Vanquishing infinity: Old methods lead to a new approach to finding a quantum theory of gravity

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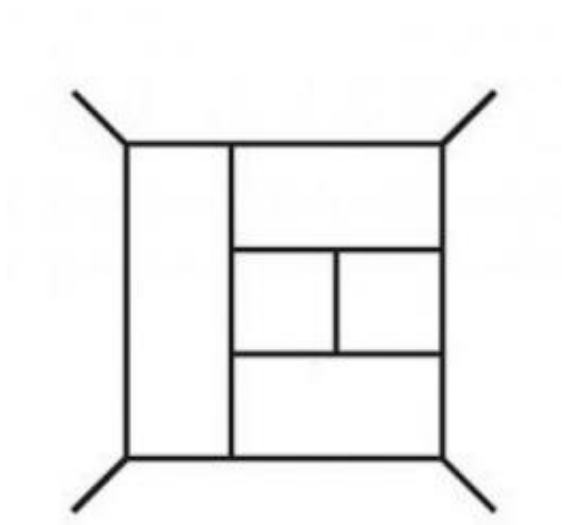

In the 1940s, Richard Feynman devised a graphical method for carrying out calculations. Bern et al. use different kinds of diagrams that permit large calculations. Owing to their resemblance to the work of artist Piet Mondrian, these graphical computational devices are sometimes referred to as Mondrian diagrams. Credit: Adapted from Bern et al., Phys. Rev. D 76, 125020 (2007)]

Quantum mechanics and Einstein's theory of general relativity are both extremely accurate theories of how the universe works, but all attempts to combine the two into a unified theory have ended in failure. When physicists try to calculate the properties of a quantum theory of gravity,

they find quantities that become infinite -- infinities that are so bad they can't be removed by mathematical gambits that work in other areas of physics.

Now, Zvi Bern, John Carrasco, and Henrik Johanssen at UCLA, Lance Dixon at the Stanford Linear Accelerator Center, and Radu Roiban at Pennsylvania State University have found a way to carry out a new set of gravity calculations with the help of an older theory that has been known since the 1980s to be finite.

Their new results are reported in *Physical Review Letters* and highlighted in a commentary by Hermann Nicolai at the Max Planck Institute for Gravitational Physics in Potsdam, Germany, in *Physics*.

Previous attempts at removing the fatal infinities in quantum gravity calculations collapsed when researchers discovered that you would need an infinite number of parameters. The problem stems from the point-like and thus infinitesimally small fundamental particles in the theories, so some physicists have developed string theory as a possible approach: instead of point particles, the fundamental entities are vibrating loops of string. But string theory is beset with its own difficulties, as it lays out a "landscape" of possibilities with an astronomical number of scenarios.

The new paper by Bern et al. shows that by combining desirable aspects of string theory and point-like particles, they can use cancellations in the calculations - done with the help of graphical computational methods called Feynman diagrams (and later elaborations) - to escape the problem of infinities. While not a solution to the problem of quantum gravity, nor a result that knocks string theory aside, the findings of Bern et al. show that theories thought to be dead ends may still show the way forward.

More information: Phys. Rev. Lett. 103, 081301 (2009),

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