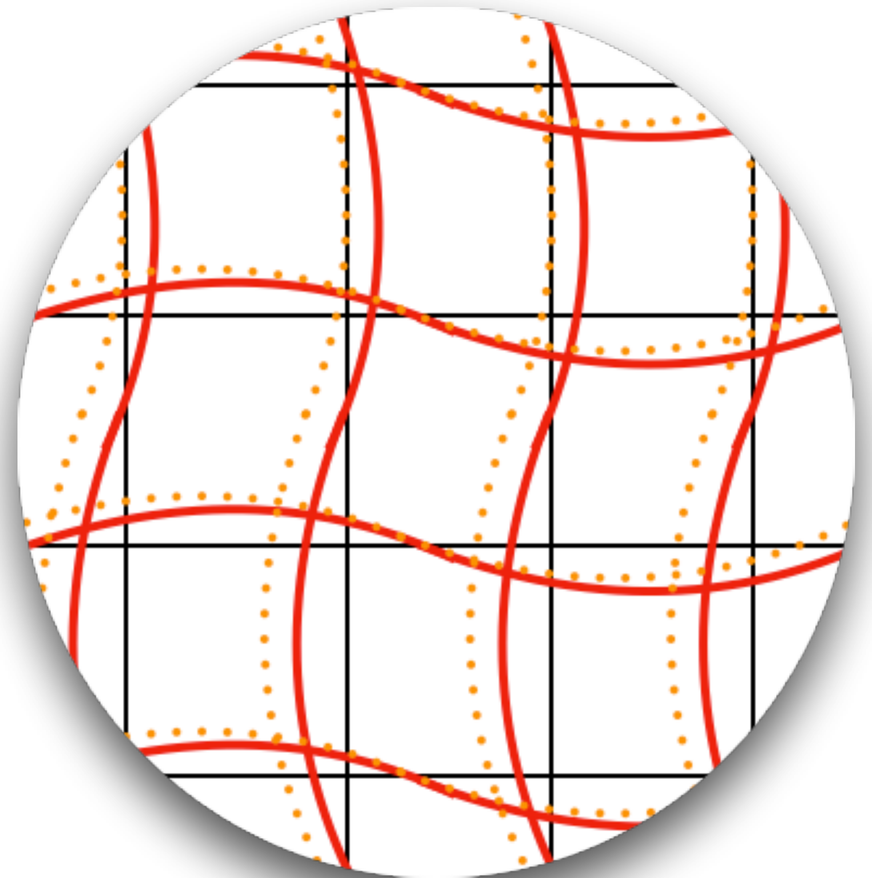
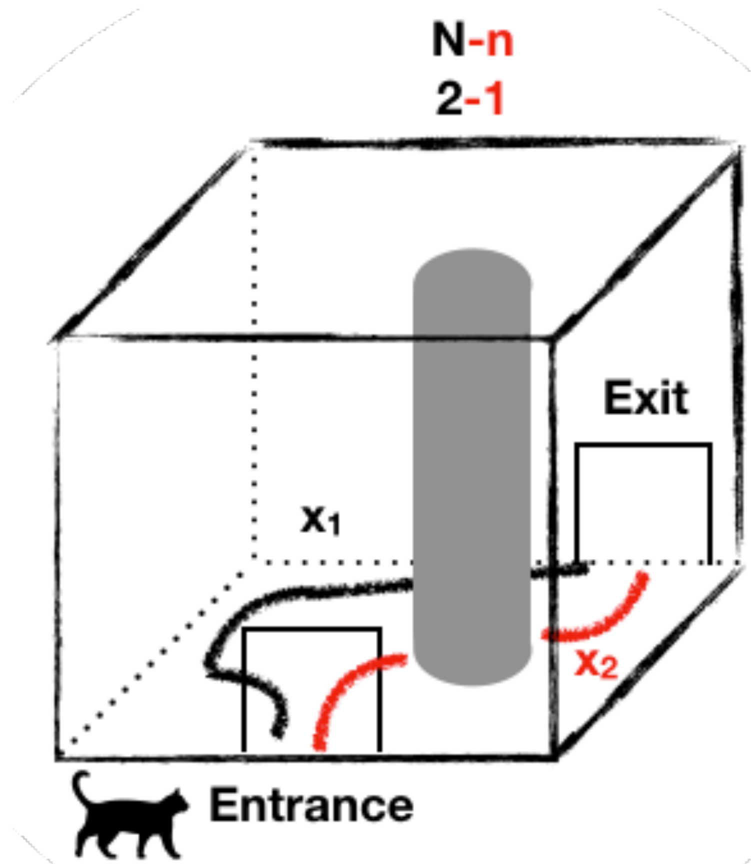
A probabilistic expanding universe under functors of actions theories





