Quantum Gravity: Extending the Stress-Energy Tensor

Jan Sova[1]

[1]Independent Researcher , honzasova@gmail.com

May 1, 2025

Abstract

This paper proposes a modification of Einstein's field equations to include an additional tensor that represents the gravitational influence of matter in the mode of potency (BEING IN POTENCY), as defined in a prior ontological framework. Assuming that certain quantum systems before measurement exist in a non-actual but real and structured state, the paper introduces a potentiality energy-momentum tensor $P_{\mu\nu}$ alongside the classical tensor $T_{\mu\nu}$. The extended field equations thus take the form $G_{\mu\nu} + \Lambda g_{\mu\nu} = \frac{8\pi G}{c^4}(T_{\mu\nu} + P_{\mu\nu})$. As a physical consequence, the article presents a revised model of black holes in which matter inside the event horizon transitions into a gravitationally effective potent state, avoiding singularities while preserving external field behavior. This approach offers a new avenue for reconciling general relativity with quantum ontological constraints.

1 Introduction

In the article *Quantum Potentiality: An Aristotelian Interpretation of Modern Physics* [Sova, 2025], I propose an extension of the ontology of contemporary physics to include genuinely existing beings in the state of potency (BEING IN POTENCY), such as free quantum systems that, at a given moment, are not in an actually realized state (BEING IN ACT), but instead exist, for example, prior to the act of measurement. Within the Aristotelian ontology [Aristotle, 1933], [Aristotle, 1957], this article attributes these beings to a full and independent ontological status. BEING IN POTENCY is thus understood as an autonomous mode of being, not as a deficiency or merely an epistemic concept.

If we accept that potency—as understood in this context—possesses a real physical status, it becomes necessary to ask whether, and how, it contributes to gravity. In other words: Can the structured potency of a quantum system act as a source of gravitational interaction and be influenced by it simultaneously? While classical theory associates gravitational interaction exclusively with what I would now call actual matter and energy, there is growing reason to consider that a nonactualized component may also be gravitationally effective. This paper highlights two physical contexts that point in this direction: (1) the tension between the Heisenberg uncertainty principle and the assumption of exact localization in general relativity, and (2) the fact that the volume beneath the event horizon of a black hole grows faster than linearly with its mass. Each additional increment of mass produces a greater increase in volume than the previous one: the more massive the black hole, the more space it generates for the same amount of absorbed matter.

If we admit that not only BEING IN ACT but also BEING IN POTENCY contributes to gravity, then Einstein's field equations of general relativity would need to be extended by an additional tensor term representing the gravitational effect of beings (or matter) in the state of potency. Such an extended framework then offers an alternative model of black holes in which the formation of singularities could be avoided, while the overall gravitational effect remains preserved.

The proposed model assumes that inside the event horizon, matter, rather than remaining fully in the mode of act, undergoes a transition to the mode of BEING IN POTENCY. If all matter were to remain in act, the resulting state would require infinite localization and thus lead to the formation of a gravitational singularity. In contrast, the transition into structured potency prevents such a singularity. Nevertheless, the external gravitational field remains equivalent to that generated by fully actualized matter. The result is a model of a black hole without an actual singularity, yet with a preserved classical horizon and gravitational influence.

2 Physical Motivations for Introducing Gravitational Potency

This article refers to gravitational potency as the capacity of structured, non-actual matter to contribute to spacetime curvature. The term designates a mode of being that is not in act, yet remains ontologically real and gravitationally effective. In this part of the paper, two physical motivations for introducing this hypothesis will be presented: the Heisenberg uncertainty principle, and the nonlinear growth of black hole volume in response to mass increase.

2.1 The Heisenberg Uncertainty Principle and the Potent Structure of Matter Inside Black Holes

The Heisenberg uncertainty principle [Heisenberg, 1927], [Kulhanek, 2024] is a fundamental characteristic of quantum mechanics [1], stating that it is impossible to simultaneously determine certain pairs of physical quantities, such as position and momentum, with unlimited precision:

$$\Delta x\, \Delta p \geq \frac{\hbar}{2}, \tag{1}$$

where Δx denotes the uncertainty in position, Δp the uncertainty in momentum, and $\hbar$ is the reduced Planck constant.

This relation has significant implications when considered in the context of extreme gravitational conditions inside a black hole. Classical general relativity predicts that matter collapsing beyond the event horizon approaches a singularity, a region where spacetime curvature diverges and the classical description breaks down. Although this does not necessarily imply that particles are precisely localized in a point, the very notion of a singularity, as a region of zero volume and infinite density, stands in strong tension with the quantum mechanical uncertainty principle. A meaningful physical state cannot entail arbitrarily sharp localization of quantum entities without violating the foundational structure of quantum theory. In this light, it becomes problematic to assume that all matter within a black hole remains in the mode of actuality. Rather, part of that matter must transition into a non-actual mode of being: structured, indetermi-

[1] This principle is not merely a technical limitation of measurement, but a *ontological feature* of quantum objects. Quantum systems do not exist in sharply defined states of position and momentum; instead, they exist as structured *beings in potency*[2] (BEING IN POTENCY).

nate, and ontologically real. This shift allows the uncertainty principle to remain valid even in the presence of extreme gravitational fields, and suggests that the interior structure of a black hole may be co-governed by a form of gravitational potency[3].

