Themata & BH theory

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Holton’s Thémata

- I suggest that Holton’s “themata” is a good tool for surveying the development of BH physics.
  - Physicists tend to approach BHs from the reductionist viewpoint
  - Astronomers sought rather to find BHs and understanding their formation procress
  - I will describe BHs using more the emergent theory language
- See G. Holton *Thematic Origins …*, Harvard U Press 1988

BH Themata

Contrasts are clear from the older usage of "frozen star" for a BH

- Reductionist views follow the matter in a collapse, and expect changes in microphysics to avoid the Oppenheimer-Snyder singularity
- My BH description regards the fate of infallen matter as undecidable, and borrows language from macrophysics.

Borrowed terms

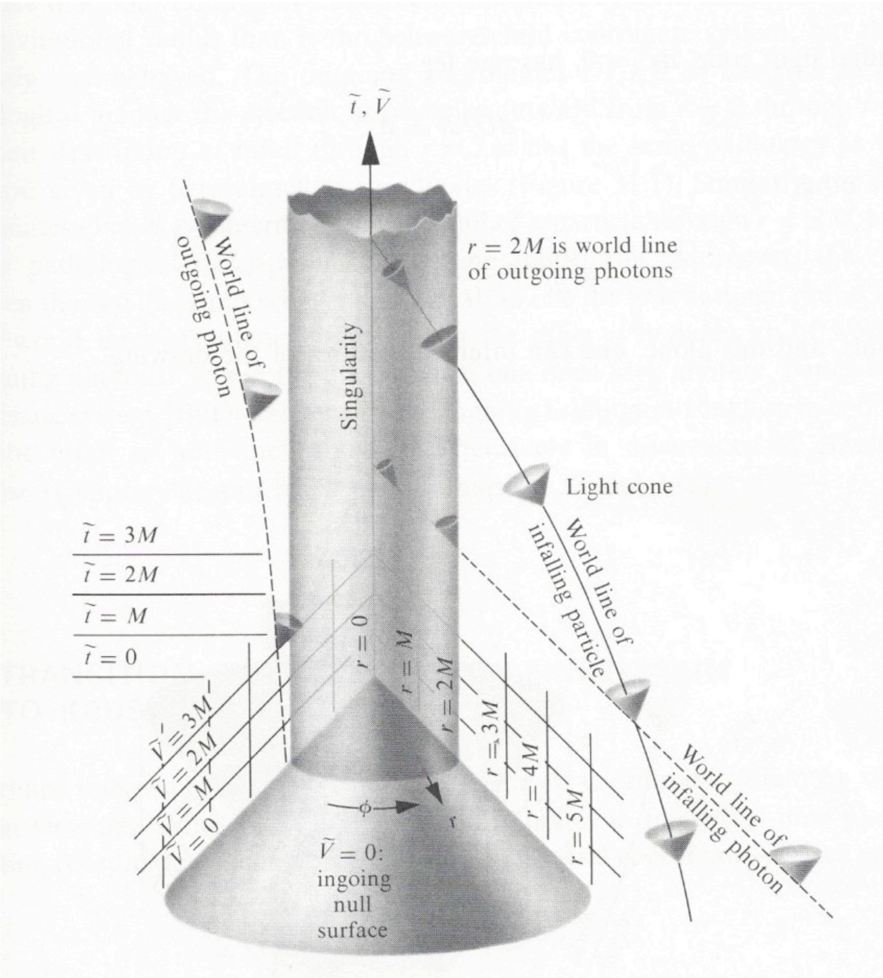
- *Phase change* as a region of nearly flat and empty spacetime is converted into a massive BH object made of pure empty spacetime.
- The collapsing matter is regarded as an *enzyme* helping empty spacetime curve, and then being discarded.
- Regions inside a BH where the Einstein equations are plausible guides to Nature show *autonomic* spacetime creation in macrophysics regions.

- Scale is important
  - For a 60 solar mass black hole, the scale of the BH is its mass, M = 90 km = 300 microseconds.
  - For the largest well measured super BH the scale is M = 24 hours
  - In these gravitational units (G=1=c) the mass of the Sun is M=500 seconds and the distance from the Sun to Pluto is 5.5 hours.

