Quantum effects in black hole interiors

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Falling into a black hole (according to GR)
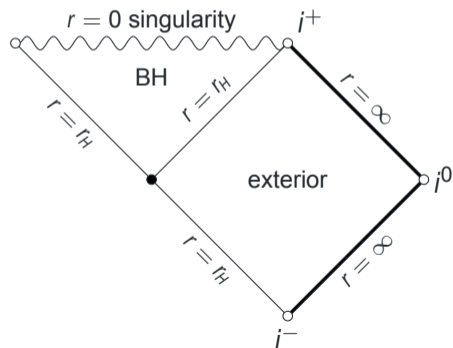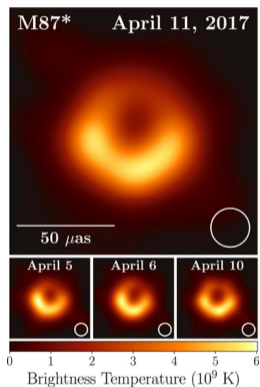
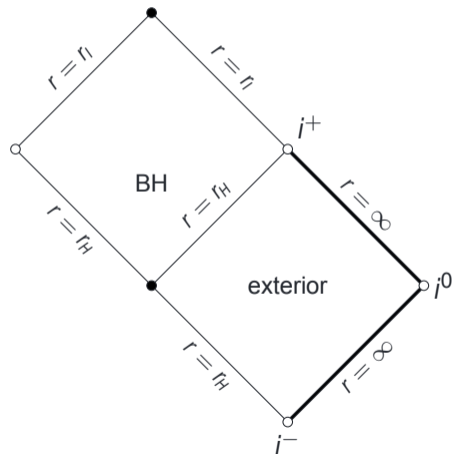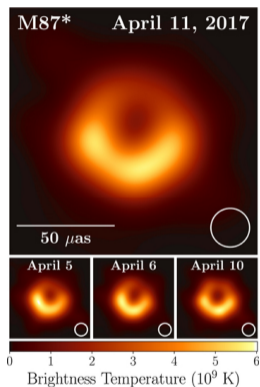First picture of a black hole [EHT collaboration, 2019]

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Strong cosmic censorship
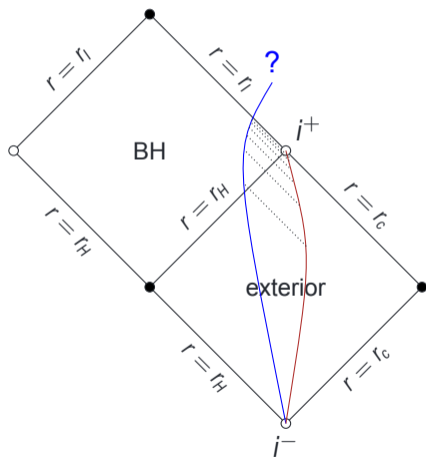
– Signals reaching inner horizon infinitely blueshifted [Penrose, 1974]$\Leftrightarrow$ Cosmological redshift

– Strong cosmic censorship conjecture (sCC): For generic initial data, metric is inextendible across inner horizon

[Christodoulou, 2008]

– Scalar test field: sCC violated for large Q

[Hintz, Vasy, 2017; Cardoso et.al., 2017]

Quantum effects
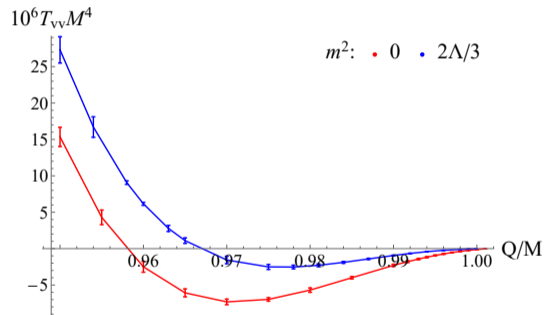

$10^6 T_{vv} M^4$

m^2: • 0   • $2\Lambda/3$

Q/M

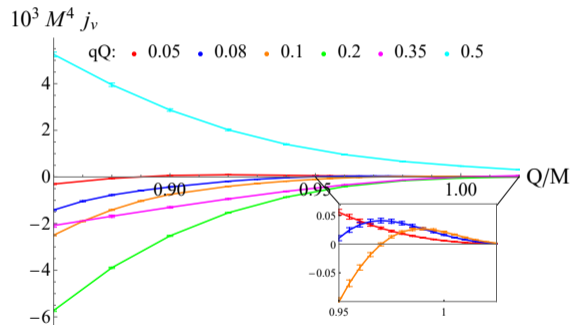0.96   0.97   0.98   0.99   1.00

Energy flux diverges to $\pm\infty$

[Hollands, CK, Zahn, 2020]

– Real quantum scalar field in state Ψ

$\Rightarrow$ Energy flux $\langle T_{VV} \rangle_\Psi \sim CV^{-2}$

[Hollands et.al., 2020]

– $C \neq 0$ in general

$\Rightarrow$ sCC restored by quantum effects

Charged scalar fields

$10^3 M^4 j_v$

qQ: • 0.05 • 0.08 • 0.1 • 0.2 • 0.35 • 0.5

The current can have either sign

[CK, Zahn, Hollands, 2021]

– Charged BH $\Rightarrow$ charged scalar

$\Rightarrow$ Non-vanishing charge current

$\Rightarrow$ Intuitive picture: Creation of particle-antiparticle pairs and rapid discharge [Herman, Hiscock, 1994]

$\Rightarrow$ Quantum effects can charge black hole

Outlook

RNdS	Kerr-de Sitter
Black hole charge Q	Black hole angular momentum a
spherically symmetric	axisymmetric
static exterior region	stationary exterior region
Charge current $\langle j_V \rangle$	Angular momentum current $\langle T_{V\varphi_-} \rangle$

– Can quantum effects increase angular momentum of black hole?

– First technical steps: construction of state [CK: 2022]

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Thank you