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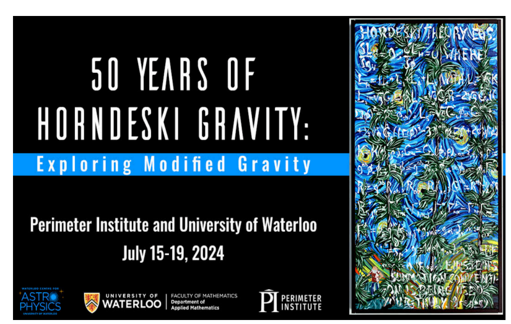

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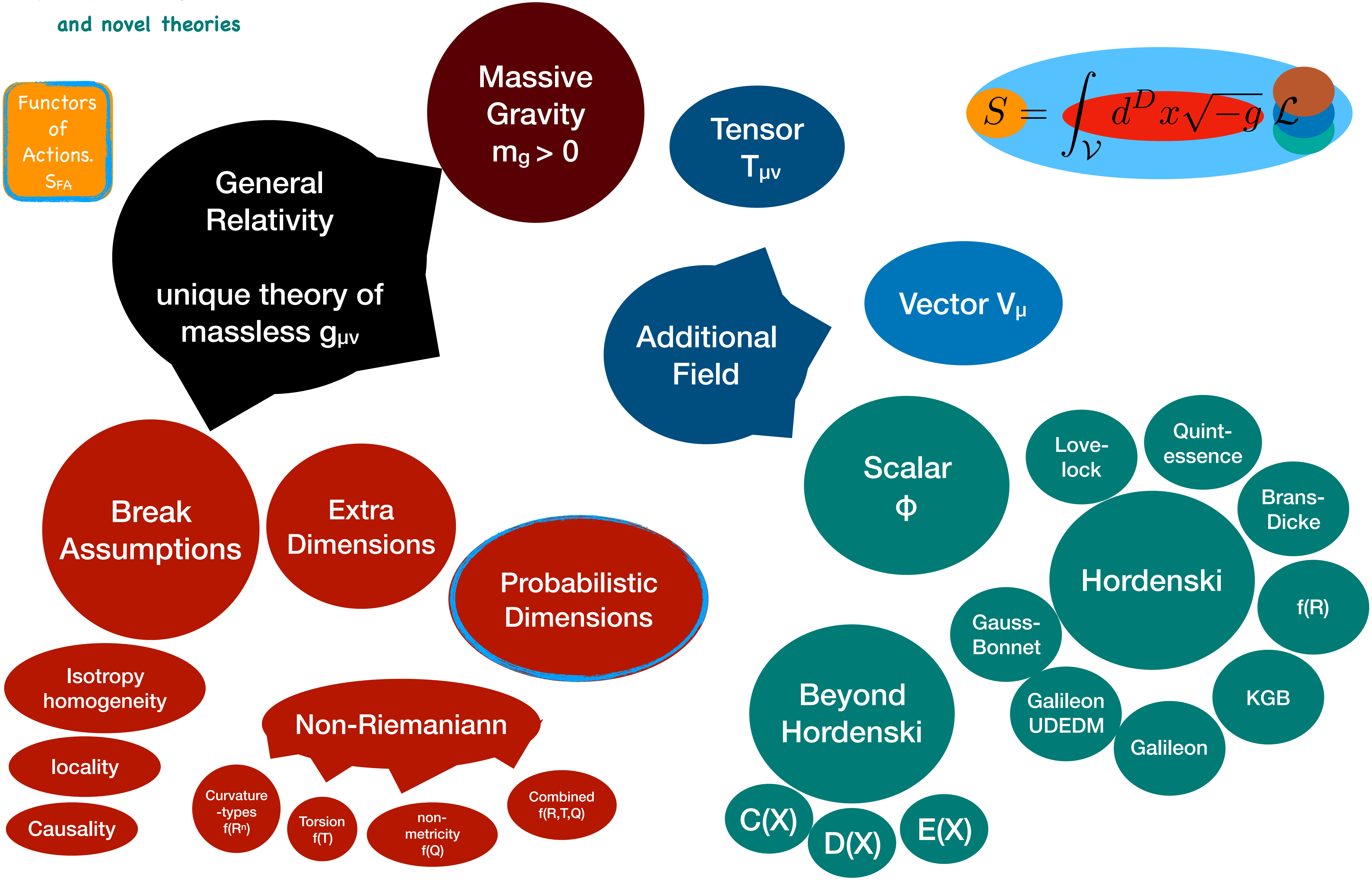
July 2024

