

# A black hole's orbiting ring of light could encrypt its inner secrets!

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**Astrophysics**

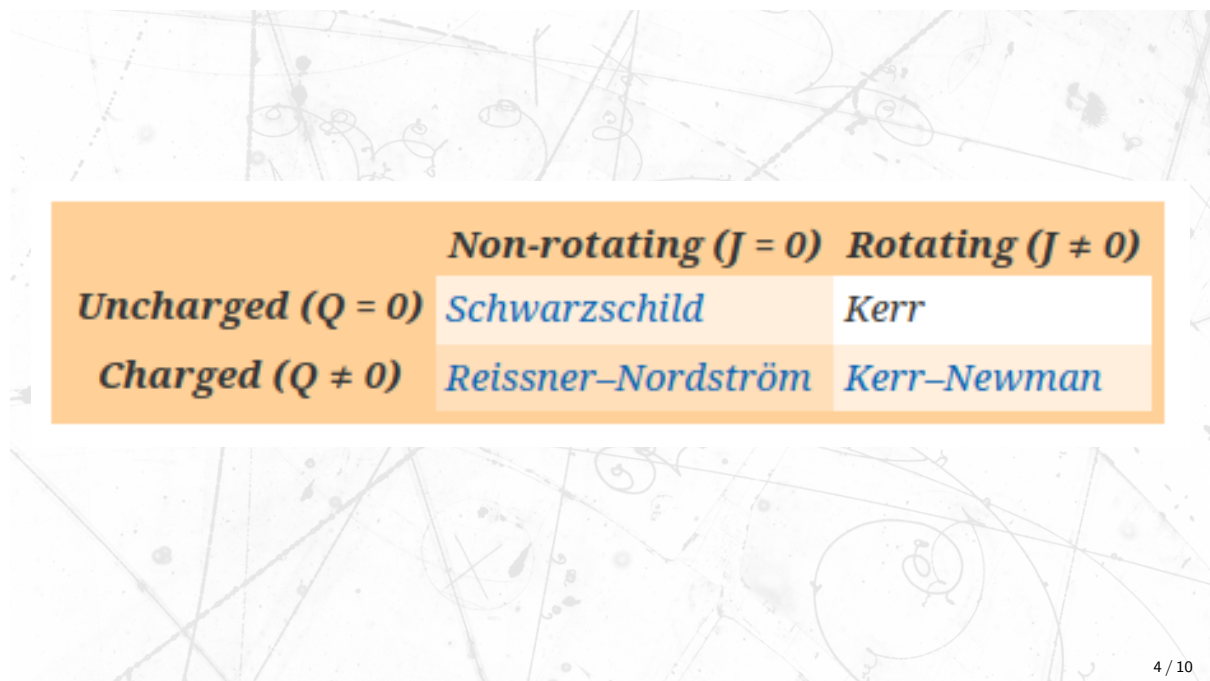


## Preliminaries

Black hole, Kerr Black hole, Conformal theory, Holography

## Black hole

- A black hole is a region of spacetime where gravity is so strong that nothing - not particles, not even electromagnetic radiation such as light - can escape from it. General relativity predicts that a sufficiently compact mass can warp spacetime, forming a black hole.
- As photons rush towards the black hole, most of them are sucked into its depths, never to return, or gently deflected away. However, some of them bypass the hole, making a series of sharp turns. Some of these photons continue to orbit the black hole almost forever.
- Described by astrophysicists as a “space movie camera” and an “endless light trap”, the resulting ring of spinning photons is one of nature’s strangest phenomena. If you detect photons, “you will see every object in the universe an infinite number of times”.



	<i>Non-rotating (<math>J = 0</math>)</i>	<i>Rotating (<math>J \neq 0</math>)</i>
<i>Uncharged (<math>Q = 0</math>)</i>	<i>Schwarzschild</i>	<i>Kerr</i>
<i>Charged (<math>Q \neq 0</math>)</i>	<i>Reissner–Nordström</i>	<i>Kerr–Newman</i>

