News: Unification of black holes (of all masses) and the Quantum interior of black holes.

The quantum Penrose diagram of black holes.
The new quantum Gibbons-Hawking instanton

Recently published in the Physical Review D 107, 126018 (2023)

[Phys. Rev. D 107, 126018 (2023) - Quantum trans-Planckian physics inside black holes and its spectrum (aps.org)](https://journals.aps.org/prd/abstract/10.1103/PhysRevD.107.126018)

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In her recent paper (20 june 2023), argentinian and french quantum physicist and cosmologist Norma G. Sanchez (Director of Research and Director of the International School Daniel Chalonge - Hector de Vega) from Paris, provides for the first time a quantum unifying picture for *all* black holes (of all masses) and their main properties covering all: classical, semiclassical and quantum gravity domains: space-time, size, mass, vacuum ("zero-point") energy, temperature, partition function, density of states and entropy.

Novel results:

After the quantum space-time trilogy in 2019, the new quantum phase of the Universe 2021 with its discrete levels and the dark energy clarification, (Phys Rev D **104**, 12357 (2021)), the novel results of her recent work 2023 are the following:

- Black hole **interiors** are always **quantum**, trans-Planckian and of constant curvature. This is so for **all black holes**, of all masses, including the most macroscopic and astrophysical ones.

- The black hole interior trans-Planckian vacuum is similar to the earliest cosmological vacuum, where the classical gravity dual is the low energy cosmological vacuum-today dark energy. There is **no singularity** at r = 0. The quantum space-time is totally regular, and there is **no initial “big bang “ singularity**.

- Norma Sanchez extends to the quantum domain the classical Penrose diagram of the Schwarschild-Kruskal black hole. *The quantum Penrose diagram* is displayed in **Fig 1**

