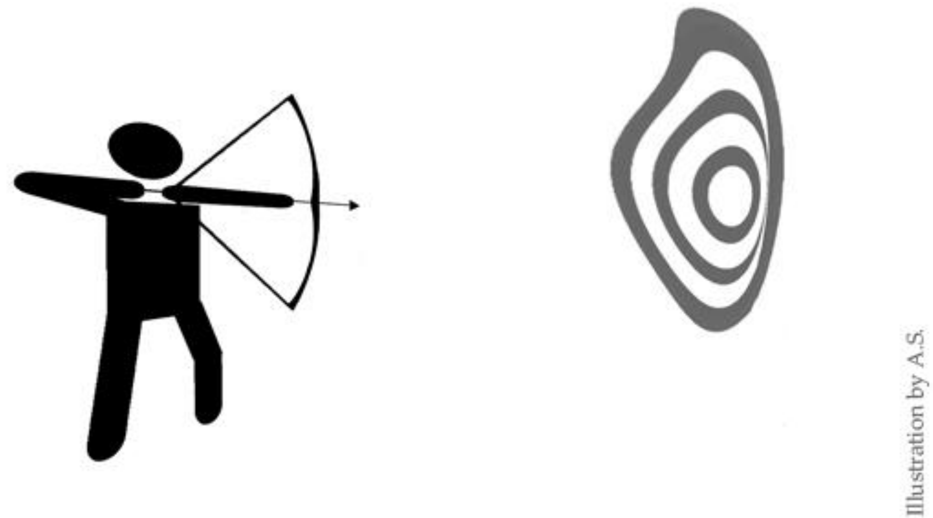
Hunting black holes

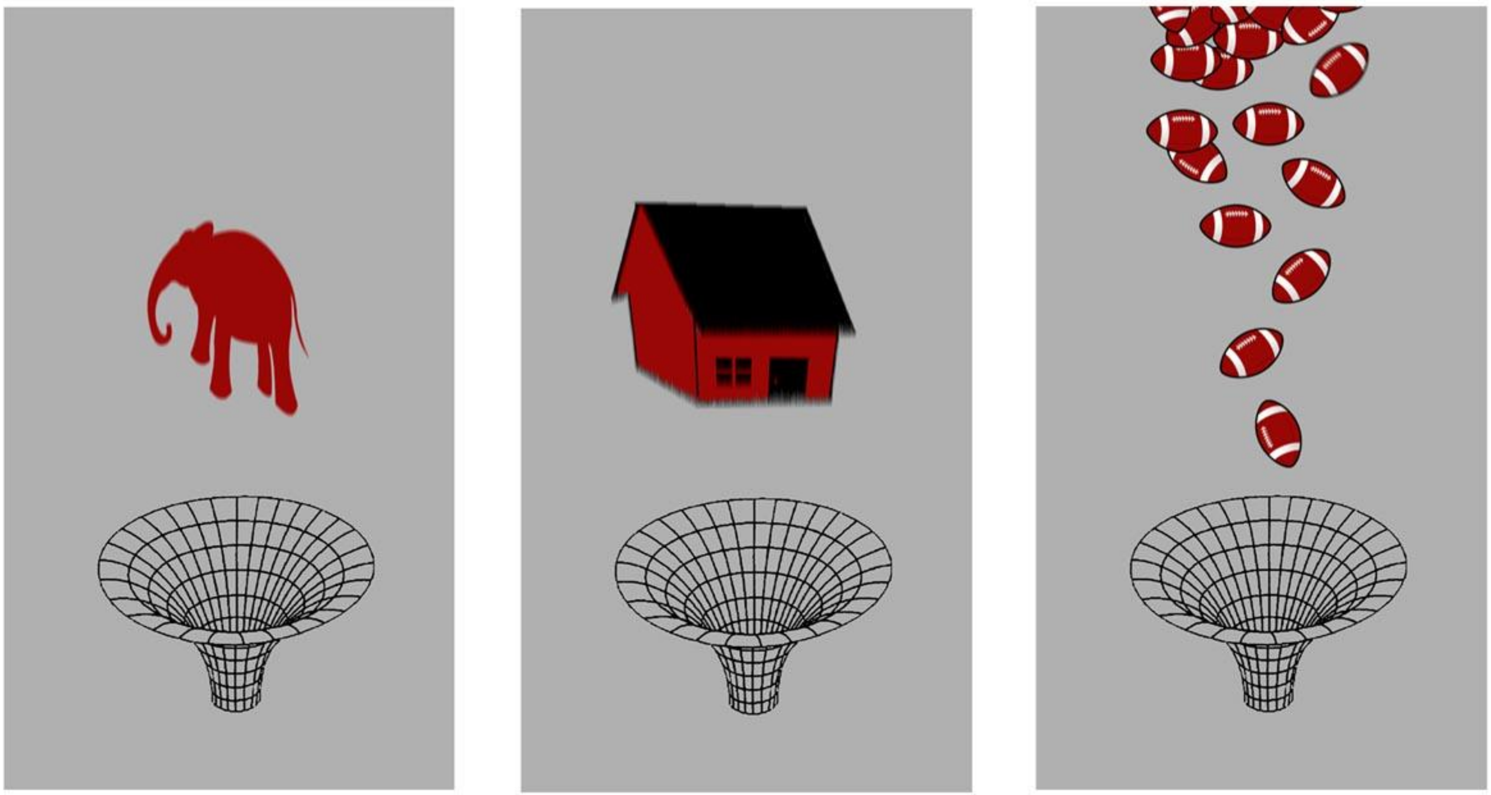


Vitor Cardoso

(CENTRA/IST & Olemiss)

Berti, Cardoso, Gualtieri, Pretorius, Sperhake, Phys.Rev.Lett.103:239001 (2009)
Bouhmadi-Lopez, Cardoso, Nerozzi, Rocha, Phys.Rev.D81:084051 (2010)
Barausse, Cardoso, Khanna, Phys.Rev.Lett., in press.

4D BHs have no hair & are L-stable



BHs in GR are characterized by only three quantities:

mass, **spin** and **electric charge**