Outline

Cosmological Gravitology

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



Cosmological Gravitology

Diagram remodified from
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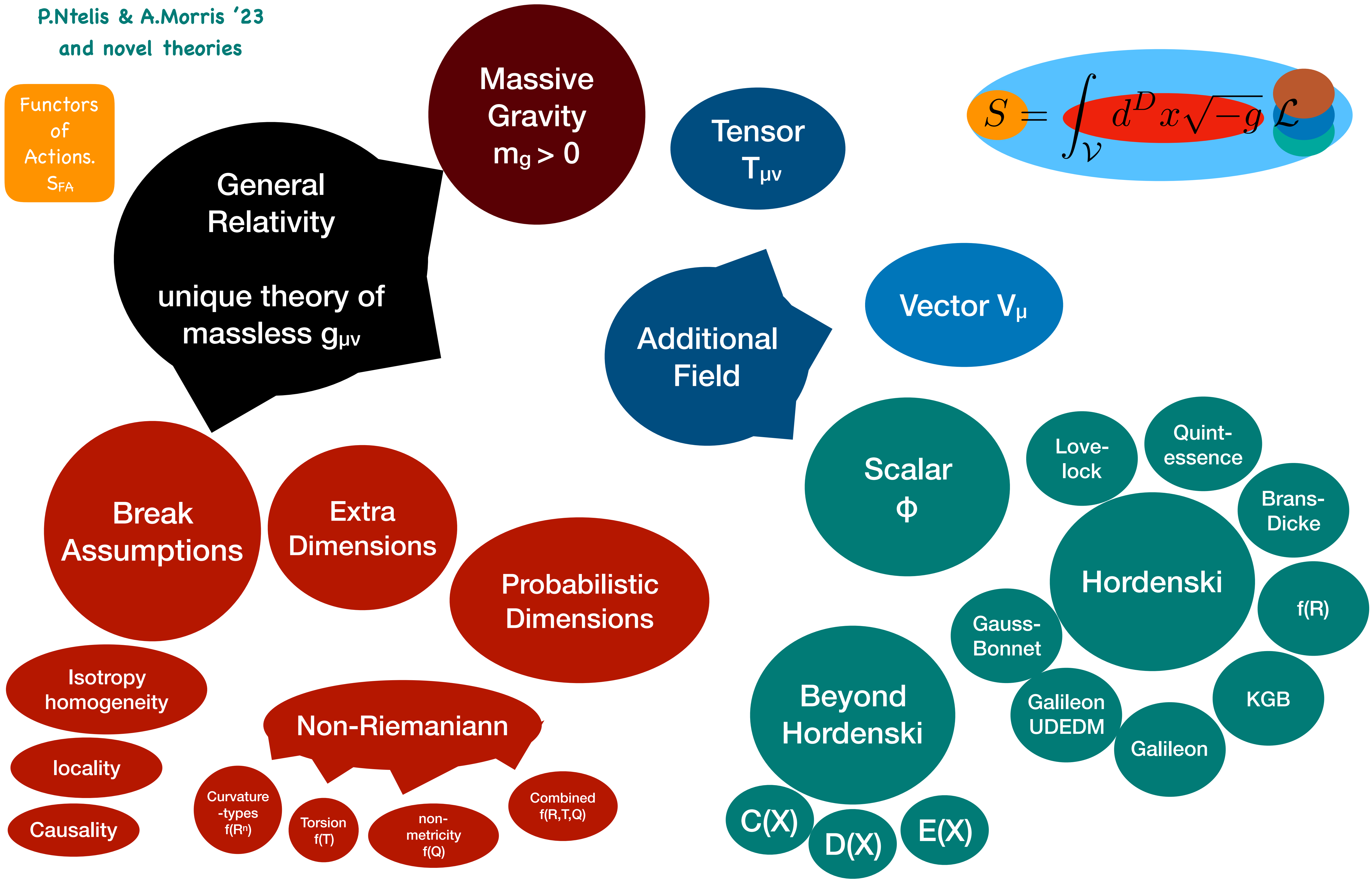


Outline

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.

