Macroscopic Microscopic Effects

Quantum Gravity and the Event Horizon Telescope

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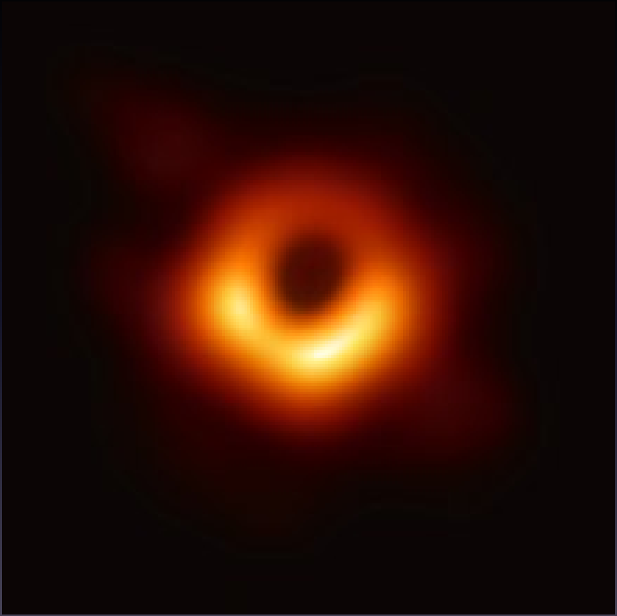
Supervisors: F. Saueressig, H. Falcke

Radboud University



Quadratic Gravity

$$S_{QG} = \int d^4x \sqrt{g} \left[\frac{1}{16\pi G} R - \alpha \, C_{\alpha\beta\mu\nu} C^{\alpha\beta\mu\nu} + \beta \, R^2 \right]$$

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The motivation is Quantum, but the treatment is Classical

The Planck scale regime: $M = 10m_{\rm pl}$

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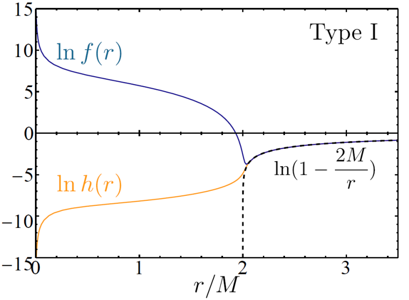
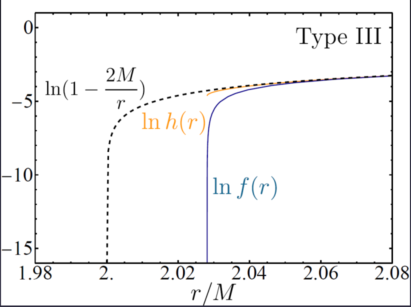


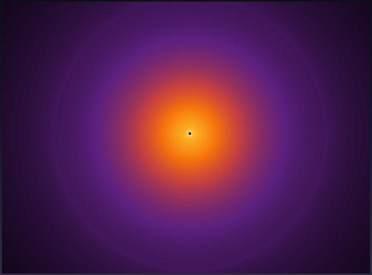
Naked Singularity

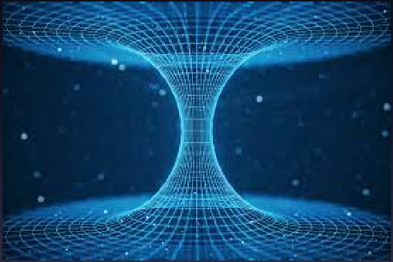


Wormhole

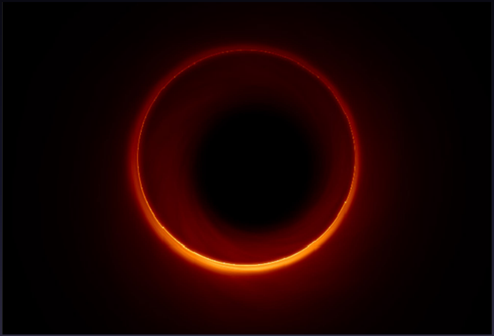
$$ds^2 = -h(r)\,dt^2 + \frac{1}{f(r)}\,dr^2 + r^2\,d\Omega^2$$