2.2 Nonlinear Growth of Black Hole Volume and the Ontological Question of Interior Structure

In classical general relativity, the geometry of a black hole is determined by its mass. For a non-rotating, uncharged black hole, the Schwarzschild radius is given [Carroll, 2004] by:

$$R_s = \frac{2GM}{c^2},$$

where G is the gravitational constant, M the mass of the black hole and c the speed of light. Assuming spherical symmetry, the spatial volume enclosed by the event horizon is:

$$V = \frac{4}{3}\pi R_s^3 = \frac{32\pi G^3}{3c^6} M^3.$$

This shows that the black hole volume increases with the cube of its mass.

Of particular interest is the behavior of the derivative of this volume with respect to mass:

$$\frac{dV}{dM} = \frac{32\pi G^3}{c^6} M^2.$$

Each additional unit of mass thus causes a greater increase in volume than the previous one: the more massive the black hole, the more spatial expansion spacetime must undergo to accommodate it.

This phenomenon raises a significant ontological question: Why should the same amount of added mass require progressively more spatial volume? If all matter inside the black hole collapsed to a single point or negligible volume, there would be no apparent reason for spacetime to generate a larger horizon. The nonlinear growth of the black hole's volume suggests that the infalling matter is not merely localized in an actual state but instead requires some degree of spatial extension. This can be interpreted as an indication that part of the interior structure of the black hole exists in the mode of *being in potency* - that is, as an ontologically real

[3]The term *cogoverned* indicates that the interior structure of the black hole is not governed solely by actualized matter-energy ($T_{\mu\nu}$), but jointly influenced by both actual and potent components of matter. This reflects the hypothesis that gravitational dynamics inside the event horizon involve a dual ontological regime, where structured potentialities ($P_{\mu\nu}$) contribute along with classical stress energy to the curvature of spacetime

but unactualized structure that contributes gravitationally and requires presence in spacetime. While classical theory relates spacetime geometry only to actualized matter and energy, the present framework suggests that the geometry may also reflect a structured potential component that is not classically localizable but still exerts gravitational influence. The nonlinear volume growth of black holes may therefore be viewed as an indirect physical signature of this hidden, yet effective, ontological layer.

3 Hypothesis: Gravity of Potentiality

Let us hypothesize that matter that crosses the event horizon undergoes an ontological transformation from BEING IN ACT to BEING IN POTENCY[4]. From the perspective of an external observer, the black hole retains its observable parameters: mass, charge, and angular momentum. However, internally matter ceases to exist as a fully actualized substance and instead persists as a structured potency.

In this framework, the gravitational field of the black hole is not generated solely by actualized mass-energy, but also by the gravitational influence of matter in potency. This leads to the proposal of an additional geometric source term in the Einstein field equations: a new *potentiality energy-momentum tensor*, denoted $P_{\mu\nu}$, capturing the contribution of matter in the mode of potency.

In this framework, the gravitational field of the black hole is not generated solely by actually existing (i.e., actualized) matter but also by matter in potency. This leads to the proposal of an additional geometric source term in the Einstein field equations: a new *potentiality energy-momentum tensor*, denoted $P_{\mu\nu}$, capturing the contribution of matter in the mode of potency.

The classical Einstein field equations [Einstein, 1920] read:

$$G_{\mu\nu} + \Lambda g_{\mu\nu} = \frac{8\pi G}{c^4} T_{\mu\nu}, \tag{2}$$

where $T_{\mu\nu}$ encodes the energy and momentum of actualized matter and fields. To

[4] This transition is not necessarily total or instantaneous. It is plausible that only a portion of the matter undergoes this ontological shift, while some aspects remain in act, particularly those associated with conserved quantities such as charge or angular momentum. The gravitational influence of the system thus results from a coexistence of actualized and potential modes of being.

incorporate gravitational potency, we propose the following extended form:

$$G_{\mu\nu} + \Lambda g_{\mu\nu} = \frac{8\pi G}{c^4}(T_{\mu\nu} + P_{\mu\nu}), \tag{3}$$

where $P_{\mu\nu}$ encodes the gravitational influence of matter in the state of potency. This tensor is expected to differ fundamentally from $T_{\mu\nu}$: It may not correspond to the localized stress energy and it may not satisfy the standard conservation condition without a reformulation of the act-potency dynamics.