Kerr naked singularities are unstable

- Against ergo-region kind of instabilities

- Against algebraically-special type

- Generically unstable to variety of effects

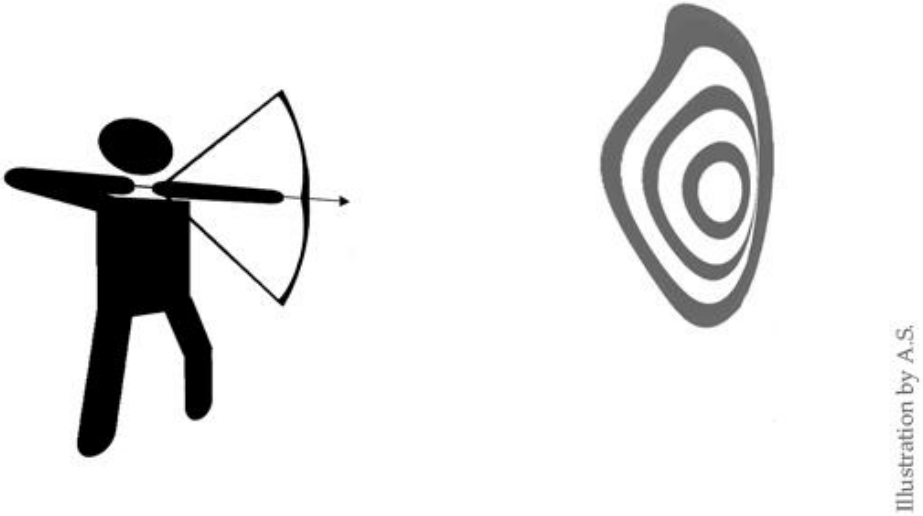
Dotti and Gleiser ’08; Cardoso et al ‘08, Barausse et al ‘10

How to kill a BH

Black holes rotate slowly… so spin them to death!
Impossible with point particles…

(Jorge Rocha, also Zaaslavki, this workshop)

But perhaps we can throw a larger rock!



