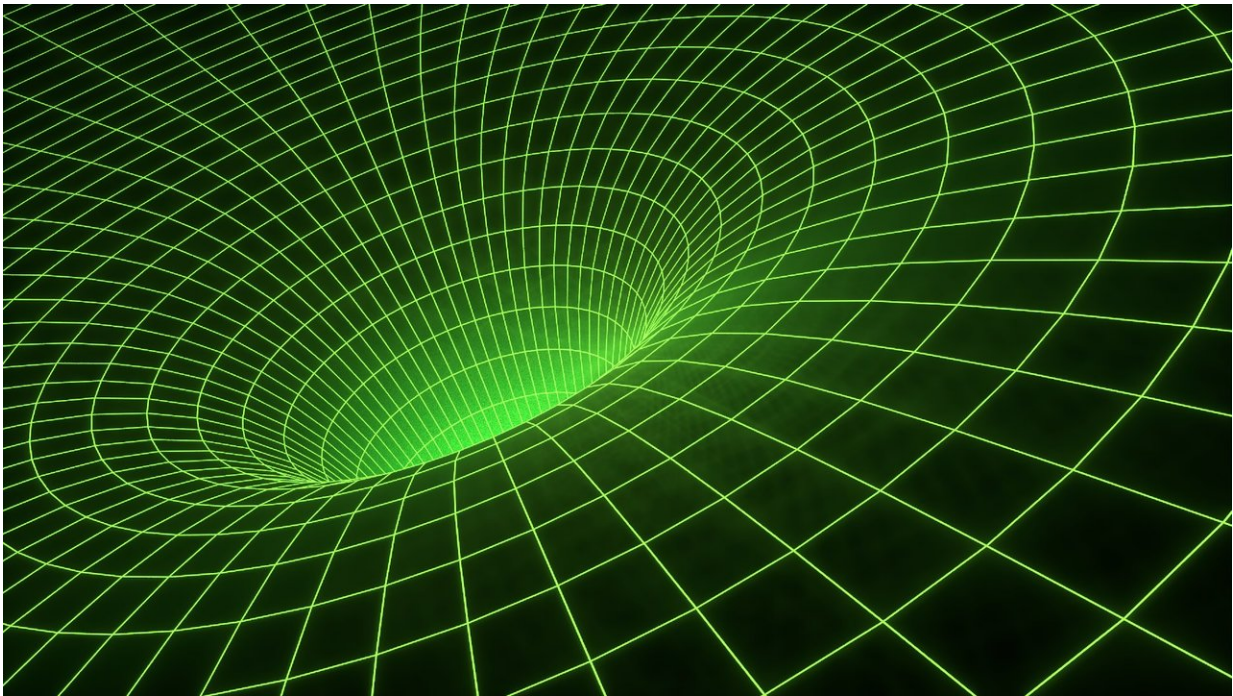


Witnessing the birth of baby universes 46 times: The link between gravity and soliton

February 27 2020



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Scientists have been attempting to come up with an equation to unify the micro and macro laws of the Universe; quantum mechanics and gravity. We are one step closer with a paper that demonstrates that this unification is successfully realized in JT gravity. In the simplified toy model of the one dimensional domain, the holographic principle, or how information is stored on a boundary that manifests in another dimension

is revealed.

How did the universe begin? How does quantum mechanics, the study of the smallest things, relate to gravity and the study of big things? These are some of the questions physicists have been working to solve ever since Einstein released his theory of relativity.

Formulas show that baby universes pops in and out of the main Universe. However, we don't realize or experience this as humans. To calculate how this scales, [theoretical physicists](#) devised the so-called JT gravity, which turns the [universe](#) into a toy-like model with only one dimension of time or space. These restricted parameters allows for a model in which scientists can test their theories.

Building on the work of others, Professor Kazumi Okuyama of Shinshu University and Kazuhiro Sakai of Meiji Gakuin University set out to show how JT gravity, the KdV equation and the macroscopic loop are related, thus pointing to the fact that gravity and quantum mechanics are unified. In the process, the duo succeeded in calculating the birth of baby universes 46 times, which has never been done before, due to the fact the more times this is calculated, the more things get increasingly complicated. Previously, Peter Zograf was able to calculate this 20 times.

The mathematical KdV equation formulated in the late 19th Century has been thought to be linked to gravity since the 1990s. The KdV equation was first used to show how [water waves](#) behave: for example, inside the canals in waterway laden Holland, solitons can be observed, or how a crest of a water wave continues unchanged for a long time when not disturbed. The macroscopic loop was also said to be related to gravity in the 1990s.

Waves and gravity are thought to be comparable in how they manifest

themselves. The [holographic principle](#) was introduced by Gerard 't Hooft as a way to understand how gravity and quantum mechanics work. When these theories are combined, one can think of the 3-D physical as the gravity and the information that it is sprung from; flat like how a hologram is on a credit card. This speaks to the dimensions in space. There is no formula yet for the holographic principle.

The bulk-boundary correspondence idea is similar to this in that the bulk is the three dimensional manifestation of the boundary which is the information that gives rise to the hologram.

Professor Okuyama was able to show in this study that the JT gravity, KdV equation and macroscopic loop are intimately connected, pointing to the fact that [quantum mechanics](#) and [gravity](#) are indeed unified holographically in this model. He hopes to keep working to solve this problem in physics by devising a method to calculate the birth of baby universes not just in the "toy model" but for the existent Universe.

More information: Kazumi Okuyama et al, JT gravity, KdV equations and macroscopic loop operators, *Journal of High Energy Physics* (2020). [DOI: 10.1007/JHEP01\(2020\)156](https://doi.org/10.1007/JHEP01(2020)156)

Provided by Shinshu University

Citation: Witnessing the birth of baby universes 46 times: The link between gravity and soliton (2020, February 27) retrieved 19 April 2024 from <https://phys.org/news/2020-02-witnessing-birth-baby-universes-link.html>

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