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Criticising the Relativistic Visualization of a Black Hole in "Interstellar"

Abstract

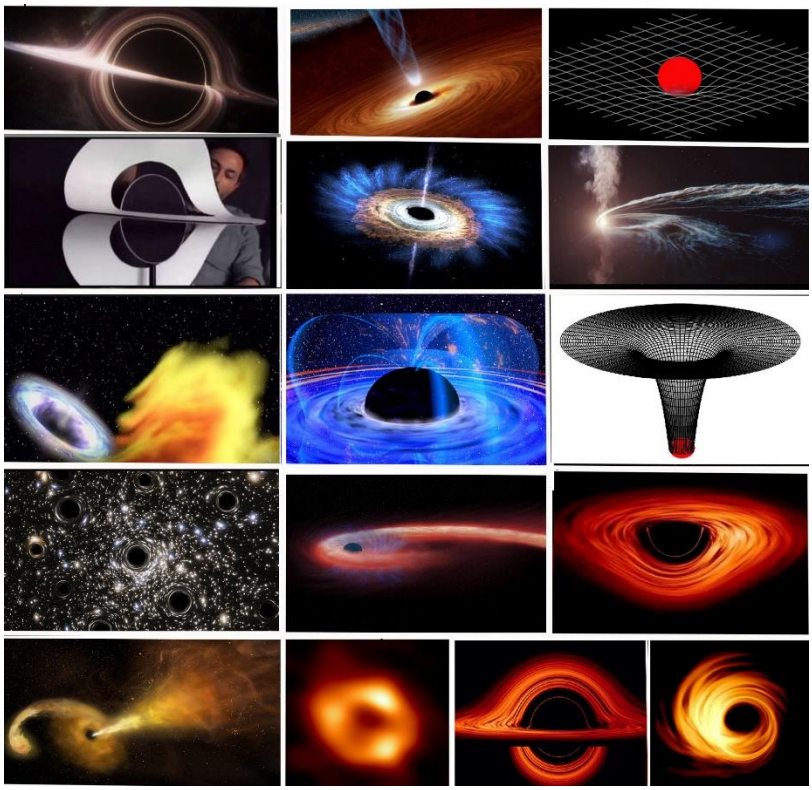
The black hole visualization presented in the film 'Interstellar' has been widely promoted as an unprecedentedly accurate depiction, grounded in Einsteinian Relativity, achieved through extensive computational ray-tracing under the guidance of a leading theoretical physicist. This paper challenges that narrative on epistemic, methodological, and conceptual grounds.
I argue that, in the absence of observational access to the purported object, and in light of the profound under-determination inherent in Relativistic Field Equations, the 'Interstellar' image cannot legitimately be regarded as *informative* about the appearance—or even the physical reality—of black holes. Rather, it should be understood only as a cinematic artefact: a visually coherent output selected from an effectively *unbounded* space of mathematically permissible renderings. The paper further contends that the authority conferred upon this image exemplifies a broader confusion between mathematical consistency, computational effort, and empirical knowledge.

The Poster.

Background

The release of ‘Interstellar’ (2014) was accompanied by widespread claims that its depiction of a black hole represented a landmark achievement in scientific realism. It was asserted that thousands of hours of computation, guided by Einstein’s Field Equations, produced an image that was not merely plausible but *physically accurate*. Such claims have since entered popular and semi-technical discourse, often cited as evidence that theoretical physics can now reveal what black holes “really look like.”

I dispute that conclusion. There is no denial that sophisticated mathematics and numerical techniques were employed, nor that the resulting image is visually striking. However, questions arise concerning the epistemic leap from *mathematical* construction to *physical* knowledge. The central thesis advanced here is that, given the radical under-determination of solutions to Einstein’s equations and the absence of direct observational constraints, the ‘Interstellar’ black hole image has no *privileged status* over countless alternative renderings. The attribution of scientific authority to this image is therefore unwarranted.



Alternative renderings.

The Field Equations

These equations do not, by themselves, *specify* unique physical outcomes. They relate ‘spacetime curvature’ to stress–energy content, but admit an enormous class of exact and approximate solutions depending on boundary conditions, symmetries, coordinate choices, and idealizations. Even in highly

idealised cases, solutions are rarely unique, and their physical interpretation is often ambiguous.

