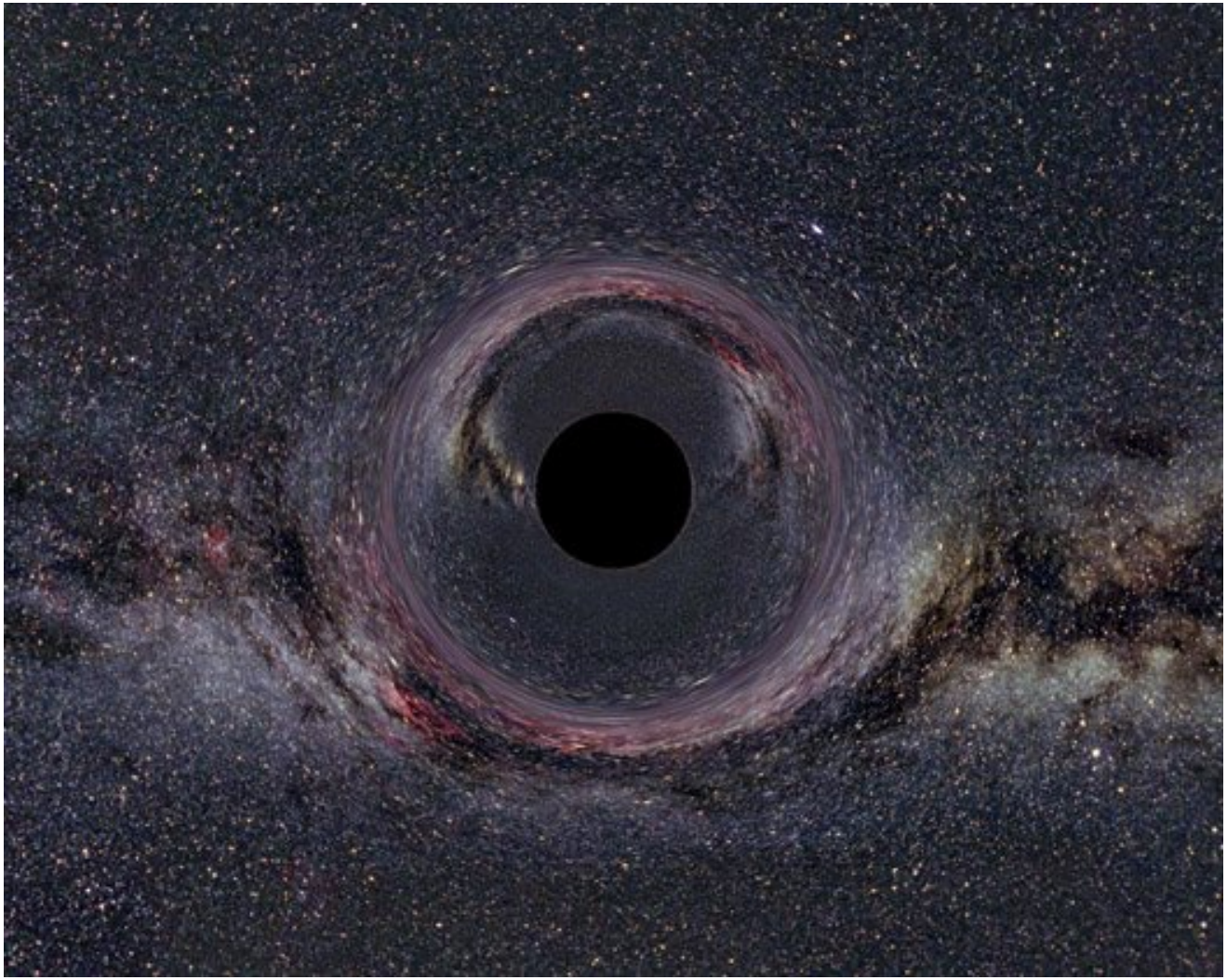
Hawking Radiation

Alison Harmon



Metrics

- Flat space-time

$$ds^2 = -c^2 dt^2 + dr^2 + r^2 d\Omega^2$$

- Schwarzschild

$$ds^2 = -\left(1 - \frac{2GM}{r}\right) c^2 dt^2 + \left(1 - \frac{2GM}{r}\right)^{-1} dr^2 + r^2 d\Omega^2$$