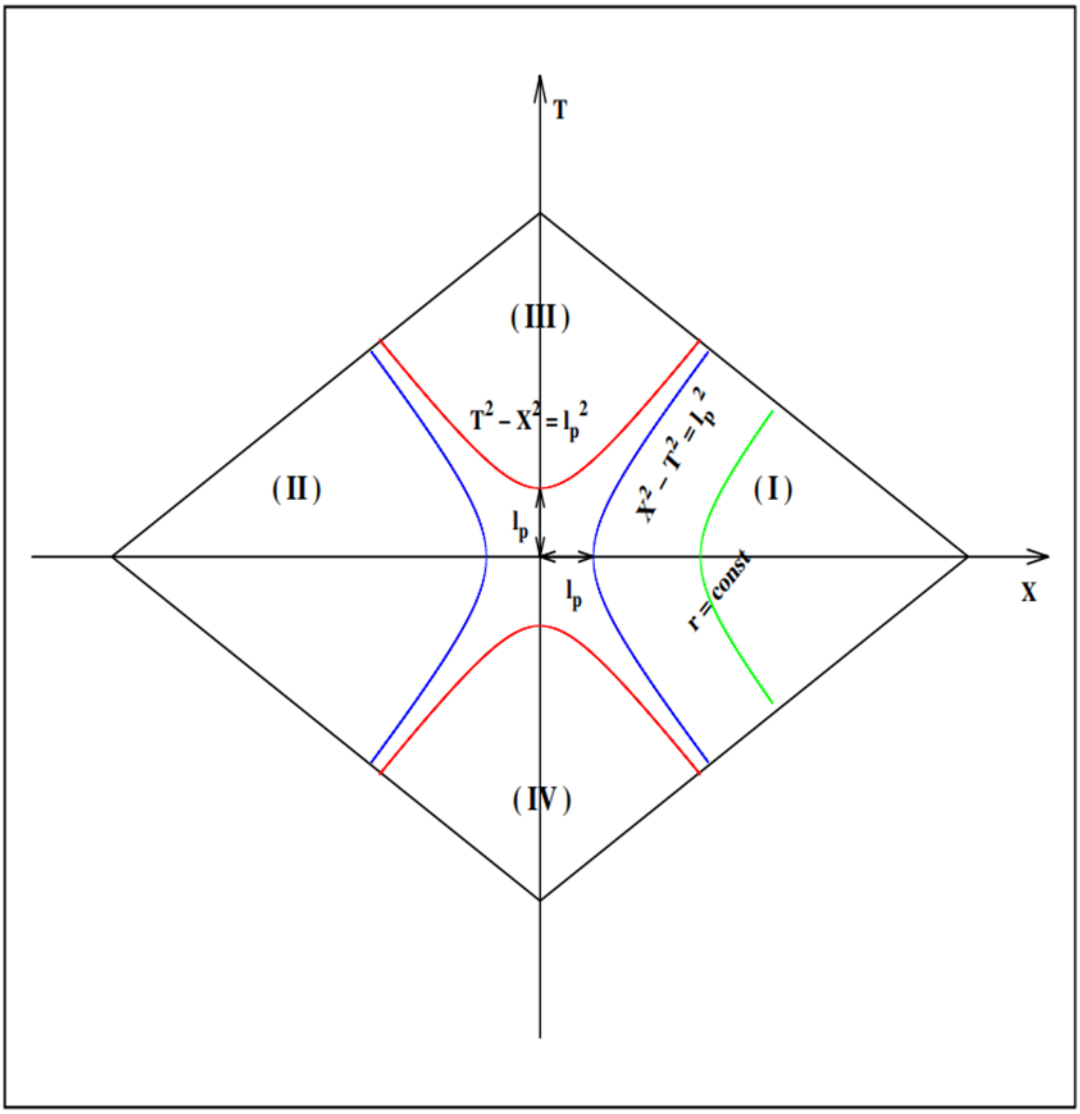

Fig.1: The new quantum Penrose diagram of the Schwarschild-Kruskal black hole.

- Dr Sanchez also extends the *Gibbons-Hawking instanton (imaginary time)* of the black hole to the quantum domain, as displayed in **Fig. 2:**

this covers the known classical instanton plus a **new**, central, highly dense quantum core of Planck length radius and constant curvature (quantum cosmic vacuum).

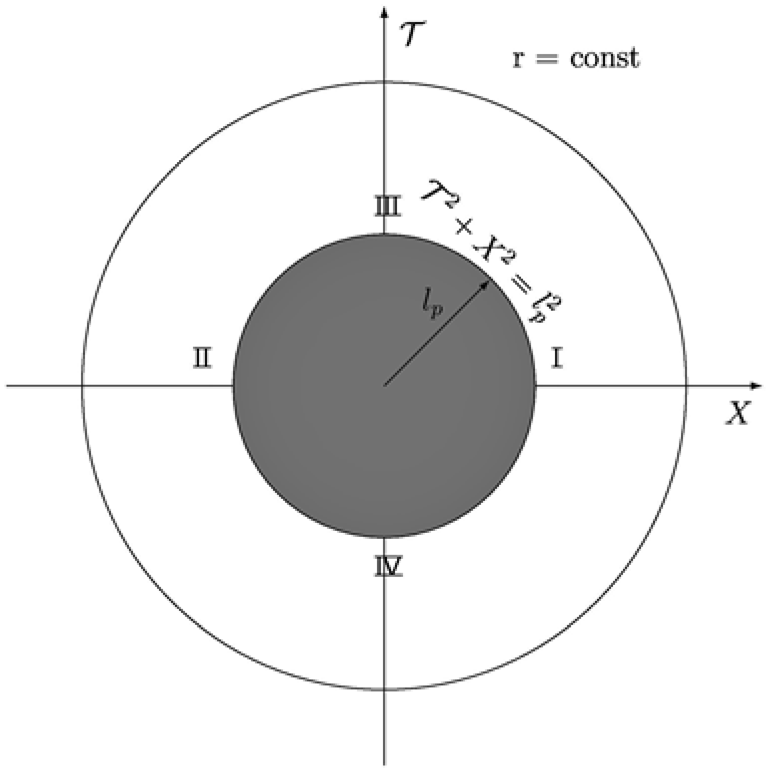

Fig. 2: The new quantum gravitational instanton of the Schwarschild-Kruskal black hole (imaginary time: T = i$\mathcal{T}$, t = i τ **). The new quantum Gibbons-Hawking instanton.**