The Planck scale regime: $M = 10m_{\mathrm{pl}}$





The Astrophysical regime: $M = M_{M87*}$



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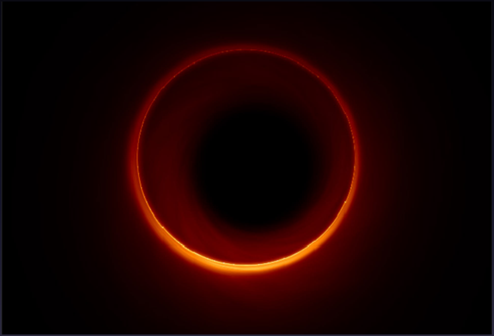

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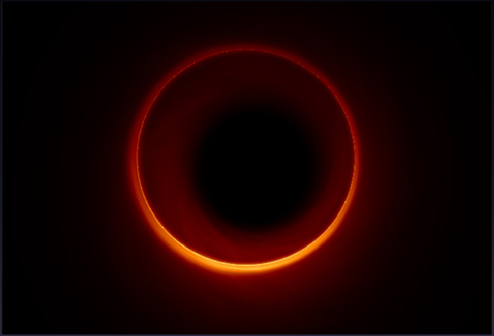

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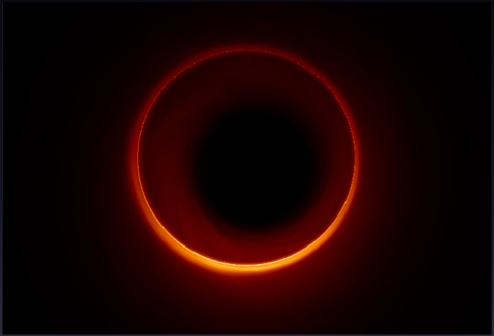

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Potential claim: *Corrections of this size are enough to prevent event horizon from being formed*

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1. $f(r)$ close to Schwarzschild

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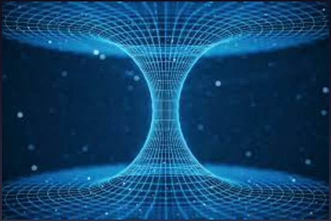
3. Update, decrease r, and go to step one if correction term is small

Prediction

- Based on tiny factor $=$ tiny factor $(\alpha, \beta, S_0, S_2, M)$, can predict the type of the solution!

$Sign(\, f^{(3)}\,) = +:$



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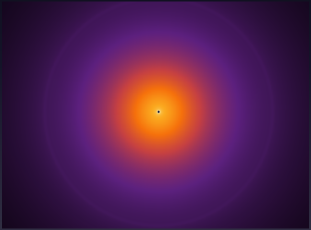

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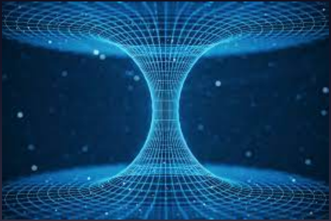

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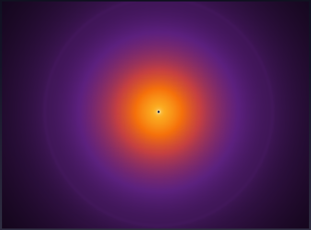

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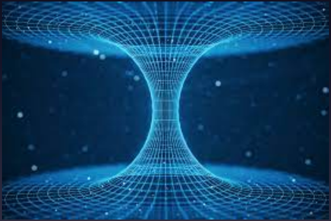

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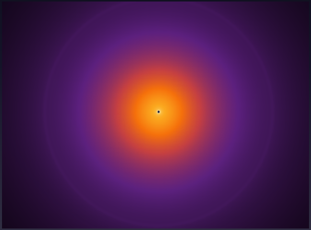

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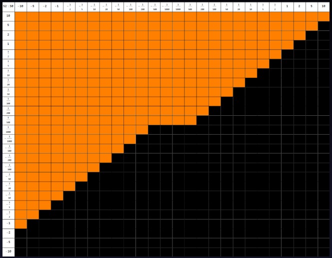
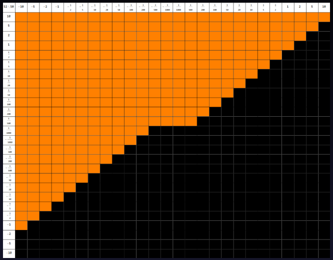
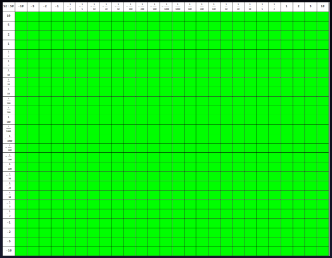
Test


