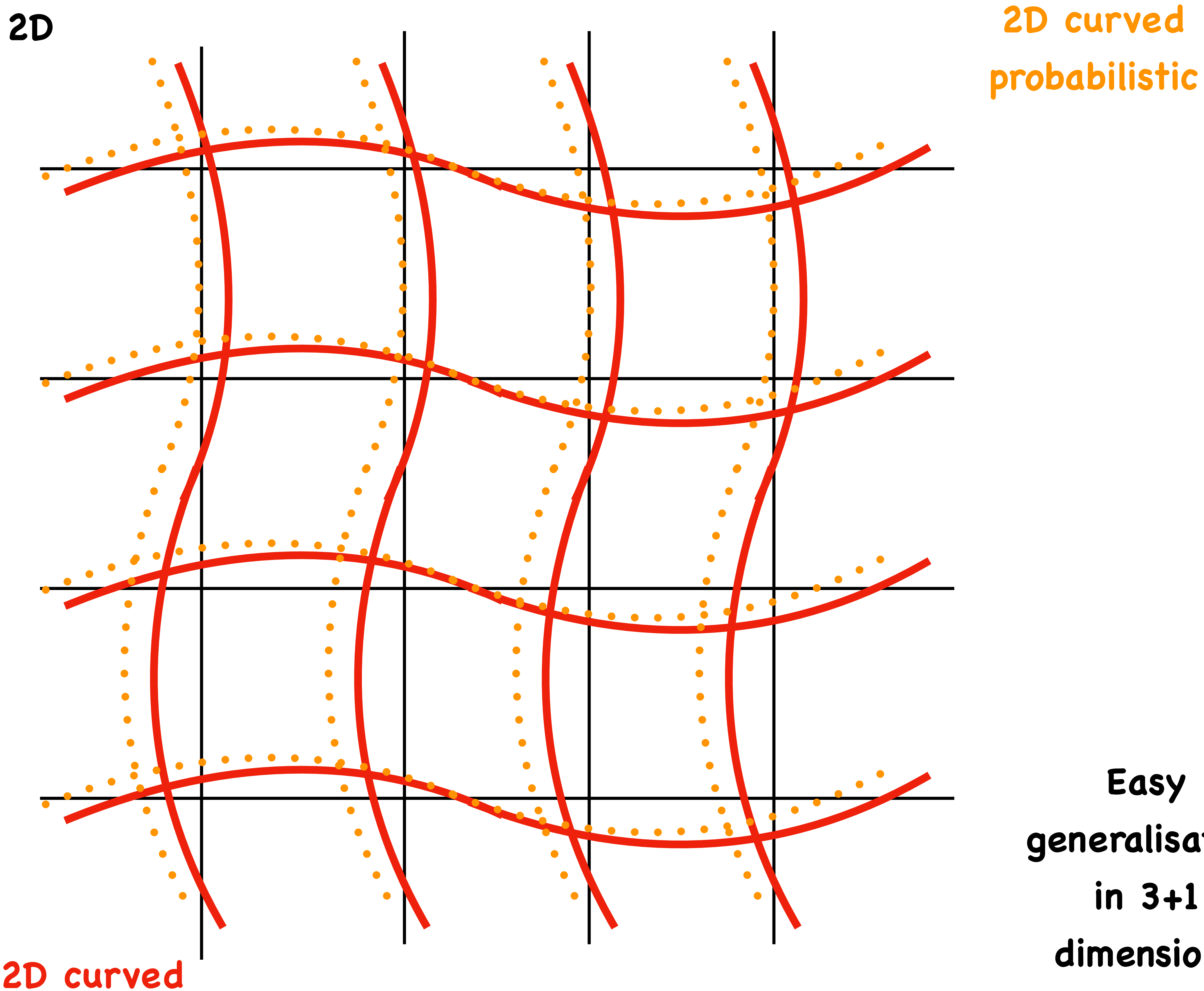
[Pardo, Fishbach, Holtz, 2018]

Probabilistic Dimensions

$d^D x$

Aix*Marseille université

Space Time Continuum



Easy generalisation in 3+1 dimensions

Figure 2. A representation of a 2 dimensional spatially curved probabilistic expanding space. This spacetime is curved in the presence of some massive object, as well as it appears, disappears and expands in time. It is easy to generalise this concept in a (3+1)D spacetime continuum. [See section 3.14]