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

Functor of actions (S_{FA}) theories

Limits we can get from these theories are
GR, Hordenski, Inflation, EFTofLSS, Strings, …

Example:

$$\mathcal{S}_{\rm FA} \ni \int_{\Omega_S} dS' \to \int_0^S dS' \overset{\text{GR limit}}{--\to} \int_0^{S_{\rm GR}} dS' = \sum_{i=1,2} S_i = S_R + S_m$$

$$= c^4 \int \sqrt{-g}\,\frac{R}{16\pi G_{\rm N}} d^4x + c^4 \int \sqrt{-g}\,\mathcal{L}_m\left(g_{\mu\nu}\right) d^4x \;,$$

$$S_{\rm GR} \equiv c^4 \int \sqrt{-g}\left[\frac{R}{16\pi G_{\rm N}} + \mathcal{L}_m\left(g_{\mu\nu}\right)\right] d^4x$$

Strings Limits
In 1981 Polyakov has studied the action of string-theory dynamics and successfully quantized string theory. Here we show that FA is also reduced to the one of the actions of string theory, simply as:

$$\mathcal{S}_{\rm FA} \ni \int_0^S dS' \xrightarrow{\text{Strings limit}} \int_0^{S_{\rm string}} dS' = S_{\rm string} = \frac{T}{2}\int d^2\sigma\sqrt{-h}h^{ab}g_{\mu\nu}(x)\partial_a x^\mu(\sigma)\partial_b x^\nu(\sigma)$$

where T is the string tension, $g_{\mu\nu}$ is the metric of any targeted manifold of a D-dimensional space and $x_\mu(\sigma)$ is the coordinate of the targeted manifold.
Moreover, h_{ab} is the worldsheet metric, (h^{ab} is its inverse), and h is, as usual, the determinant.
The signatures of the metrics are chosen so that the timelike directions are positive while the spacelike directions are negative. The spacelike coordinate is denoted with σ, while the timelike coordinate is denoted with τ.

Prediction of Modification of Einstein Field Equations

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

Prediction of Actionic fields (similar to energy fields)

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

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

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

Functors of actions

Constraints and Prediction of Modification of EFE

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

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

=>

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

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

Functors of actions

Constraints and Prediction of Modification of EFE

$$\boxed{S_{\mathrm{EFT}}^{\mathrm{Quadratic}} = S_R + \beta S_R^2 + S_m}$$

Stationary Action Principle

$$\begin{aligned} 0 &= \delta S_{\mathrm{EFT}}^{\mathrm{Quadratic}} \\ &= \delta S_R + \beta\delta\left(S_R^2\right) + \delta S_m \end{aligned}$$

$$\boxed{R_{\mu\nu} - \frac{1}{2}Rg_{\mu\nu} = \left[1 + \beta\int d^4x\sqrt{-g}\left(\frac{c^4}{8\pi G_{\mathrm{N}}}R\right)\right]^{-1}\frac{8\pi G_{\mathrm{N}}}{c^4}T_{\mu\nu}}$$

$$\boxed{G_{\mathrm{eff}} = G_{\mathrm{N}}\left[1 + \beta\int d^4x\sqrt{-g}\left(\frac{c^4}{8\pi G_{\mathrm{N}}}R\right)\right]^{-1}}$$