Eddington–Finkelstein Coordinates

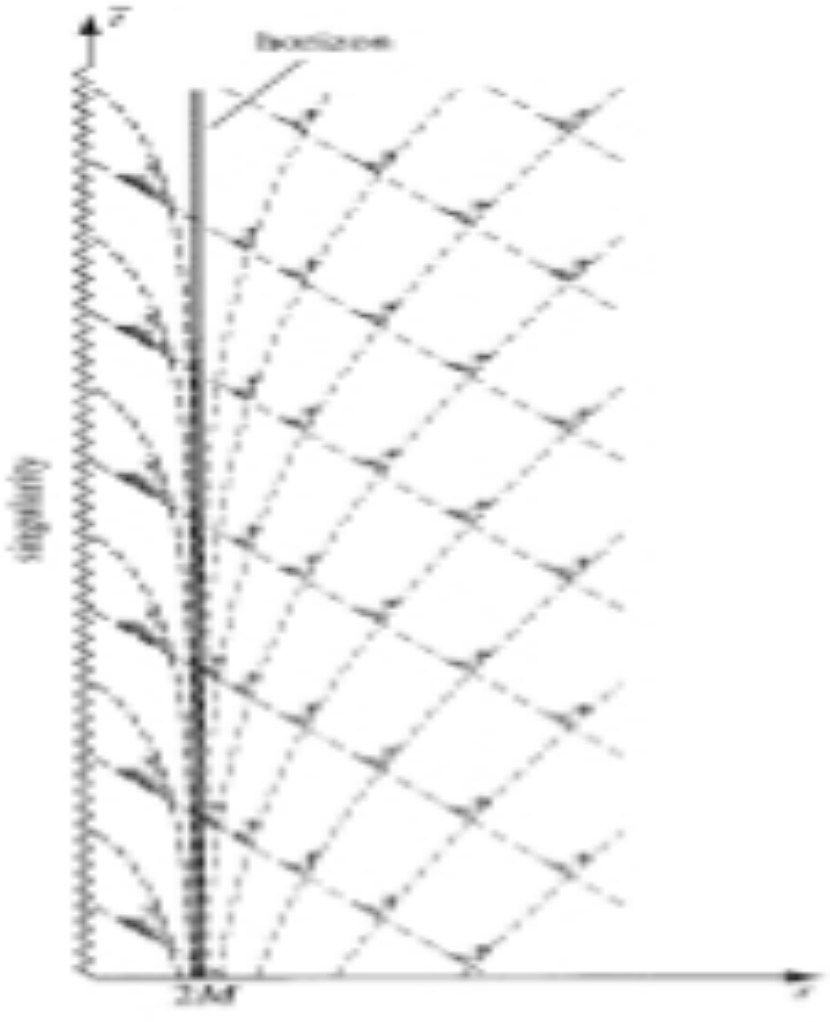
- Ingoing:

$$ds^2 = -\left(1 - \frac{2GM}{r}\right) dv^2 + 2dvdr + r^2 d\Omega^2.$$

- Outgoing:

$$ds^2 = -\left(1 - \frac{2GM}{r}\right) du^2 - 2dudr + r^2 d\Omega^2.$$

Eddington–Finkelstein Light Cone Diagram



Conservation Laws

- Classically:
  - Energy conservation, momentum conservation, etc.
- In General Relativity:
  - Conserved quantities are attained through observed symmetries in different space-times

No-Hair Theorem

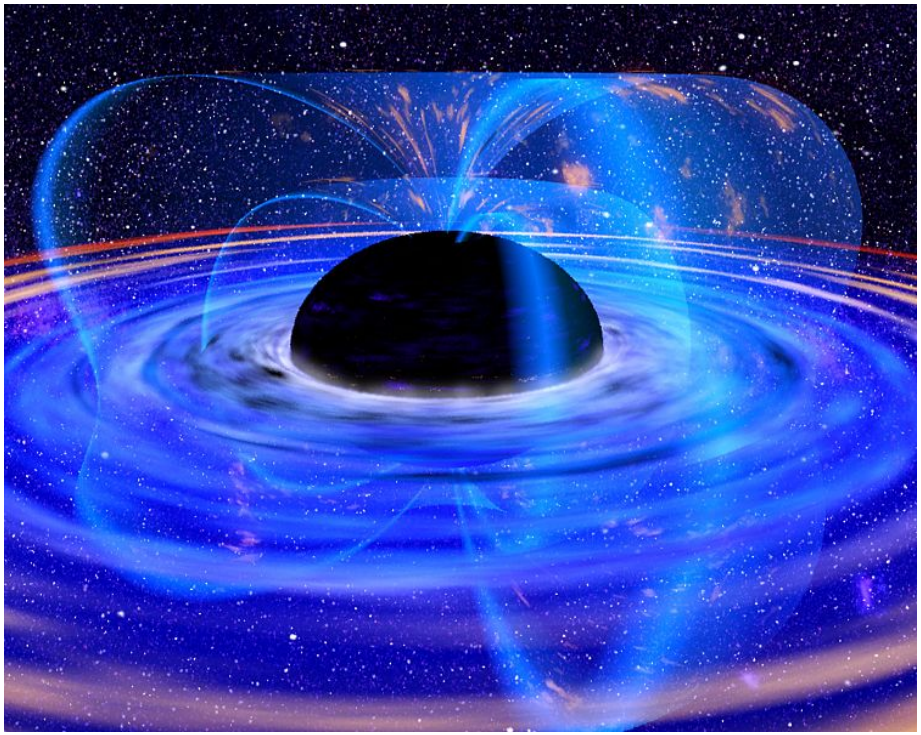
- "black holes have no hair" - John Wheeler
- Hair as a metaphor for information
- Black holes are perfectly defined by 3 characteristics:
  - Mass
  - Charge
  - Angular momentum
- No mathematical proof

