Oppenheim’s “Postquantum Theory of Classical Gravity” and “OUR” “Theory of Everything”

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Abstract

In this brief paper we are going to show how Jonethan Oppenheimer’s “Postquantum Theory of Classical Gravity” [A1] can directly be obtained from “our” Quantum Gravity ansatz (e.g. [A2, A3, A4, A5, A6, A7]), whereby we use the quotation marks for the word “our” to point out that – in principle – David Hilbert [A8] already had such a general theory, only that – at the time of the publication of his work in 1915, he had no chance to realize this (c.f. [A2]). We will show that our approach produces both, the classical Einstein-Field-Equations [A9] and the quantum theory. We will also show how from there the Oppenheim ansatz can be extracted in a simplest possible way.

Abstract References

[A1] J. Oppenheim, “A Postquantum Theory of Classical Gravity?”, PHYSICAL REVIEW X 13, 041040 (2023), DOI: 10.1103/PhysRevX.13.041040
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[A8] D. Hilbert, Die Grundlagen der Physik, Teil 1, Göttinger Nachrichten, 395-407 (1915)
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Oppenheim Gravity Theory (an AI-generated text)

“Jonathan Oppenheim, a physicist at University College London, has proposed a radical alternative to the standard quest for quantum gravity, suggesting that gravity might be fundamentally classical rather than quantum. His theory, termed a "postquantum theory of classical gravity," posits that spacetime is smooth and continuous but inherently wobbly due to random fluctuations. These fluctuations are not merely noise but a necessary feature to reconcile classical gravity with quantum mechanics, preventing the violation of the uncertainty principle that would otherwise occur when coupling the two.

The core idea is that the gravitational field itself, and thus the geometry of spacetime, undergoes random fluctuations. This randomness means that the interaction between quantum matter and gravity is not deterministic but probabilistic. For instance, in the double-slit experiment, a standard classical gravity theory would allow the precise determination of which slit a particle passed through by measuring its gravitational field, destroying the interference pattern. However, Oppenheim's theory, with its inherent randomness, prevents such precise measurement, preserving the quantum interference pattern.

This stochastic coupling allows gravity to remain classical while still being compatible with quantum phenomena. The theory suggests that the interaction between quantum matter and the gravitational field causes a gradual decoherence of the quantum state, effectively collapsing the wavefunction over time. This process is driven by the feedback between the random fluctuations in spacetime and the quantum matter generating the field. The theory also predicts an intrinsic breakdown in predictability, meaning the future state of a system cannot be determined with certainty from its current state, a feature that contrasts with the reversibility of standard physical laws.

Oppenheim's framework is supported by the idea that quantum theory itself may require a classical spacetime foundation to be well-formulated, as a shifting quantum foundation would undermine the stability of quantum states. The theory has been published in Physical Review X and Nature Communications, with co-authors including Zach Weller-Davies from the Perimeter Institute. Experimental tests are being developed to detect these random gravitational fluctuations, such as measuring the response of a mass to a gravitational field with extreme precision or testing how long a heavy atom can remain in a superposition of locations. The theory also offers potential explanations for phenomena like galactic rotation curves and the expansion of the universe without invoking dark matter or dark energy, attributing the necessary energy to the background hum of spacetime fluctuations."

Oppenheim Gravity Theory- A Simple Explanation about its Mathematical Core

We might just simplify the core of Oppenheim's approach [1] by, just as Oppenheim has done himself, using the fundamental incompatibility problem of quantum theory and Einstein's General Theory of Relativity [2]:

$$G_{\alpha\beta} = R_{\alpha\beta} - R\frac{g_{\alpha\beta}}{2} = \quad \Leftrightarrow \quad = \frac{8\pi G}{c^4}\hat{T}_{\alpha\beta}, \tag{1}$$

where we see that we have two completely different mathematical structures. While, on the lefthand side we have a classical curvature term with the Einstein tensor being constructed out of the Ricci tensor $R_{\alpha\beta}$ and the Ricci scalar R, the righthand side (with the energy momentum tensor, Newton's constant G, and the speed of light in vacuum c) should be a quantum theoretical operator object. But we cannot have an operator on one side and something classical on the other. This does not fit. We refer to Oppenheim's paper [1] regarding the elaboration, especially with respect to the usual attempt to make the lefthand side also an operator equation. In contrast to the complex path Oppenheim used in his approach, we here point out that – perhaps – we might reconcile the two sides by dragging a bit of the jittery right hand side over to the left, thereby kind of destabilizing the classical gravity theory a bit, which is to say, just enough to make the whole equation balanced:

$$\hat{F}\cdot G_{\alpha\beta}=\hat{F}\cdot\left(R_{\alpha\beta}-R\frac{g_{\alpha\beta}}{2}\right)=\frac{8\pi G}{c^4}\hat{T}_{\alpha\beta}[F]. \tag{2}$$

This is just Oppenheim's post-quantization of the classical gravity theory.