Probabilistic dimensions turn up *probabilistic gravity*

$$D \to \bar{D} = \int_{\Omega_D} dX_D \; Gaussian(X_D; D, \sigma_D)$$

modifying dimensions

means that we need to modify

- topology (metric, manifold, curvature tensor)

- matter content evolution

$$\mathcal{S}_{Probabilistic\ gravity} \propto \int d^{\bar{D}}x\sqrt{-g^{\bar{D}}}\left[\frac{R^{\bar{D}}}{16\pi G_N} + \mathcal{L}_m^{\bar{D}}\left(g_{\mu\nu}^{\bar{D}}, \psi_m, ...\right)\right]$$

Sophisticated and Simple modifications

Simple probabilistic metric : $ds^2 = a^2(\tau)\left[-P^2(\tau)e^{2\Psi(\tau,\vec{x})}d\tau^2 + e^{-2\Phi(\tau,\vec{x})}dx^i dx^j \delta_{ij}\right]$

P.Ntelis 2024 under review

Results

Einstein Field Equation results to modified Friedmann equations

$$\mathcal{H}^2(\tau) = \frac{8\pi G_{\rm N}}{3c^4} a^2(\tau) P^2(\tau) \sum_{s\in\{m,r,\Lambda,k\}} \bar{\rho}_s(\tau)$$

$$2\mathcal{H}'(\tau) + \mathcal{H}^2(\tau) = -\frac{8\pi G_{\rm N}}{3c^4} a^2(\tau) P^2(\tau) \sum_{s\in\{m,r,\Lambda,k\}} w_s(\tau)\bar{\rho}_s(\tau)$$

while continuity equation remains the same

$$\bar{\rho}_s = -\left[1 + w_s(\tau)\right]\mathcal{H}(\tau)\bar{\rho}_s(\tau)$$

Currently working on solutions!

P.Ntelis 2024 under review

Results

This probabilistic perturbed expanding Manifold-metric

modifies

the Einstein-Boltzmann equations (find them in doc).

P.Ntelis 2024 under review

Results

A collection of Probabilistic Manifold-Metric pairs in the doc:

P.Ntelis 2024 under review

Qualitative results

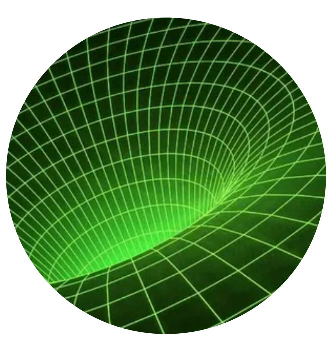
Connections of probabilities with information

$$\mathcal{I}(E) = -\log\left[\mathcal{P}(E)\right]$$

New kind of manifold-metric pairs
using probabilities and information

Correspondence with field-particles characterisation (spacions):