Take $\epsilon \ll 1$ with $a \equiv J/M^2 = 1 - 2\epsilon^2$

$$L_{\min} = 2\epsilon^2 + 2E + E^2 < L < L_{\max} = (2 + 4\epsilon)E$$

Imposing $L_{\max} > L_{\min}$ then yields

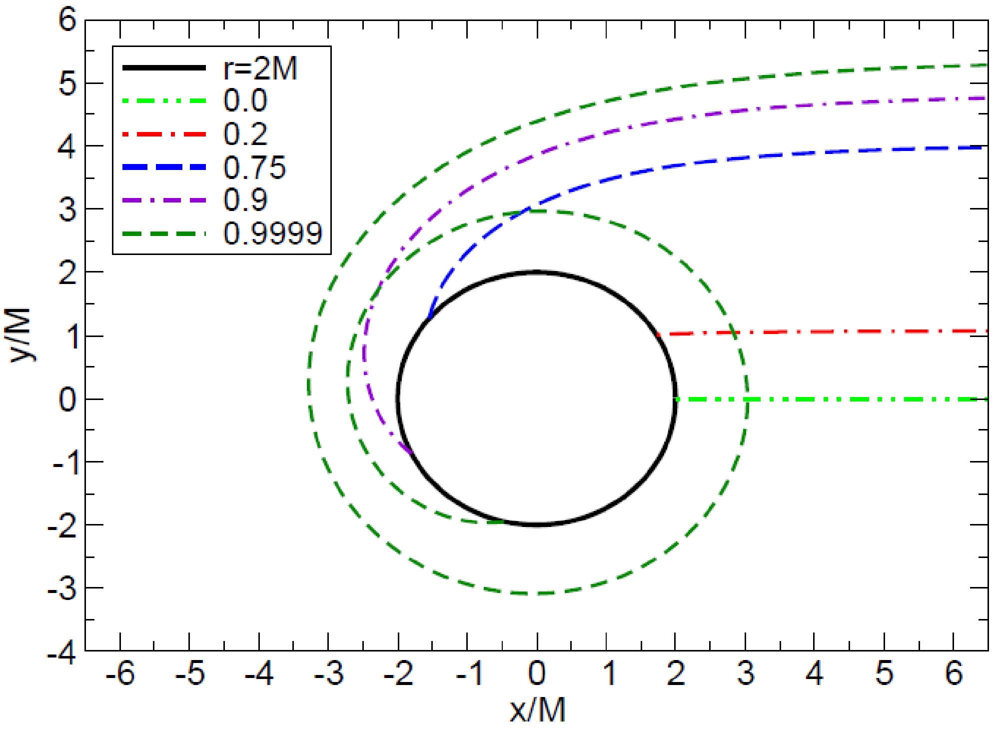
$$\begin{aligned} a_f^{JS} &= \frac{a + L}{(1+E)^2} = 1 + 8\epsilon^2(1-x)xy + \mathcal{O}(\epsilon^3) > 1 \\ E_{\min} &= (2 - \sqrt{2})\epsilon < E < E_{\max} = (2 + \sqrt{2})\epsilon \end{aligned}$$

Jacobson & Sotiriou, '09

Radiation reaction

$$a_f = 1 + 8\epsilon^2(1-x)xy + 2E_{\rm rad} - L_{\rm rad} + \mathcal{O}(\epsilon^3)$$

Radiation reaction



L/E=2 is critical for extreme Kerr…

Thus *some* impact parameters *must* give rise to too large radiation…

Do all?