Remark. In regions where matter remains fully actualized[5], the tensor $P_{\mu\nu}$ vanishes: $P_{\mu\nu} = 0$.

Table 1: Comparison between the Energy-Momentum Tensor for Actual Matter $T_{\mu\nu}$ and for Potential Matter $P_{\mu\nu}$

Property	**Actual Matter** ($T_{\mu\nu}$)	**Potential Matter** ($P_{\mu\nu}$)
Localization	Locally defined energy and momentum	Delocalized, non-actual spatial structure
Pressure	Real, possibly positive or negative	Possibly zero or effectively negative
Energy Density	Measurable and observable	Latent capacity, not directly measurable
Lorentz Transformation	Standard rank-2 tensor	Rank-2 tensor, potentially with relaxed covariance
Conservation Law	$\nabla^\mu T_{\mu\nu} = 0$	May require modified conservation tied to transitions between act and potency
Presence in Spacetime	Yes, wherever matter is in act	Possibly nonzero even in vacuum; expected to dominate near horizons or at Planck scales

The tensor $P_{\mu\nu}$ is introduced to encode the gravitational influence of matter that no longer exists in an actualized mode, but rather in the ontological state of BEING IN POTENCY. Such matter is not tied to a classically localized energy distribution,

[5]Strictly speaking, it is not evident whether any region of spacetime exists in which the tensor $P_{\mu\nu}$ vanishes identically. Even the quantum vacuum exhibits structured potentiality—e.g., through fluctuations and zero-point energy—which may imply a nonzero contribution to gravitational curvature. Accordingly, the notion of a region entirely devoid of gravitational potency remains physically and ontologically questionable.

but is understood as a structured set of directed potencies, configurations of possible actualizations constrained by physical law. Although these potencies are not manifest in observable form, they retain a real, non-epistemic gravitational effect.

Currently, the tensor $P_{\mu\nu}$ remains formally undefined. However, its conceptual necessity follows from the ontological recognition of *structured potency* as a real and gravitationally effective mode of being. Just as dark energy was initially posited as an unknown source term in cosmological equations, I posit $P_{\mu\nu}$ as a placeholder for a yet-to-be formalized structure rooted in metaphysical potentiality.

4 Avoiding Singularities Through Gravitational Potency

In classical general relativity, gravitational singularities arise when the curvature of spacetime becomes infinite and the Einstein field equations cease to provide a meaningful description. This typically occurs when the energy-momentum tensor $T_{\mu\nu}$ leads to a solution in which the space-time metric $g_{\mu\nu}$ becomes singular, e.g., at the center of a Schwarzschild black hole where $r \to 0$, and curvature invariants such as the Kretschmann scalar $K = R^{\mu\nu\rho\sigma}R_{\mu\nu\rho\sigma}$ diverge.

4.1 Ontological Source of the Singularity

In the standard framework, this divergence results from modeling all matter as fully actualized, that is, as encoded exclusively in $T_{\mu\nu}$, which represents localized, classical energy and momentum. However, this approach neglects the possibility that under extreme gravitational compression, matter may cease to exist in an actualized state and instead transition into a nonlocal structured mode of BEING IN POTENCY.

According to the hypothesis developed in this paper, such potent matter contributes to spacetime curvature through an additional tensor $P_{\mu\nu}$, the *potentiality energy-momentum tensor*, which supplements the classical source term:

$$G_{\mu\nu} + \Lambda g_{\mu\nu} = \frac{8\pi G}{c^4} \left(T_{\mu\nu} + P_{\mu\nu}\right).$$

4.2 Mechanism of Singularity Avoidance

Consider a collapsing spherical body. In the standard model, as $r \to 0$, the energy density encoded in $T_{\mu\nu}$ increases without bound. However, the Heisenberg uncertainty principle prohibits perfect localization of quantum entities. Hence, if the matter were to remain entirely in act down to $r = 0$, this would violate quantum mechanical constraints.

In the proposed framework, as the collapse progresses and classical localization becomes physically and ontologically impossible, a transition occurs:

$$T_{\mu\nu}(x) \to 0, \quad \text{while} \quad P_{\mu\nu}(x) \to P^{\text{eff}}_{\mu\nu}(x) \neq 0.$$

The tensor $P^{\text{eff}}_{\mu\nu}$ captures the gravitational effect of matter in the state of potency. Crucially, while $T_{\mu\nu}$ vanishes or diverges pathologically, $P^{\text{eff}}_{\mu\nu}$ remains finite and smooth, preserving the geometric structure of the field equations.