S2 \ S0
-10
-5
-2
-1
-1/2
-1/5
-1/10
-1/20
-1/50
-1/100
-1/200
-1/500
-1/1000
1/1000
1/500
1/200
1/100
1/50
1/20
1/10
1/5
1/2
1
2
5
10

Test


S2 \ S0
-10 -5 -2 -1 -1/2 -1/5 -1/10 -1/20 -1/50 -1/100 -1/200 -1/500 -1/1000 1/1000 1/500 1/200 1/100 1/50 1/20 1/10 1/5 1/2 1 2 5 10
10 5 2 1 1/2 1/5 1/10 1/20 1/50 1/100 1/200 1/500 1/1000 -1/1000 -1/500 -1/200 -1/100 -1/50 -1/20 -1/10 -1/5 -1/2 -1 -2 -5 -10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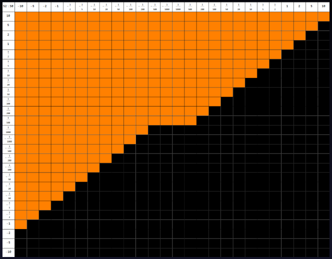

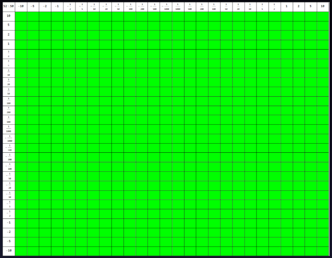

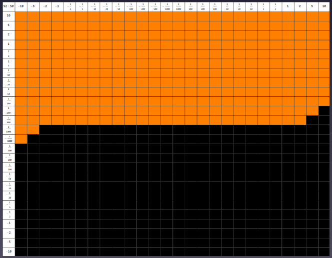

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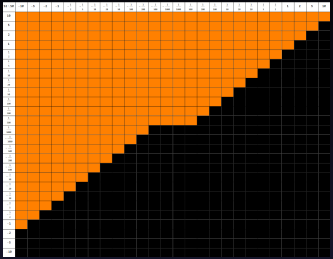

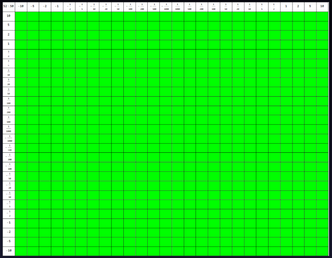

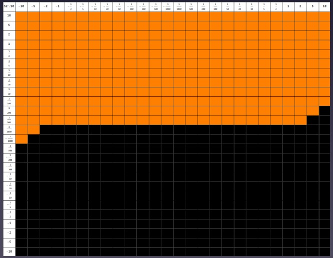

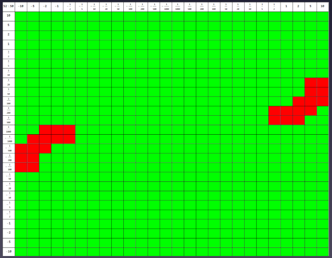

Upshot

Of the parameters α, β, S_2, S_0 the EHT images can potentially rule out the parameters for which

$$(6\,\beta - 1)\left[m_0^2\, S_0\, e^{-2\, m_0\, M} - S_2\, e^{-2\, M}\right] < 0$$

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- *If* ... and *if* ...

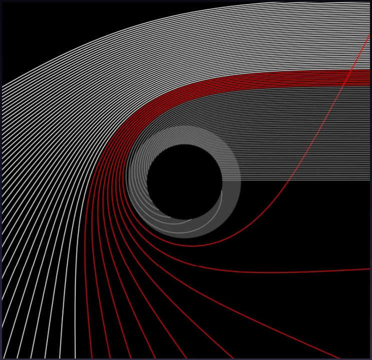
  ... then the EHT may be able to rule out Planck-sized, Quantum Gravity induced parameters

Open Questions

- What about stability?
- Do images of these spacetimes really not posses a shadow?
- How general is this blow-up mechanism?

$\rightarrow$ Interesting enough to find out for sure!

Shadow



The shadow is a consequence of General Relativity!