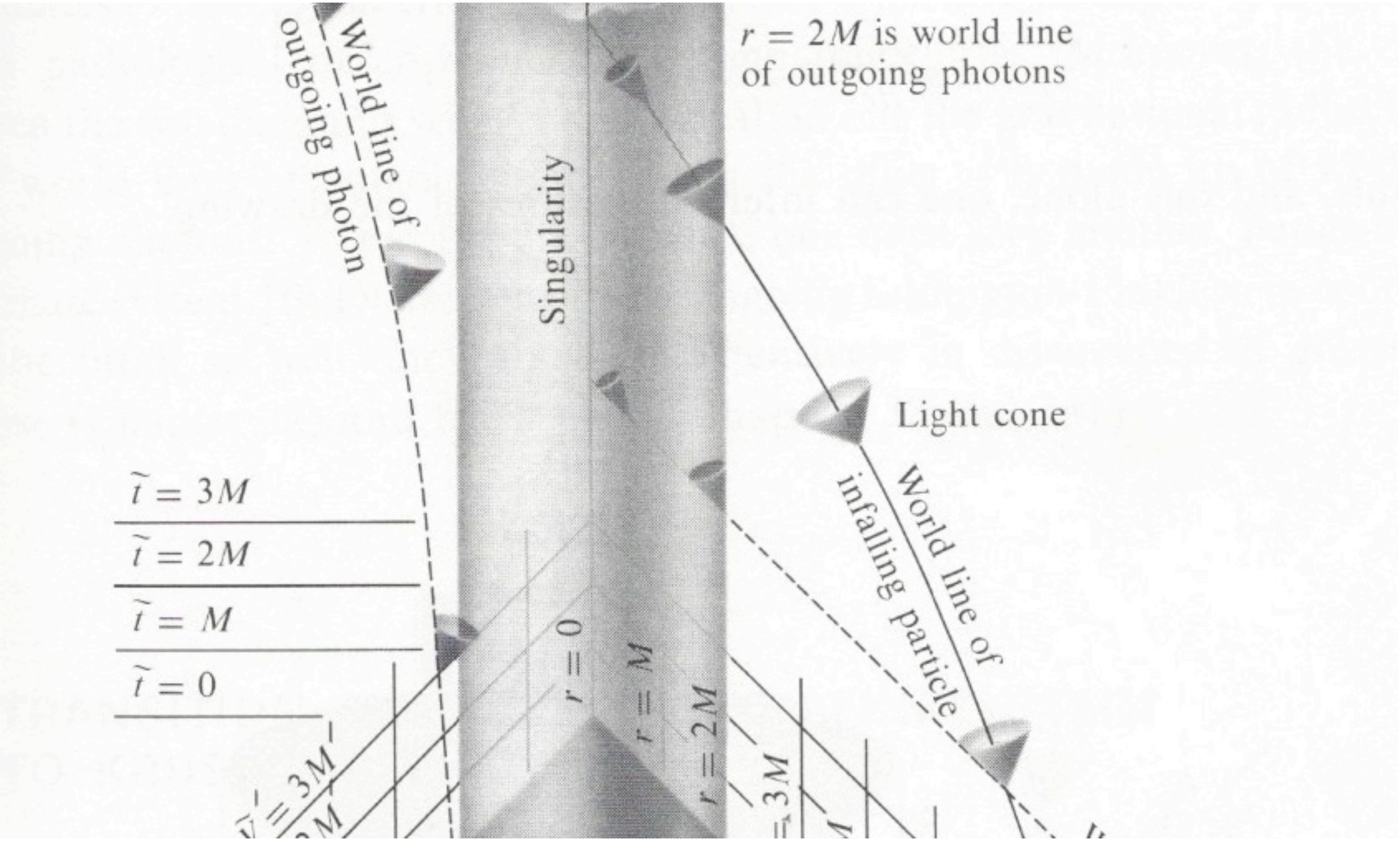
Where does the matter go?

There is a lot of non-singular spacetime inside the black hole horizon that was produced by the LIGO GW150914 event about a billion years ago. The observed part of that formation event took only about a fifth of a second. If a few bits of stray matter were to have fallen into that 60 solar mass black hole, each would take about 300 microseconds to fall to the causal horizon of the empty space inside. But a similar bit of matter that fell in on a parallel world line a billion years later would end up a billion light years in *spacelike* distance away from the first in this interior empty space.