$$b = b_{\rm ph}(1-k), \text{ with } k \ll \epsilon \ll 1$$

$$\frac{d\phi}{dr} \approx \left(\frac{8}{3} + \frac{\sqrt{3}}{2\epsilon}\right)\left[\frac{8}{\sqrt{3}}k\epsilon + 3(r - r_{\rm min})^2\right]^{-1/2}$$

$$N_{\rm cycles} \approx \left[A + B\log\left(k\epsilon\right)\right]\left(\frac{8}{3} + \frac{\sqrt{3}}{2\epsilon}\right)$$

But fluxes are proportional to number of cycles

$$\begin{aligned}\Delta E(\epsilon) &= E_1(\epsilon)(1+e_2\epsilon)\,,\\ \Delta L(\epsilon) &= 2E_1(\epsilon)[1+(\sqrt{3}+e_2)\epsilon]\end{aligned}$$

$E_1(\epsilon)$ is the energy flux for a single orbit, e_2 is an undetermined coefficient

$$E_1 \sim (r-r_H)E^2 \sim \epsilon E^2 \sim \epsilon^3$$

At leading order in ϵ, this results in

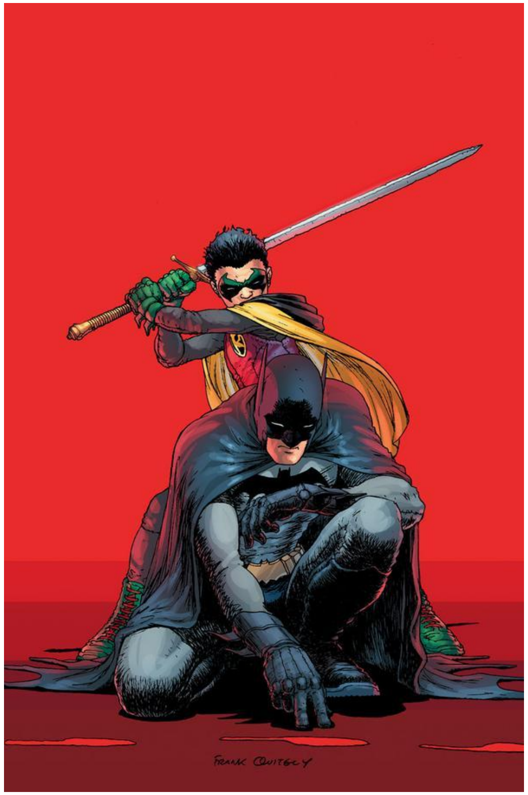
$$E_{\rm rad} = \Delta E(\epsilon) \times N_{\rm cycles} \sim \log(k\epsilon)\epsilon^2$$

Chrzanowski '76, Chrzanowski & Misner '74

Numerical results

a	0.99	0.992	0.994	0.996	0.998	0.999	0.9998
a_f	0.882	0.928	0.961	0.984	0.997	0.9996	1.00006
a_f^{JS}	1.0043	1.0035	1.0026	1.0018	1.0009	1.00045	1.00009

Particle with energy $E = 2\epsilon$ and angular momentum $L = b_{\rm ph} E(1 - 10^{-5})$

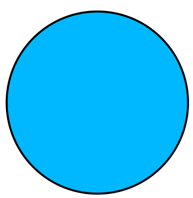


Is this the end of the dynamic duo?

…Perhaps not…

Consider BH with radius Rg=2M in background with curvature L>>Rg

To study motion of BH do matched asymptotic expansion:



gint=BH+H1(r/L)+… gext=background+h1(Rg/L)+…

Match & get motion $$u^{\mu}\nabla_{\mu}u^{\nu} = f^{\nu}_{\rm cons} + f^{\nu}_{\rm diss} + \mathcal{O}(R_g/\mathcal{L})^2$$

Dissipative is taken care of…conservative seems to have correct sign *(Barack & Sago, 2010)* and magnitude to prevent absorption…but much more work is needed

Is GR self-consistent? The CCC is a wonderful tool to think about universe, but far from established

✷

The event horizon is a stabilizing surface against instabilities

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In the case of PP, dissipative effects do not save the BH…but conservative effects shrink the BH to dodge the bullet!

Thank you