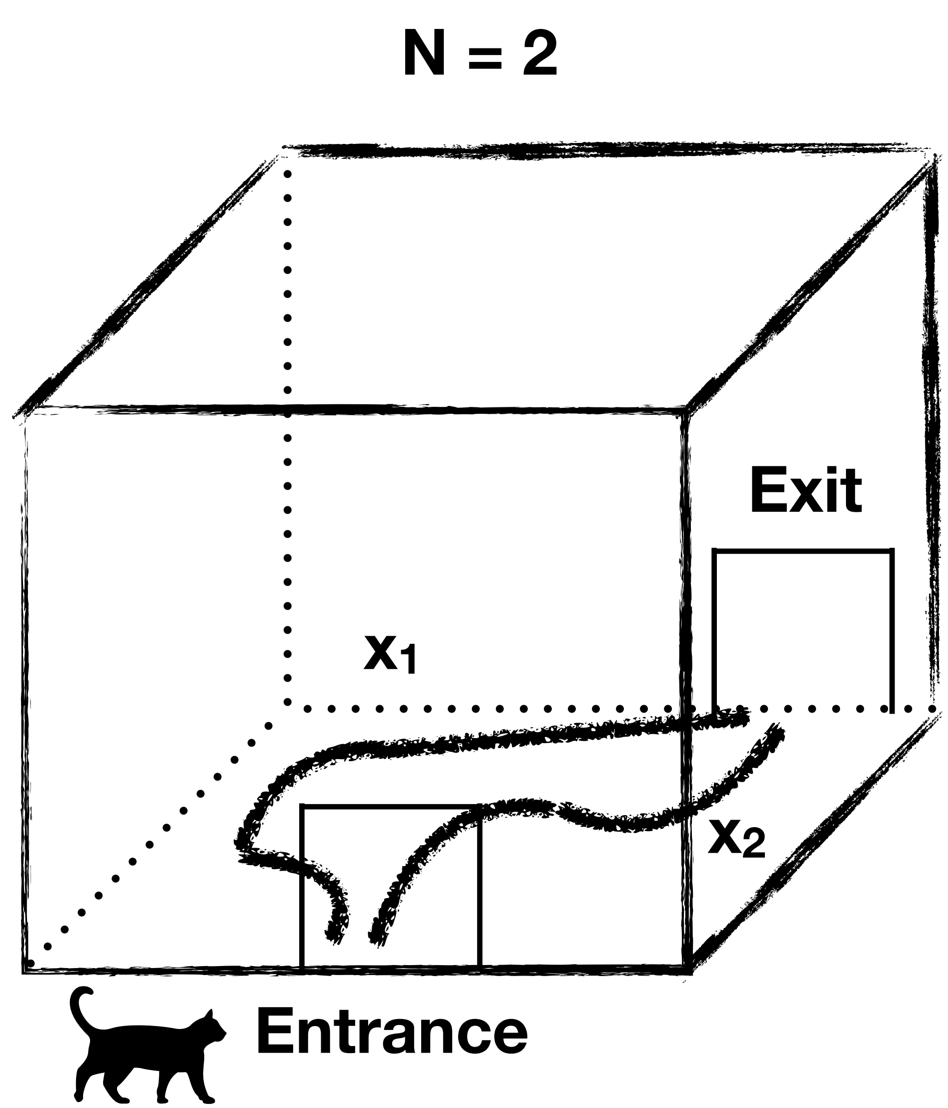
Modification of G_{eff}

Currently working on solutions, through Dynamical Analysis

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 ?



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

space, x

Aix*Marseille université

Actionic field interpretation

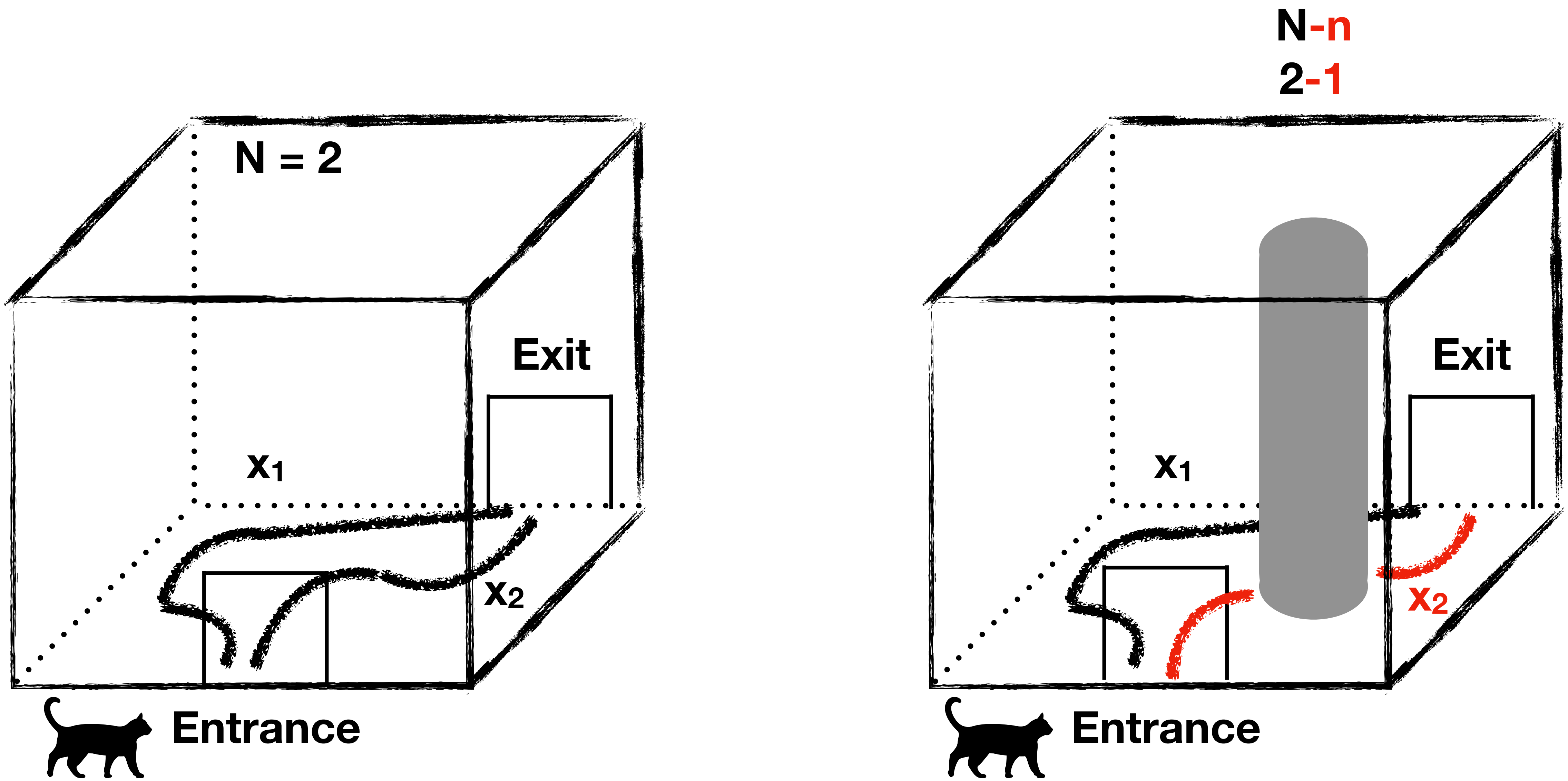
Action answers to the question :