Spherical BH



Spherical BH



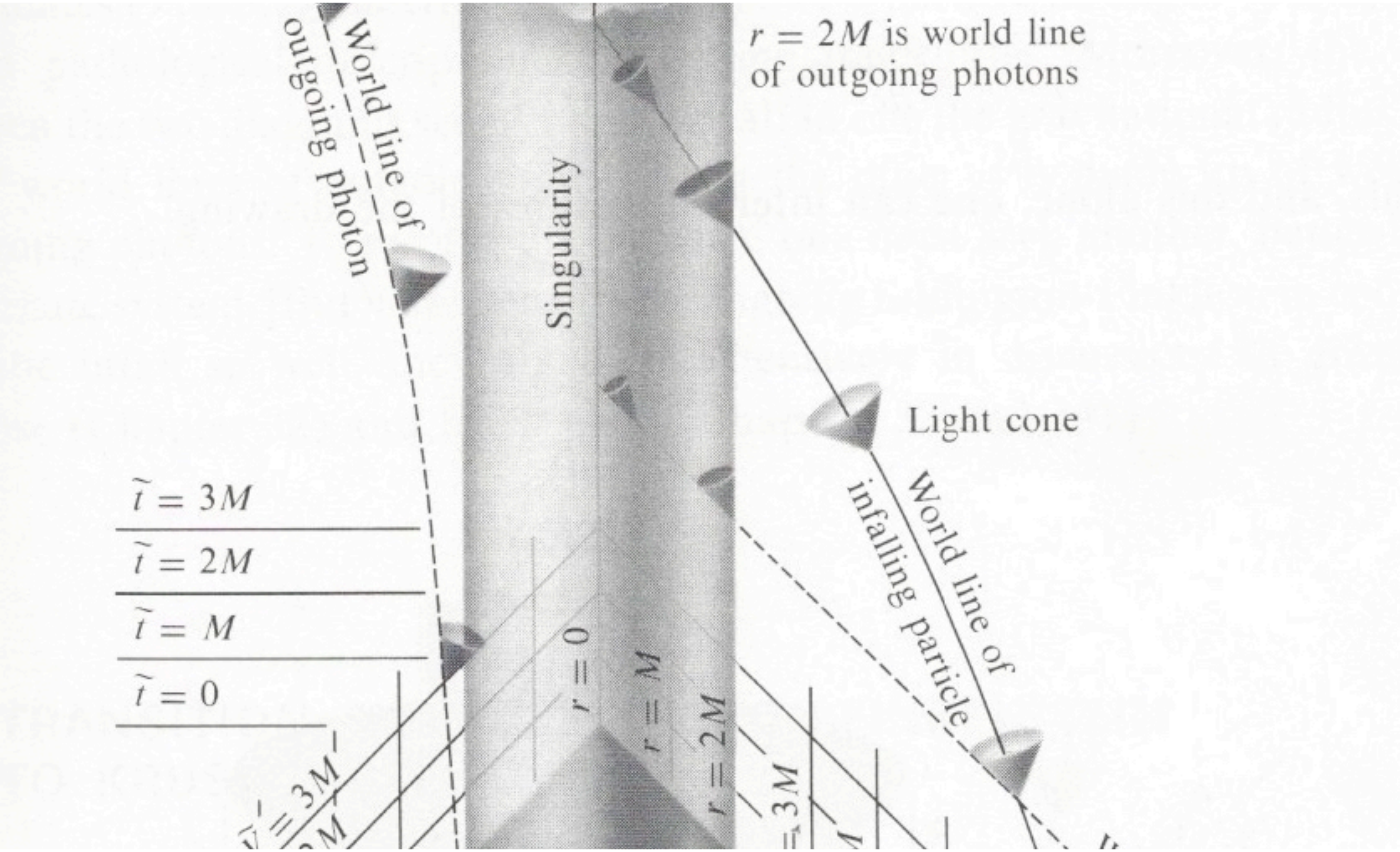
Finkelstein metric

$$ds^2 = (dt_* + dr)\left[\left(\frac{2M}{r} - 1\right)dt_* + \left(\frac{2M}{r} + 1\right)dr\right]$$

$$+r^2 d\Omega^2$$

Here $r^2 d\Omega^2 = dx^2 + dy^2 + dz^2 - dr^2$ shows the spherically symmetric metric in rectangular coordinates with $r^2 = x^2 + y^2 + z^2$ so that the smoothness of this metric can be verified for all points t,x,y,z with $r > 0$.