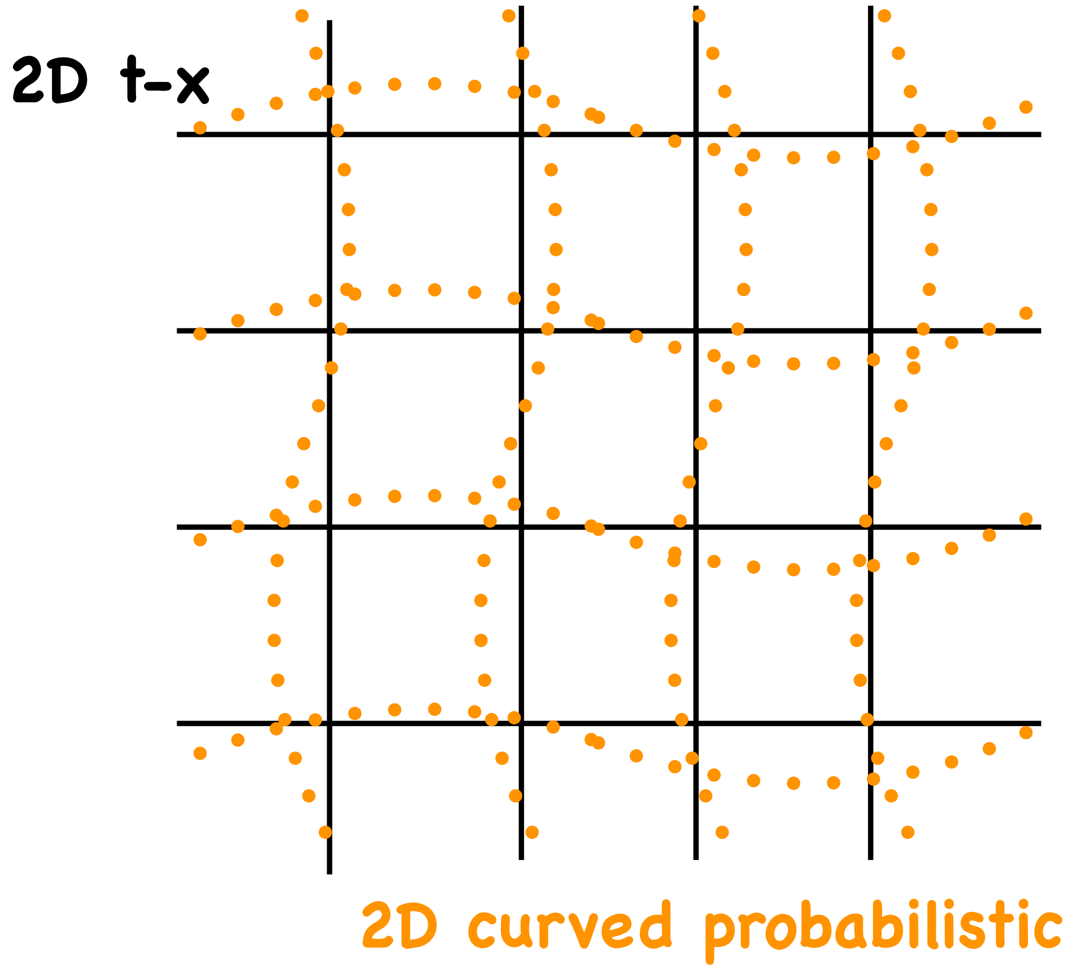
spaciallion, timions, probablons, informatons.



P.Ntelis 2024 under review

A probabilistic expanding universe under functors of actions theories

$$ds^2 = a^2(\tau)\left[-P^2(\tau)e^{2\Psi(\tau,\vec{x})}d\tau^2 + e^{-2\Phi(\tau,\vec{x})}dx^i dx^j \delta_{ij}\right] \,.$$