## Conformal field theory

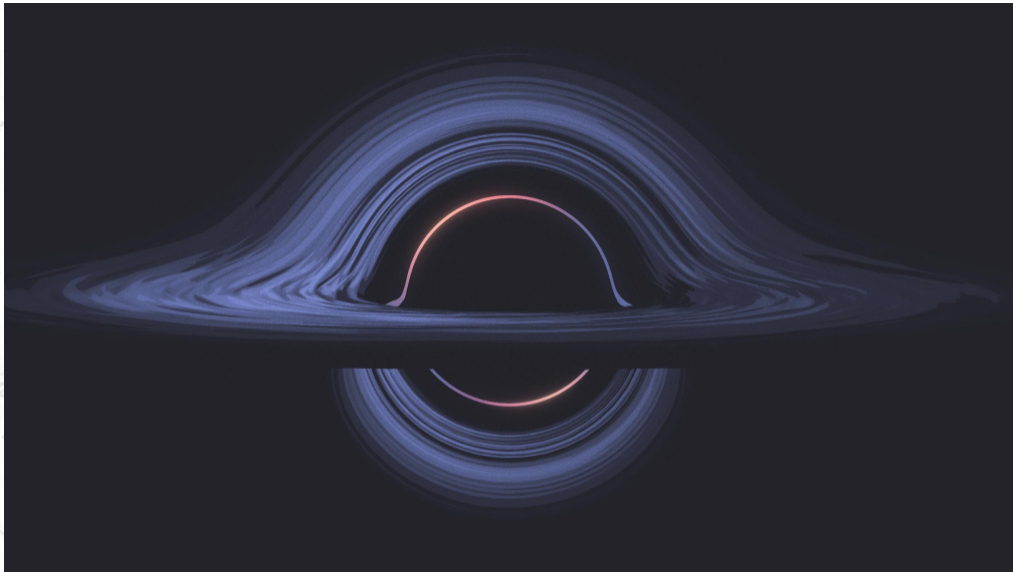
- A conformal field theory (CFT) is a quantum field theory that is invariant under conformal transformations. In two dimensions, there is an infinite-dimensional algebra of local conformal transformations, and conformal field theories can sometimes be exactly solved or classified.
- Conformal field theory has important applications to condensed matter physics, statistical mechanics, quantum statistical mechanics, and string theory. Statistical and condensed matter systems are, indeed, often conformally invariant at their thermodynamic or quantum critical points.

## Holography

- Sometimes the holographic principle is formulated as follows: “Each theory with gravity in  $D$ -dimensions (in a certain pre-existing space-time background) can be described by a  $(D-1)$ -field theory WITHOUT gravity at the boundary (space-time background).

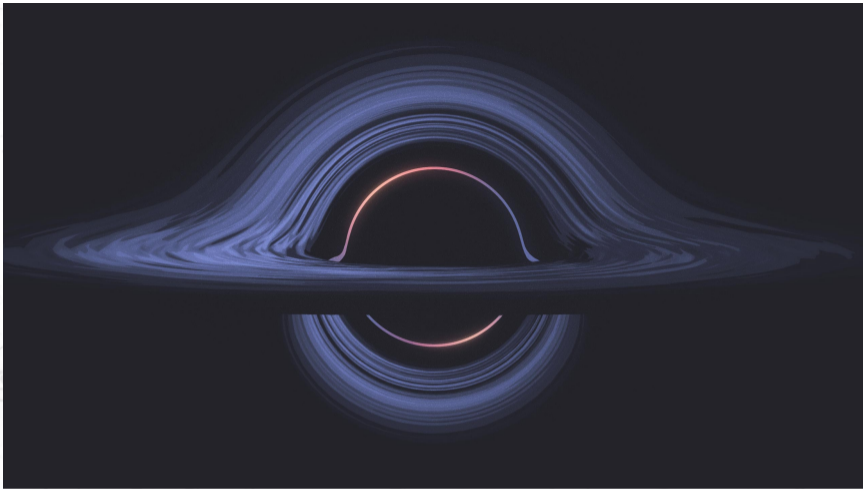
## Holography of the photon ring

- “I thought the event horizon was something we needed to understand, and I thought of the photon ring as some kind of technical, complicated thing with no deep meaning”, said Andrew Strominger.
- Now Andrew Strominger is saying, “we’re excited to explore the possibility that the photon ring is what you need to understand in order to unlock the secrets of Kerr black holes”.
- Referring to the kind of spinning black holes that form when stars die and gravitational collapse. At the same time, a photon ring is formed.
- Example: Messier 87 black hole
- Strominger and his collaborators found that the photon ring around a spinning black hole has an unexpected kind of symmetry - the way it can transform and still stay the same. The symmetry suggests that the ring can encode information about the hole’s quantum structure.



The photon ring, which glows orange in this visualization of light flowing around a black hole, contains a sequence of images of the entire universe.





Photons that make one turn around the black hole before leaving it create an image of the ring, shown in the video  $n = 1$ . Photons that are redirected twice before leaving the hole form an image of a thinner ring inside the first ring, as shown in the video. video  $n = 2$ , and so on.



A global network of radio telescopes known as the Event Horizon Telescope released this first-ever photo of a black hole in 2019 - the supermassive one at the center of nearby galaxy Messier 87.