Black Hole Information Paradox

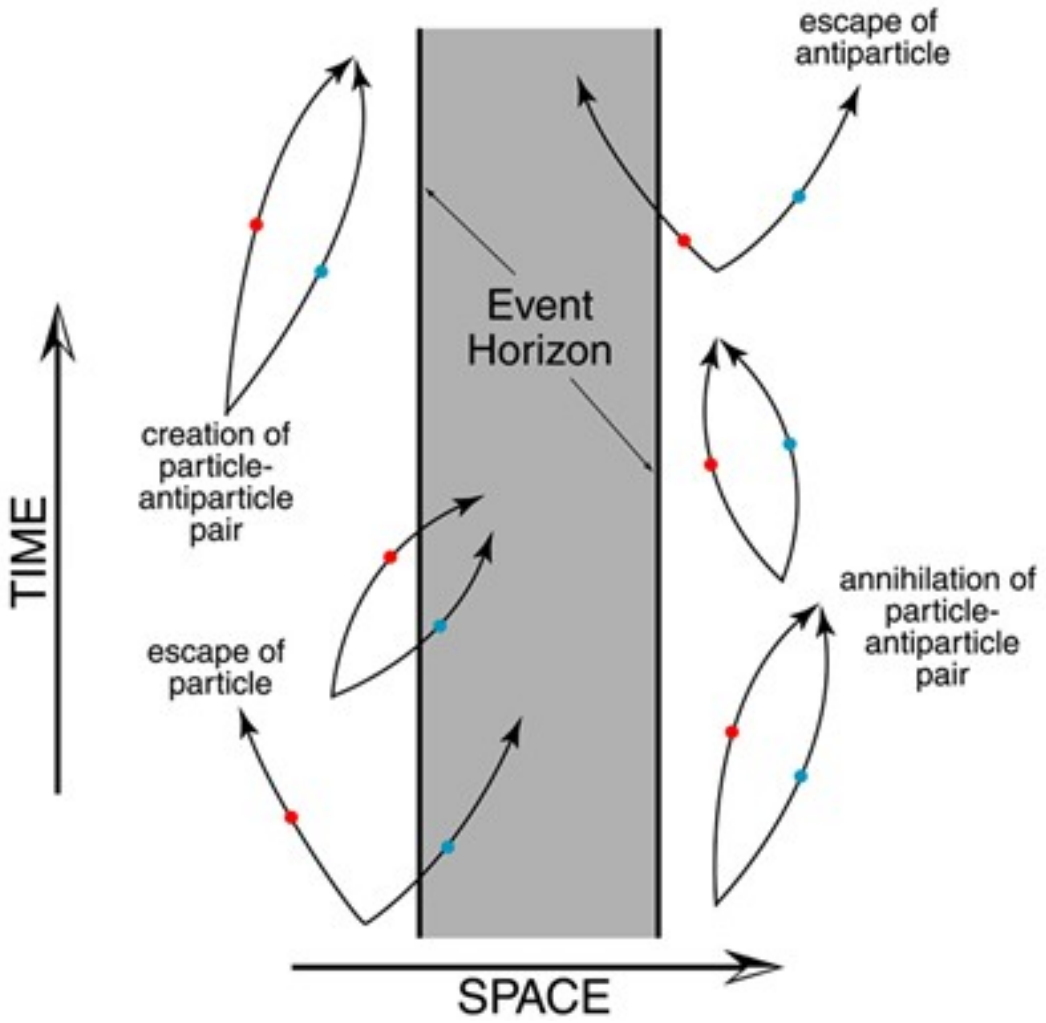
- Main problem:
  - Quantum mechanically, the past and present of a system is governed by its wave equation and how that wave equation evolves
- Accepted idea:
  - Information is always preserved
- Problem:
  - Information is “lost” once is crosses the event horizon of a black hole

Hawking Radiation

- Proposed by Stephen Hawking in 1974
- Reduces mass and energy of a black hole



Particle/Anti-Particle Creation



Temperature

- Temperature of a black hole decreases when it gain mass and increases when mass is radiated away
- Temperature of the CMB:
  - 2.73 K
- Temperature of a black hole as a black body:
  - T = (6 x 10-8) M
- Therefore, black holes gain energy from the CMB

Thorne–Hawking–Preskill Bet

- Made in 1974 on the black hole information paradox
- Hawking/Thorne: the information radiating from black holes was new
- Preskill: the information radiating related to what was inside the black hole
- Hawking conceded in 1997
- Bought Preskill a baseball encyclopedia

Observations and Experiments

- Too small to observe directly on a laboratory scale
- LHC/CERN could produce MBH's (Micro Black Holes) which radiate more
- Sonic black holes using perfect fluid and sound vibrations

Observed!

- September 2010
- Franco Belgiorno at the University of Milan
- White hole: a horizon beyond which light can't penetrate
- Ultrashort laser pulse filaments
- Different wavelength going in and coming out
- … probably not Hawking radiation though.