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 ?



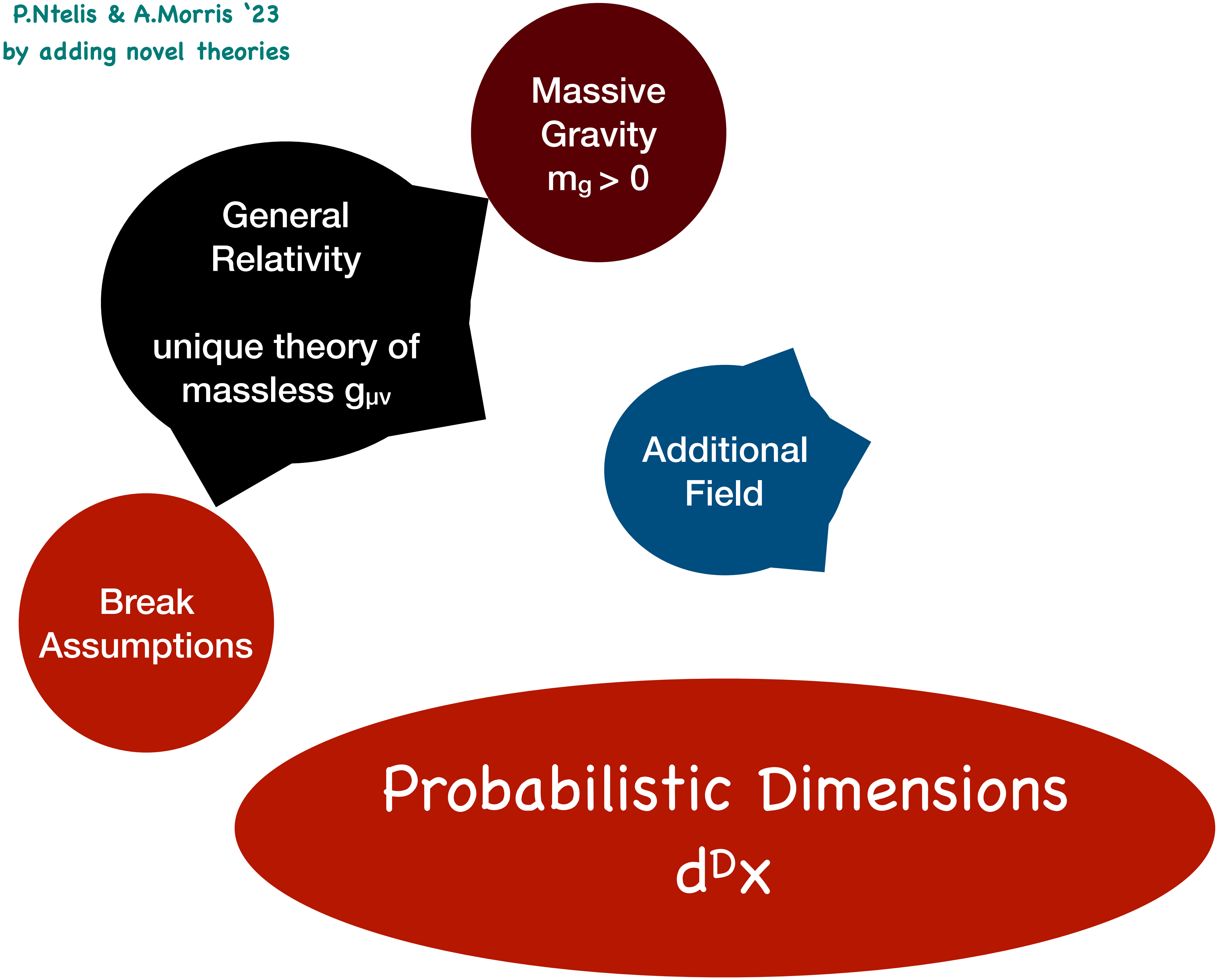
x_1 is possible for both rooms, x_2 is not possible for the 2nd room