- The complete partition function, entropy, temperature, decay rate, discrete levels and density of states **al**l include the quantum gravity (trans-Planckian) domain. The semiclassical black hole entropy (the Bekenstein-Hawking entropy) *(√n)*^{2} "interpolates" between the quantum point particle entropy *(n)* and the quantum string entropy *(√n)*, while the quantum trans-Planckian entropy is 1/(√n)^2 . Black hole evaporation finishes in a *pure (nonmixed*) quantum state of particles, gravitons, and radiation.

The key points of the novel Norma Sanchez's approach for a consistent Quantum theory of gravity are:

(i) Instead of starting as usual from classical gravity by quantizing general relativity or other gravity theory, Norma Sanchez starts from the opposite side: She starts from quantum physics to reach the Planck scale and the trans-Planckian domain.

(ii) Quantum gravity is *a finite theory*, not a renormalizable theory. There is no cuttoff in quantum gravity. Quantum gravity is a theory of pure numbers.

(iii) Quantum space-time is described by a quantum algebra with discrete levels. The classical space-time is recovered when the quantum operators are the classical space-time continuum coordinates (c-numbers) with all commutators vanishing.

The hyperbolic quantum space-time structure generates **the quantum light cone** and a new quantum vacuum region beyond the Planck scale emerges. This is so in *all* space-times, including flat (Minkowski) space-time. The quantum pressure (due to quantum uncertainty) bends the vacuum and generates the quantum curvature. At the quantum level, space-time is necessarily curved (non flat).

The Article :

Norma G. Sanchez, *Quantum trans-Planckian physics inside black holes and its spectrum,* Phys Rev D **107**, 126018 (2023)

https://journals.aps.org/prd/abstract/10.1103/PhysRevD.107.126018

https://chalonge-devega.fr/PhysRevD-Quantum_Trans_Planckian_Physics_inside_Black_Holes_and_its_Spectrum.pdf

https://chalonge-devega.fr/sanchez

Further reading :

[1] *Unifying quantum mechanics with Einstein's general relativity,* Research Outreach 111, (2019)

https://researchoutreach.org/articles/unifying-quantum-mechanics-einstein-general-relativity

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DOI: 10.32907/RO-111-138141 (Harvard Reference)

[2] *The Wave-Particle Duality of Quantum Physics extended for the first time to Einstein's Gravitation*
https://chalonge-devega.fr/NewsNSanchezEnglish.pdf

[3] N. G. Sanchez*, Quantum Discrete levels of Universe from the early trans-Planckian Vacuum to the late Dark Energy,* Phys. Rev. **D 104**, 123517 (2021).
https://journals.aps.org/prd/abstract/10.1103/PhysRevD.104.123517

[4] N. G. Sanchez*, The Classical – Quantum Duality of Nature including Gravity*, Int. J. Mod Phys **D28**, 1950055 (2019).
https://www.worldscientific.com/doi/abs/10.1142/S021827181950055X
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[5] N. G. Sanchez, *New quantum phase of the Universe before inflation and its cosmological and dark energy implications*. Int. J. Mod Phys **A34**, 1950155 (2019)
https://www.worldscientific.com/doi/abs/10.1142/S0217751X19501550
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[6] N. G. Sanchez, *New Quantum Structure the Space-Time,* Gravitation and Cosmology **25**, 91 (2019) Springer.
https://link.springer.com/article/10.1134/S0202289319020142

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