How physics breaks down in a black hole

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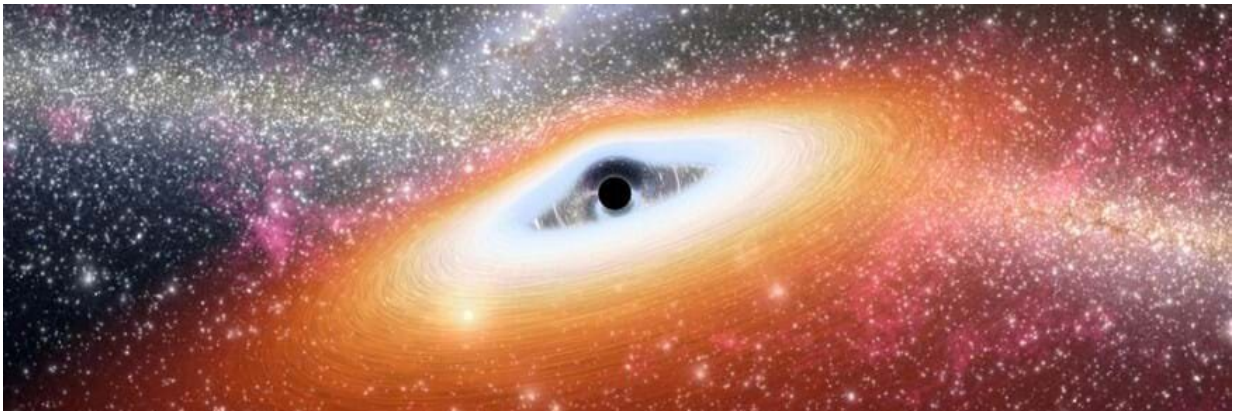

An artist's conception illustrates one of the most primitive supermassive black holes known (central black dot) at the core of a young, star-rich galaxy. Credit: NASA/JPL-Caltech

One of the most cherished laws of physics—the conservation of charge—has come under fire in "startling" research by physicists.

The paper by Dr. Jonathan Gratus from Lancaster University and Dr. Paul Kinsler and Professor Martin McCall from Imperial College London demonstrates how the laws of physics break down in a black hole or "singularity."

"As the place where physics 'breaks down' in a black-hole, we have the sense that anything might happen at a singularity. Although perhaps most useful as a plot device for science fiction stories, should we as concerned

physicists nevertheless check what conservation laws might no longer hold?"

The physicists investigated the behavior of charge conservation which is the principle that the total electric charge in an isolated system never changes.

To their surprise, they found that they could overturn this "usually sacrosanct principle of standard electromagnetism."

Dr. Kinsler said: "By dropping an 'axion-bomb' into a temporary singularity, such as an evaporating black hole, we can create or destroy electrical charge."

Axions are a hypothesized particle that are a candidate for dark matter, although their exact properties are still debated, and they have not yet been detected.

Professor Martin McCall said: "This so-called axion-bomb is a mathematical construct that combines electromagnetic fields and axion particle fields in the correct way.'"

Dr. Jonathan Gratus said: "The construction shrinks and disappears into the singularity, taking electrical charge with it. And it is the combination of a temporary singularity and a newly proposed type of axion field that is crucial to its success."

Dr. Kinsler added: "Although people often like to say that physics 'breaks down," here, we show that although exotic phenomena might occur, what actually happens is nevertheless constrained by the still-working laws of physics around the singularity."

The researchers said: "Our conclusion appears to be at once startling and

undeniable: global charge conservation cannot be guaranteed in the presence of axionic electromagnetic interaction."

More information: Jonathan Gratus et al, Temporary Singularities and Axions: An Analytic Solution that Challenges Charge Conservation, *Annalen der Physik* (2021). DOI: 10.1002/andp.202000565

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