Crucially, the equations *do not* encode a prescription for visual appearance. Any attempt to generate an “image” from them requires a cascade of additional assumptions: the nature and distribution of matter, emission mechanisms, optical properties, observer location, coordinate mapping, and numerical regularisation schemes. Each assumption restricts the solution space, not on empirical grounds, but on pragmatic or aesthetic ones.

Thus, the claim that Einstein’s equations were “used to compute what a black hole looks like” is, at best, a rhetorical compression. What was actually computed was *one member* of a vast equivalence class of mathematically admissible constructions, conditioned by choices *external* to the theory itself.

The Role of ray-tracing algorithms

The Interstellar visualization relied on bespoke ray-tracing algorithms, propagating light-paths through a prescribed spacetime geometry.
While technically impressive, this process necessarily involved the selection of a particular spacetime metric- from *infinitely* many admissible forms, with the imposition of symmetry and smoothness conditions for numerical tractability. It also required the adoption of specific emission and absorption rules for hypothetical surrounding matter with post-processing and visual filtering to achieve cinematic clarity and narrative legibility.

None of these steps is dictated *uniquely* by General Relativity. Each constitutes a modelling decision that narrows the outcome space. That the final image appears internally consistent, is a testament to the *coherence of the algorithm*, not to the truth of the object depicted.

The emphasis on the number of computational hours expended is particularly misleading. Computational cost measures only the difficulty of producing an image under a chosen model, *not* the likelihood that the model corresponds to anything physically real.

Cinematic Constraint

Film is an inherently didactic medium: images must be intelligible, stable, and narratively supportive. As a result, *ambiguity*—an unavoidable feature of serious theoretical physics—must be suppressed. Visual elements that would undermine coherence or confuse the audience are eliminated or softened.

We see, then, that the ‘Interstellar’ black hole image is, therefore, doubly hampered: first by speculative theoretical assumptions, and second by cinematic necessity.
The final product is not an unconstrained consequence of physical law, but a negotiated compromise between mathematics and storytelling. To present such an image as a scientific revelation is to misunderstand both enterprises.

The misconception of the authority of a professional physicist

Public reception of the ‘Interstellar’ image has been strongly influenced by the presence of an eminent physicist associated with its production. Expertise, however, does not collapse under-determination. No matter how distinguished the theorist, mathematical elegance and professional authority cannot transform a speculative construction into empirical knowledge.

Professor Kip Thorne, the black hole ‘expert’.

The impression of convergence—of theory finally revealing reality—is illusory. Given the same equations, different teams, with different modelling priorities, could *and demonstrably do* generate radically different visual outcomes. That one such outcome achieved cultural prominence reflects social dynamics, not epistemic superiority.

Mathematics v. Physical Existence

A persistent confusion in discussions of black holes, both cinematic and scientific, lies in conflating mathematical consistency with physical existence. That a solution to a set of equations can be written down, does not entail that nature realises it. Mathematics explores possibility; physics requires constraint.

Absent decisive empirical access, claims about the structure, appearance, or even existence of black holes remain provisional. Visualisations derived from theory alone cannot escape this limitation. They may illustrate assumptions, but they *cannot* verify them.

Conclusion

The black hole image in Interstellar should be understood neither as a failure nor as a triumph of physics, but as an artefact of applied mathematics deployed in the service of cinema. Its subsequent elevation to the status of quasi-empirical evidence represents a category error: the substitution of computational sophistication for observational warrant.

In the present state of knowledge, *no* image of a black hole—whether cinematic, artistic, or algorithmic—can *legitimately* claim to show what such an

object “looks like.” At best, such images depict what certain assumptions, embedded in certain equations and filtered through certain aesthetic choices, happen to produce. To mistake this for discovery is to mistake mathematics for measurement.

This paper is intended as a methodological critique. The issue at stake is not the competence or integrity of individuals involved, but the epistemological limits of theory-driven visualization- in the absence of decisive empirical constraint.

References;

The sighting of telescopes
https://www.youtube.com/watch?v=Q1bSDnuIPbo

Event Horizon Procedure
https://www.gsjournal.net/Science-Journals/Research%20Papers-Philosophy/Download/8859 from page 30

https://www.gsjournal.net/Science-Journals/Research%20Papers-Cosmology/Download/9591 from page 19

https://eventhorizontelescope.org/science

Kip Thorne lecture
https://www.youtube.com/watch?v=GlmMxmWHEfg

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