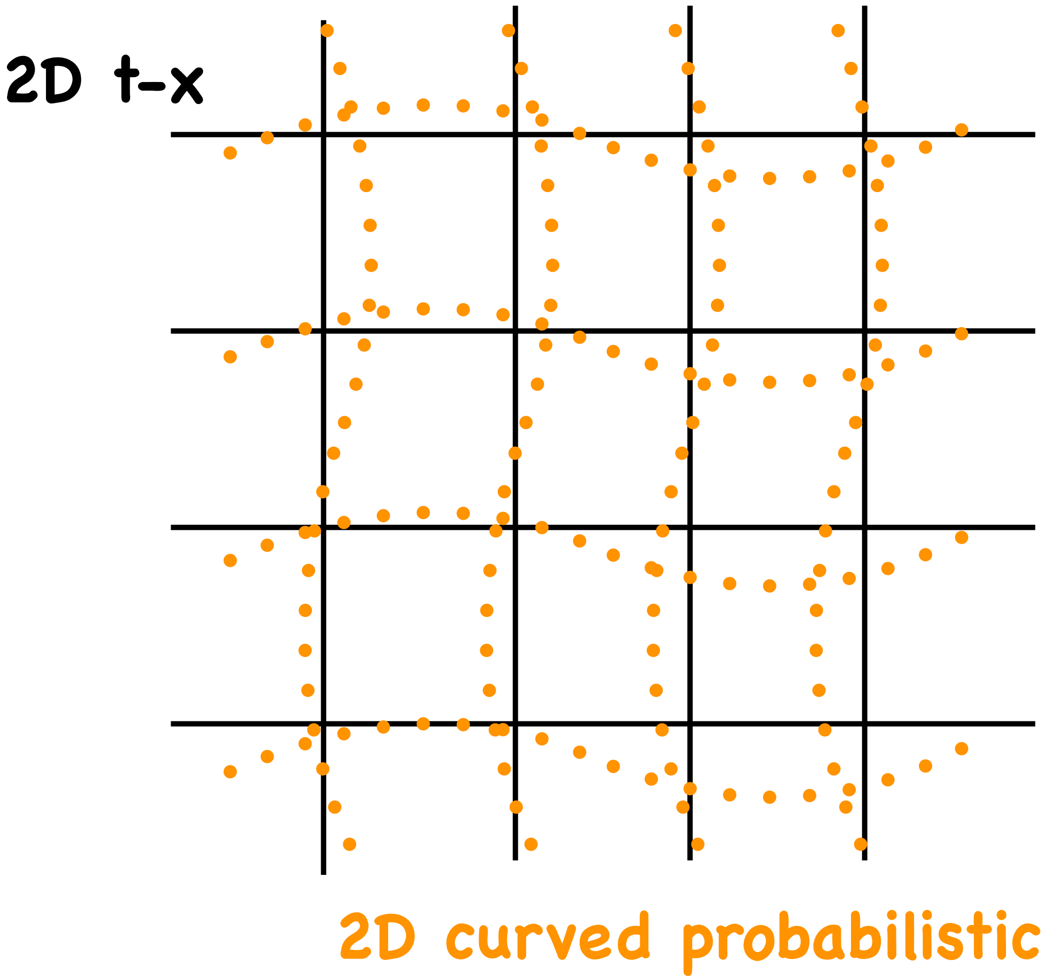
$$\mathcal{H}^2(\tau) = \frac{8\pi G_{\mathrm{N}}}{3c^4}a^2(\tau)P^2(\tau)\bar{\rho}(\tau) + \frac{1}{3}a^2(\tau)P^2(\tau)\Lambda$$

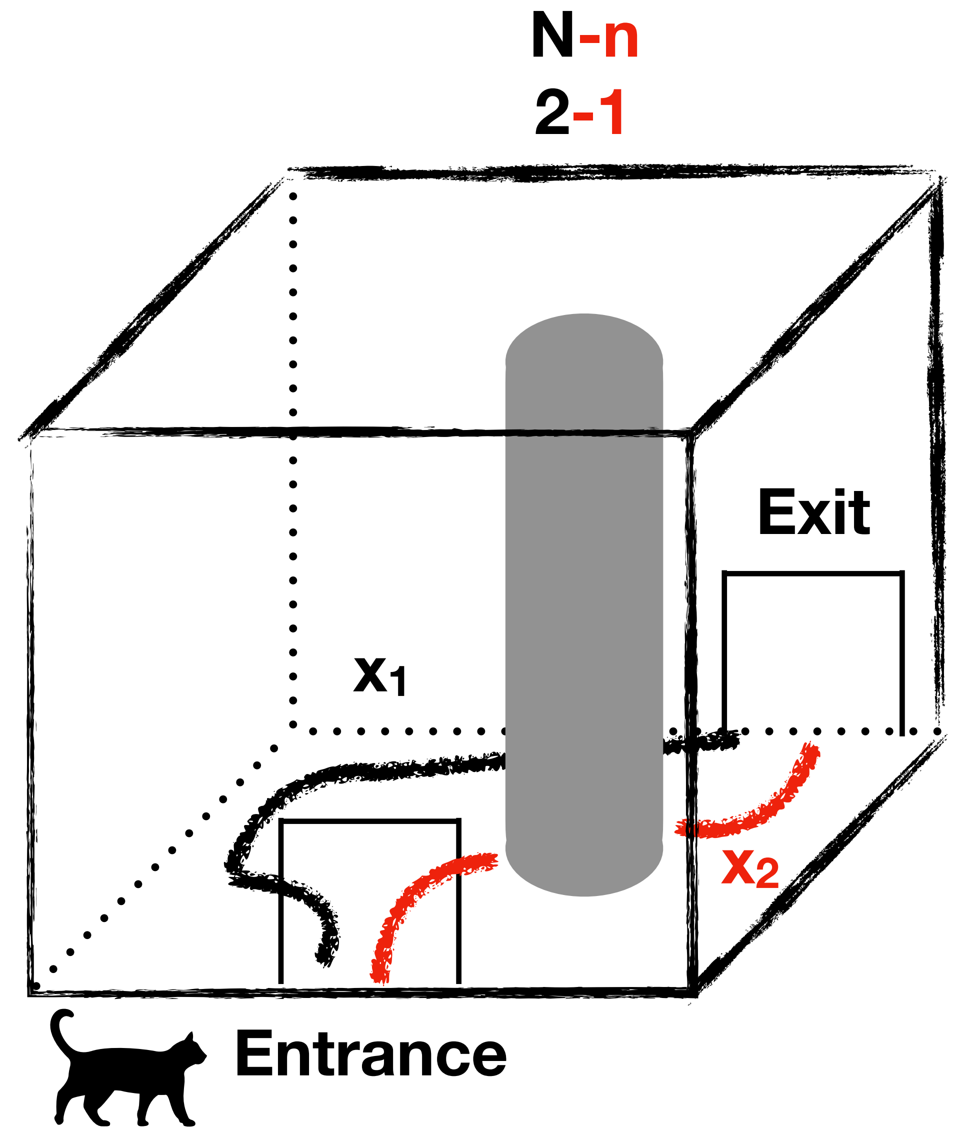
$$2\mathcal{H}'(\tau) + \mathcal{H}^2(\tau) = \frac{8\pi G_{\mathrm{N}}}{3c^4}a^2(\tau)P^2(\tau)\bar{\bar{P}}(\tau) + \Lambda a^2(\tau)P^2(\tau)$$