We start looking for such a structure in the simplest form as an eigenequation as follows:

$$\hat{F}\cdot G_{\alpha\beta}=F\cdot G_{\alpha\beta}=F\cdot\left(R_{\alpha\beta}-R\frac{g_{\alpha\beta}}{2}\right)=\frac{8\pi G}{c^4}\hat{T}_{\alpha\beta}[F]. \tag{3}$$

Our Quantum Gravity Theory

We start with the following scaled metric tensor and force it into the Einstein-Hilbert action [3] variational problem as follows:

$$\Gamma_{\alpha\beta}=g_{\alpha\beta}\cdot F[f]\quad\rightarrow\quad\delta W=0=\delta\int_V d^n x\sqrt{-\Gamma}\cdot R^{*} \tag{4}$$

Here Γ denotes the determinant of the metric tensor from (4) and R^{*} gives the corresponding Ricci scalar. Performing the variation with respect to the metric $\Gamma_{\alpha\beta}$ results in:

$$0=\left(\begin{array}{l}\boxed{R_{\alpha\beta}-R\frac{g_{\alpha\beta}}{2}}+\frac{1}{4F^2}\left(F_{,\alpha}\cdot F_{,\beta}(3n-6)+g_{\alpha\beta}F_{,c}F_{,d}g^{cd}(4-n)\right)\\ -\frac{1}{2F}\left(\begin{array}{c}F_{,\alpha\beta}(n-2)+F_{,ab}g_{\alpha\beta}g^{ab}+F_{,a}g^{ab}\left(g_{\beta b,\alpha}-g_{\beta\alpha,b}\right)-\\ F_{,\alpha}g^{ab}g_{\beta b,a}-F_{,\beta}g^{ab}g_{\alpha b,a}+F_{,d}g^{cd}\left(\begin{array}{l}g_{\alpha c,\beta}-\frac{1}{2}ng_{\alpha c,\beta}-\frac{1}{2}ng_{\beta c,\alpha}\\ +\frac{1}{2}ng_{\alpha\beta,c}+\frac{1}{2}g_{\alpha\beta}g_{ab,c}g^{ab}\end{array}\right)\end{array}\right)\\ +(n-1)\left(\frac{1}{2F}\left(\begin{array}{c}2\Delta F-2F_{,d}g^{cd}{}_{,c}\\ -\frac{n}{(n-1)}F_{,d}g^{cd}g^{ab}g_{ac,b}\end{array}\right)+\frac{g^{ab}F_{,a}\cdot F_{,b}}{4F^2}(n-6)\right)\cdot\frac{g_{\alpha\beta}}{2}\end{array}\right)\delta\Gamma^{\alpha\beta} \tag{5}$$

and shows us that we have not only obtained the classical Einstein Theory of Relativity [2] (see boxed terms exactly giving the Einstein Field Equations in vacuum), but also a set of quantum field equations for the scaling function F, clearly playing the role of the wave-function. It was shown in our previous publications [4, 5, 6, 7, 8] that these additional terms are clearly quantum equations fully covering the main aspects of relativistic classical quantum theory. So, we conclude, that we indeed have a Quantum Gravity Theory or Theory of Everything, as one also calls it, at hand.

Towards Oppenheim's Jittering Gravity

Simply taking our result (5) and reordering it a bit as follows:

$$
F\cdot G_{\alpha\beta}=F\cdot\left(R_{\alpha\beta}-R\frac{g_{\alpha\beta}}{2}\right)
$$

$$
=\frac{1}{2}\left(\begin{array}{c}
\left(\begin{array}{c}
F_{,\alpha\beta}(n-2)+F_{,ab}g_{\alpha\beta}g^{ab}+F_{,a}g^{ab}\left(g_{\beta b,\alpha}-g_{\beta\alpha,b}\right)- \\
F_{,\alpha}g^{ab}g_{\beta b,a}-F_{,\beta}g^{ab}g_{\alpha b,a}+F_{,d}g^{cd}\left(\begin{array}{c}
g_{\alpha c,\beta}-\frac{1}{2}ng_{\alpha c,\beta}-\frac{1}{2}ng_{\beta c,\alpha} \\
+\frac{1}{2}ng_{\alpha\beta,c}+\frac{1}{2}g_{\alpha\beta}g_{ab,c}g^{ab}
\end{array}\right)
\end{array}\right) \\
-\frac{1}{2F}\left(F_{,\alpha}\cdot F_{,\beta}(3n-6)+g_{\alpha\beta}F_{,c}F_{,d}g^{cd}(4-n)\right) \\
-(n-1)\left(\left(\begin{array}{c}
2\Delta F-2F_{,d}g^{cd}{}_{,c} \\
-\frac{n}{(n-1)}F_{,d}g^{cd}g^{ab}g_{ac,b}
\end{array}\right)+\frac{g^{ab}F_{,a}\cdot F_{,b}}{2F}(n-6)\right)\cdot\frac{g_{\alpha\beta}}{2}
\end{array}\right) \tag{6}
$$

gives us the required structure (3) in its proper expanded form. Hence, we have obtained a post-quantized gravity right out of our quantum gravity approach of a scaled metric tensor (4), thereby sticking to the classical Hilbert variation.

Conclusions

We have shown that Oppenheim's idea of a post-quantized gravity is part of "our" quantum gravity theory, respectively, already was a part of Hilbert's "Grundlagen der Physik" (Fundamentals of physics → see [3]). It only requires a bit of extension and reordering of the classical equations in order to obtain the necessary post-quantum/jittering-gravity structure.

References

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