A breakthrough on the mathematical understanding of Einstein's equations

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Proposed 15 years ago, the bounded L2 curvature conjecture has finally been proved by a group of three researchers at the Laboratoire Jacques-Louis Lions (CNRS / UPMC / Université Paris Diderot) and Princeton University. It provides a potentially minimal framework in which it is possible to solve the Einstein equations, which in turn could be a critical step toward the proof of major conjectures, such as Penrose's cosmic censorship conjectures. This work has appeared in Inventiones Mathematicae on October 14.

Even though this year marks its 100th anniversary, Albert Einstein's theory of general relativity still holds its share of mysteries. This theory of gravitation stipulates that matter curves spacetime in proportion to the mass of the object. This phenomenon is measured using a mathematical tool called the curvature tensor, on which the bounded L2 curvature conjecture focuses to find possible frameworks for making sense of solutions to Einstein's equations. Proposed 15 years ago by Sergiu Klainerman, this conjecture has at last been demonstrated by Sergiu Klainerman, Igor Rodnianski and Jérémie Szeftel.

The bounded L2 curvature conjecture stipulates that Einstein's equations admit a solution if, at the initial time, the space curvature tensor is square-integrable—in other words, if the integral of its square is a finite number. This resolution of the bounded L2 curvature conjecture is important because it is a potential step towards the proof of Penrose's famous cosmic censorship conjectures, which concerns gravitational singularities: pathological regions of spacetime where the gravitational field becomes infinite, like in the center of a black hole. The presence of such cases in the solutions to Einstein's equations could challenge the physical validity of general relativity.

Roger Penrose posits that these singularities are never visible because they are generically hidden behind the event horizon: the region of a black hole from which light cannot escape and become perceptible to observers. Although much remains to be learnt about these phenomena, the equations that govern them are now somewhat less mysterious in light of this new proof.

More information: Sergiu Klainerman et al. "The bounded $$L^2$$ L 2 curvature conjecture," *Inventiones mathematicae* (2015). DOI: 10.1007/s00222-014-0567-3

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