$$\mathcal{S}_{\mathrm{FA}} \supset \int_{\Omega_{\mathrm{S}}} dS' \supset$$

A probabilistic expanding universe under functors of actions theories

$$ds^2 = a^2(\tau)\left[-P^2(\tau)e^{2\Psi(\tau,\vec{x})}d\tau^2 + e^{-2\Phi(\tau,\vec{x})}dx^i dx^j \delta_{ij}\right] .$$





$$\mathcal{H}^2(\tau) = \frac{8\pi G_{\rm N}}{3c^4}a^2(\tau)P^2(\tau)\bar{\rho}(\tau) + \frac{1}{3}a^2(\tau)P^2(\tau)\Lambda$$

$$2\mathcal{H}'(\tau) + \mathcal{H}^2(\tau) = \frac{8\pi G_{\rm N}}{3c^4}a^2(\tau)P^2(\tau)\bar{\tilde{P}}(\tau) + \Lambda a^2(\tau)P^2(\tau)$$

$$\mathcal{S}_{\rm FA} \supset \int_{\Omega_{\rm S}} dS' \supset$$

Outline

Introduction

Functors of actions

Probabilistic universe

Dynamical Analysis

Conclusions and future

Conclusions

- Mathematical and Observational evidence for
  - Functors of actions theories predictions of actionions
  - Probabilistic dimensions, probabilistic manifold-metric pairs

- Dynamical analysis on standard ΛCDM cosmology
  important tool for analysing other cosmic systems

Future plan
Develop further 4 axis of research:

- Functors of actions through category theory

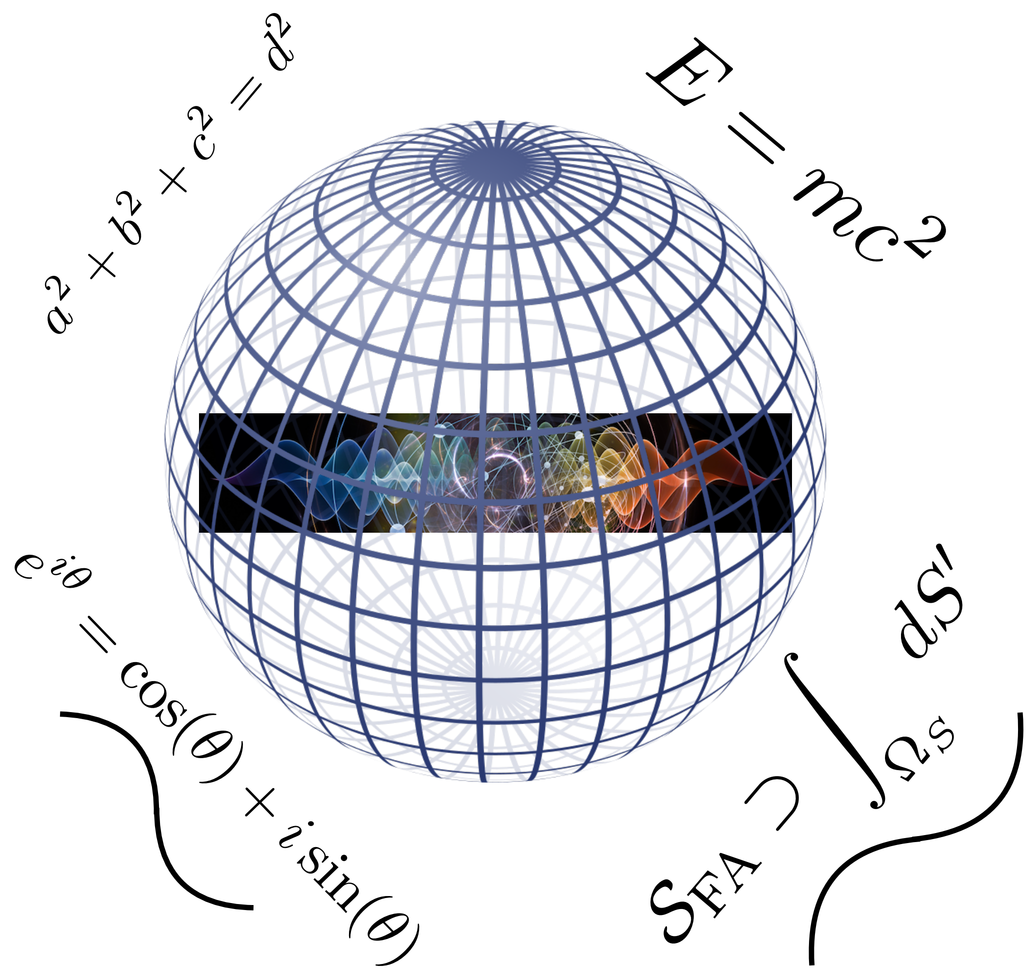
- Probabilistic and informatics model

- Dynamical analysis systems, numerical/analytical solutions

- Statistical tests of above theories (Early, Late Universe, GW)

Collaboration on models and tests with other cosmologists

Universions



Subscribe to support Art & Science ! :)

References

[1] Menger 1942. Statistical metrics. Proc. National Academy

[2] Drossos 1977. Stochastic menger spaces and convergence in probability. Rev. Roumaine Math. Pures et Appliqus

[3] Polyakov 1981. Quantum Geometry of boson strings. Physics Letters B

[4] Rovelli 2004. Loop Quantum Gravity. Monograph at Cambridge

[5] Pardo, M. Fishback, and Holtz, 2018. Limits on the number of spacetime dimensions from GW. JCAP

[6] P.Ntelis, A.Morris 2023. Functors of actions. Foundations of Physics Journal

[7] P.Ntelis 2024. A probabilistic expanding universe. Under Review

[8] P.Ntelis et. J.L.Said 2024. Exploring $\varphi\Lambda$CDM dynamics. Under Review

[9] P.Ntelis et. J.L.Said 2024. Simple $\varphi\Lambda$CDM dynamics. Under Review

[10] P.Ntelis et. J.L.Said 2024. A quad FAT-ΛCDM dynamics. Under Review

[11] Bahamonde et al. 2018 Dynamics of dark energy. Physics Reports.

[12] Copeland, E. J., M. Sami, and S. Tsujikawa. 2006 Dynamics of dark energy. Int.J.Mod.Phys.

Thank you for your attention!

Thanks to Organisers of the

for hosting me!

Aix*Marseille université