Spherical BH



Kerr metric

$$ds^2 = ds_0{}^2 + \frac{2Mr^3}{r^4 + a^2 z^2}\omega^2$$

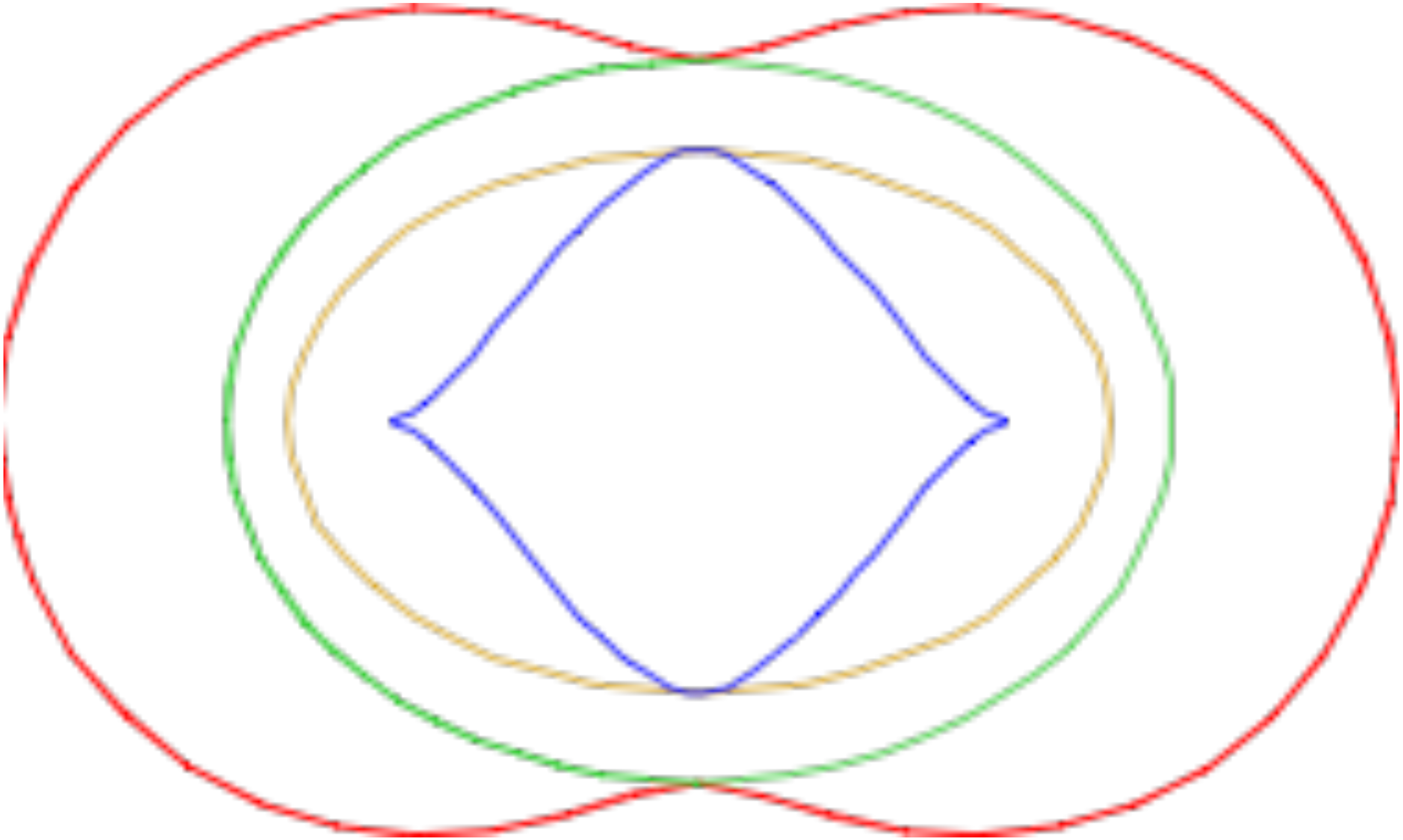
$$\omega = dt_* + \frac{rx + ay}{r^2 + a^2}dx + \frac{ry - ax}{r^2 + a^2}dy + \frac{z}{r}dz$$

$$ds_0{}^2 = -dt_*{}^2 + dx^2 + dy^2 + dz^2$$

Kerr r(x,y,z)

$$\frac{x^2+y^2}{r^2+a^2}+\frac{z^2}{r^2}=1$$

Kerr spacetime noted surfaces



Kerr special surfaces

Polar slice through the Kerr spacetime in Cartesian Kerr–Schild coordinates. Location of the horizons, ergosurfaces, and curvature singularity is shown for $a = 0.99\,M$ and $M = 1$. Note that the inner and outer horizons are ellipses in these coordinates, while the inner and outer ergosurfaces are more complicated. The curvature singularity lies at the kink in the inner ergosurface. [from Visser]