This means that the curvature tensors, such as the Ricci tensor $R_{\mu\nu}$, Ricci scalar R, and the Einstein tensor $G_{\mu\nu}$, remain well-defined throughout the interior spacetime:

$$\text{If} \quad G_{\mu\nu} \sim \frac{8\pi G}{c^4} P^{\text{eff}}_{\mu\nu}, \quad \text{then} \quad \text{no divergence occurs as } r \to 0.$$

4.3 Implications for the Interior Geometry

The absence of divergence implies that the spacetime geometry continues smoothly inside the black hole, beyond where the classical singularity was expected. The region where $P_{\mu\nu}$ dominates defines a *potent domain* $\mathcal{D}_P \subset \mathcal{M}$, where $\mathcal{M}$ is the spacetime manifold. In this domain:

$$T_{\mu\nu} \approx 0, \quad P_{\mu\nu} \neq 0, \quad \nabla^{\mu} P_{\mu\nu} \approx 0,$$

and the spacetime metric $g_{\mu\nu}$ remains regular, though potentially non-analytic or delocalized due to the non-pointlike nature of the source.

The boundary of $\mathcal{D}_P$ may be identified with the surface beyond which classical matter transitions to the potent regime, potentially associated with Planck-scale densities or the breakdown of semiclassical localization.

The inclusion of the tensor $P_{\mu\nu}$ into the field equations permits the gravitational influence of non-actual matter to be incorporated consistently within general relativity. In doing so, it prevents the emergence of singularities by replacing them with structured, non-singular domains where matter persists in the mode of potency. The resulting theory remains regular and predictive throughout the entire space-time manifold, including the interior of black holes.

This mechanism reflects a shift from an actualist to a potency-inclusive ontology and reinterprets the gravitational collapse not as a failure of geometry but as a transition in the mode of being of matter.

5 Conclusion

This paper has proposed a conceptual and mathematical extension of Einstein's field equations by introducing a new energy-momentum tensor $P_{\mu\nu}$, representing the gravitational influence of matter in the ontological mode of BEING IN POTENCY. Drawing upon Aristotelian ontology, the framework postulates that quantum systems that are not yet actualized can nevertheless exist as structured, law-constrained configurations of potentiality that are ontologically real and gravitationally effective.

Two key physical motivations have supported this proposal. First, the Heisenberg uncertainty principle limits the possibility of complete localization of quantum entities, challenging the notion of singularities, where matter would have to be infinitely confined. Second, the nonlinear growth of black hole volume with increasing mass suggests the presence of internal structure that cannot be attributed solely to actual matter but may point to an extended, nonactual component contributing to curvature.

In response, I have proposed a generalization of the Einstein field equations of the form:

$$G_{\mu\nu} + \Lambda g_{\mu\nu} = \frac{8\pi G}{c^4}(T_{\mu\nu} + P_{\mu\nu}),$$

where $P_{\mu\nu}$ vanishes in regions of fully actualized matter, but becomes significant (for instance) under extreme gravitational conditions, particularly inside black holes. This addition allows the field equations to remain regular and physically meaningful even where classical theory predicts breakdowns. Singularities, in this framework, are avoided not by modifying the geometry of spacetime directly but by recognizing a deeper ontological layer of matter that continues to gravitate without being actualized.

The inclusion of gravitational potency reinterprets gravitational collapse as an ontological transition rather than a geometric failure. In doing so, it opens a new pathway toward integrating quantum ontology with the geometric language of general relativity. Future work will be required to formalize the properties, dynamics and conservation behavior of the tensor $P_{\mu\nu}$, but the framework presented here lays the philosophical and physical foundations for such an endeavor.

References

Jan Sova. Quantum potentiality: An aristotelian interpretation of modern physics. *viXra*, (2504.0168), 2025. https://vixra.org/abs/2504.0168.

Aristotle. *Metaphysics, Volume I: Books 1–9*, volume 271 of *Loeb Classical Library*. Harvard University Press, Cambridge, MA, 1933. URL https://www.loebclassics.com/view/LCL271/1933/volume.xml.

Aristotle. *Physics, Volume I: Books 1–4*, volume 228 of *Loeb Classical Library*. Harvard University Press, Cambridge, MA, 1957. URL https://www.loebclassics.com/view/LCL228/1957/volume.xml.

Werner Heisenberg. Über den anschaulichen inhalt der quantentheoretischen kinematik und mechanik. *Zeitschrift für Physik*, 43:172–198, 1927. doi: 10.1007/BF01397280.

Petr Kulhanek. *Vybrane kapitoly z teoreticke fyziky*. AGA, 2024. ISBN 978-80-904582-8-4. URL https://www.aldebaran.cz/studium/tf.pdf. Available online.

Sean M. Carroll. *Spacetime and Geometry: An Introduction to General Relativity*. Addison Wesley, 2004. Available online at https://fma.if.usp.br/~mlima/teaching/PGF5292_2021/Carroll_SG.pdf.

Albert Einstein. *Relativity: The Special and the General Theory*. Henry Holt and Company, New York, 1920. Translated by Robert W. Lawson.