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

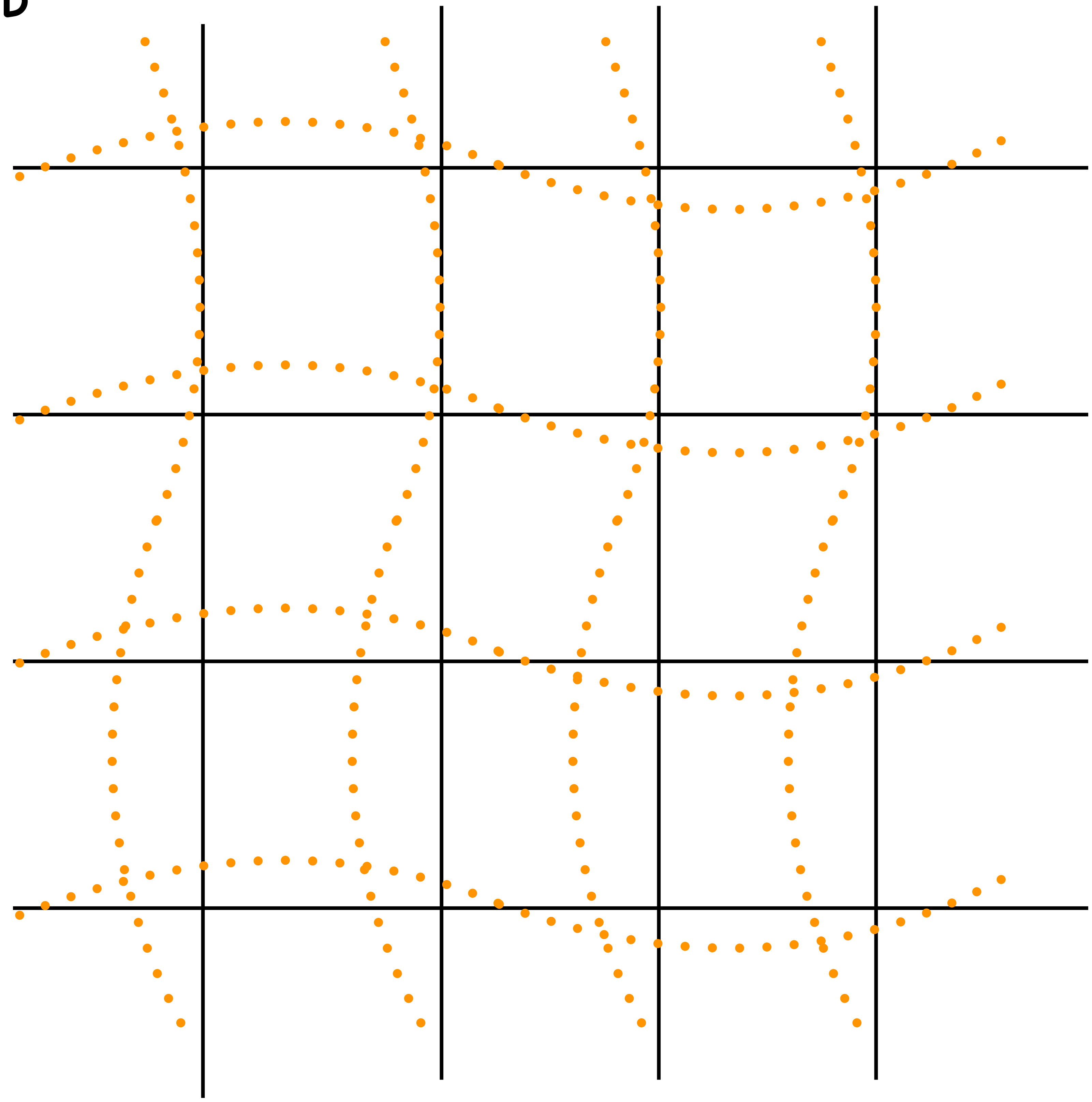
Evidence for a semi analytical model is found to be

Dimensions = 4 ± 0.1
from gravitational wave estimates
[Pardo, Fishbach, Holtz, 2018]

Probabilistic Dimensions
$d^D x$

Space Time Continuum

2D



2D curved probabilistic

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*

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

modifying dimensions

means that we need to modify

- topology (metric, manifold, curvature tensor)

- matter content evolution

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

Sophisticated and $\boxed{\text{Simple modifications}}$

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

P.Ntelis 2024 under review

Results

Einstein Field Equation results to modified Friedmann equations

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

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

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

Qualitative results

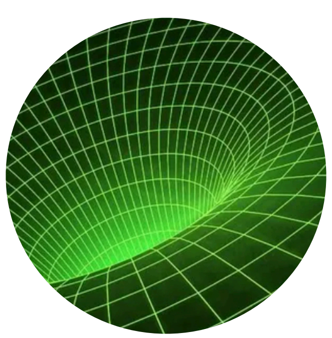
Connections of probabilities with information

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

New kind of manifold-metric pairs
using probabilities and information

Correspondence with field-particles characterisation (spacions):

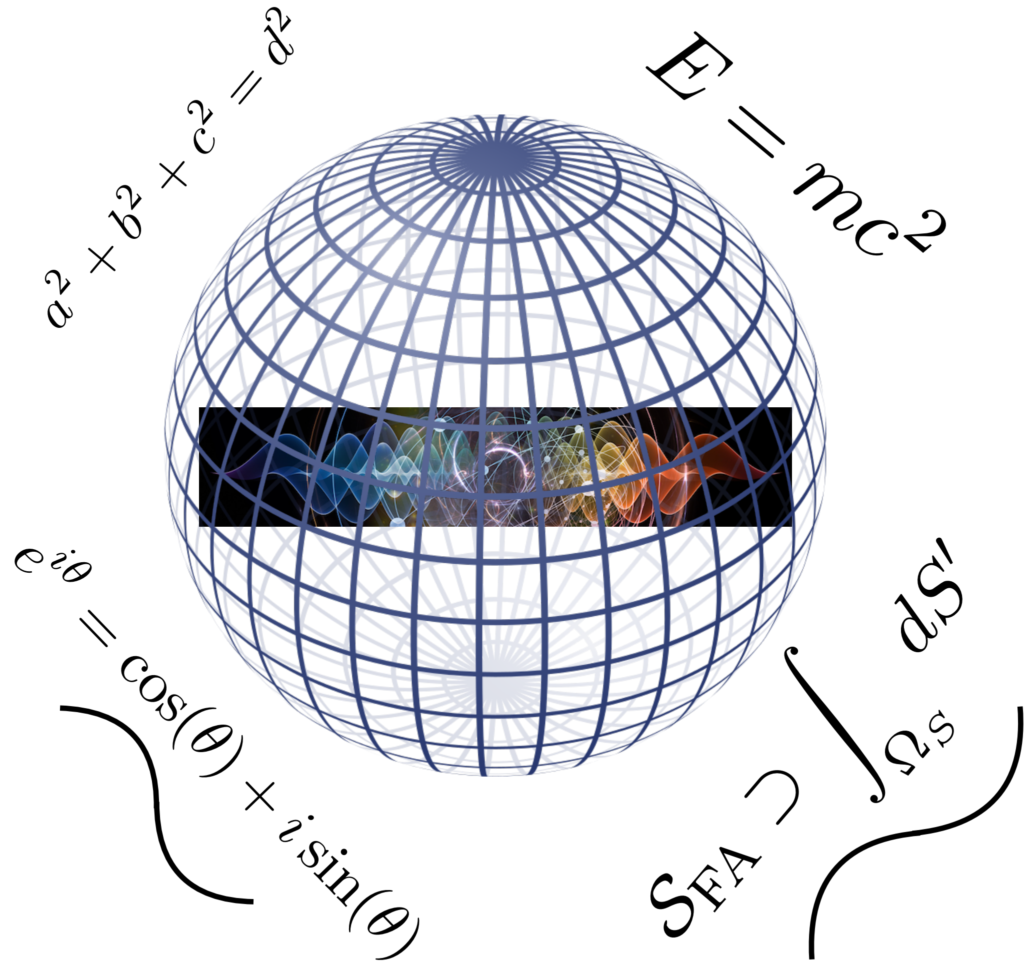
spaciallion, timions, probablons, informatons.



<u>**P.Ntelis 2024 under review**</u>

Outline

Universions



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

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

Conclusions

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

- Predictions of Spacions: Spatiallions, Timions, Probablons, Informatons

Future plans

Develop further 5 axis of research:

- Functors of actions cosmologies
- Probabilistic and informatics cosmologies
- Non-Riemannian cosmologies
- Dynamical analysis systems, numerical/analytical solutions
- Statistical tests of above theories (Early, Late Universe, GW)

Collaboration on models and tests with other cosmologists