
ajsh movie


Black holes
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MIT

Our topics

Black holes

- what they are and aren't
- basic properties
- River model
- Evidence for them

If time: time travel

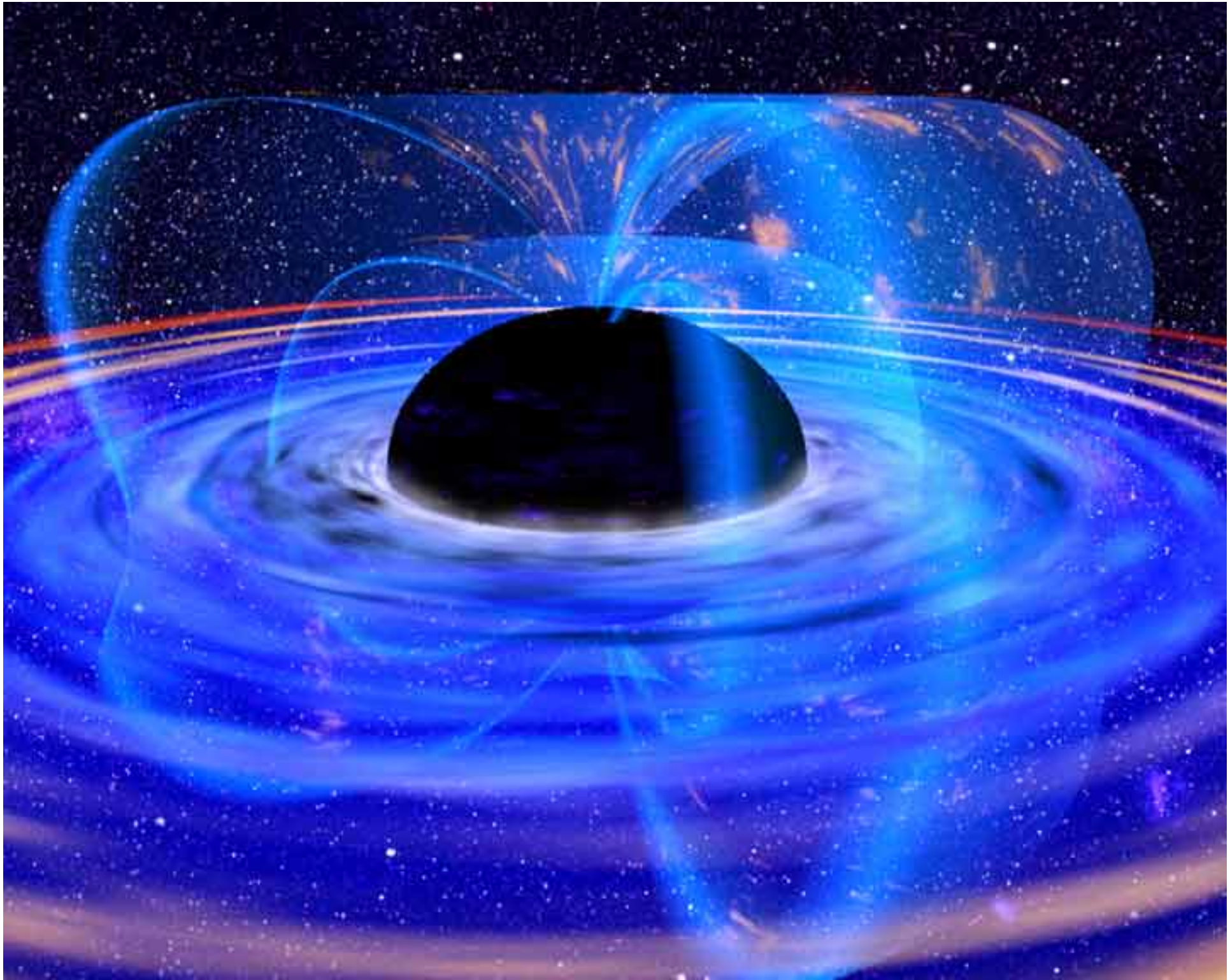
Q: What is a black hole?

A: An object contained within its own event horizon.

Q: What 3 measureble properties do black holes have?

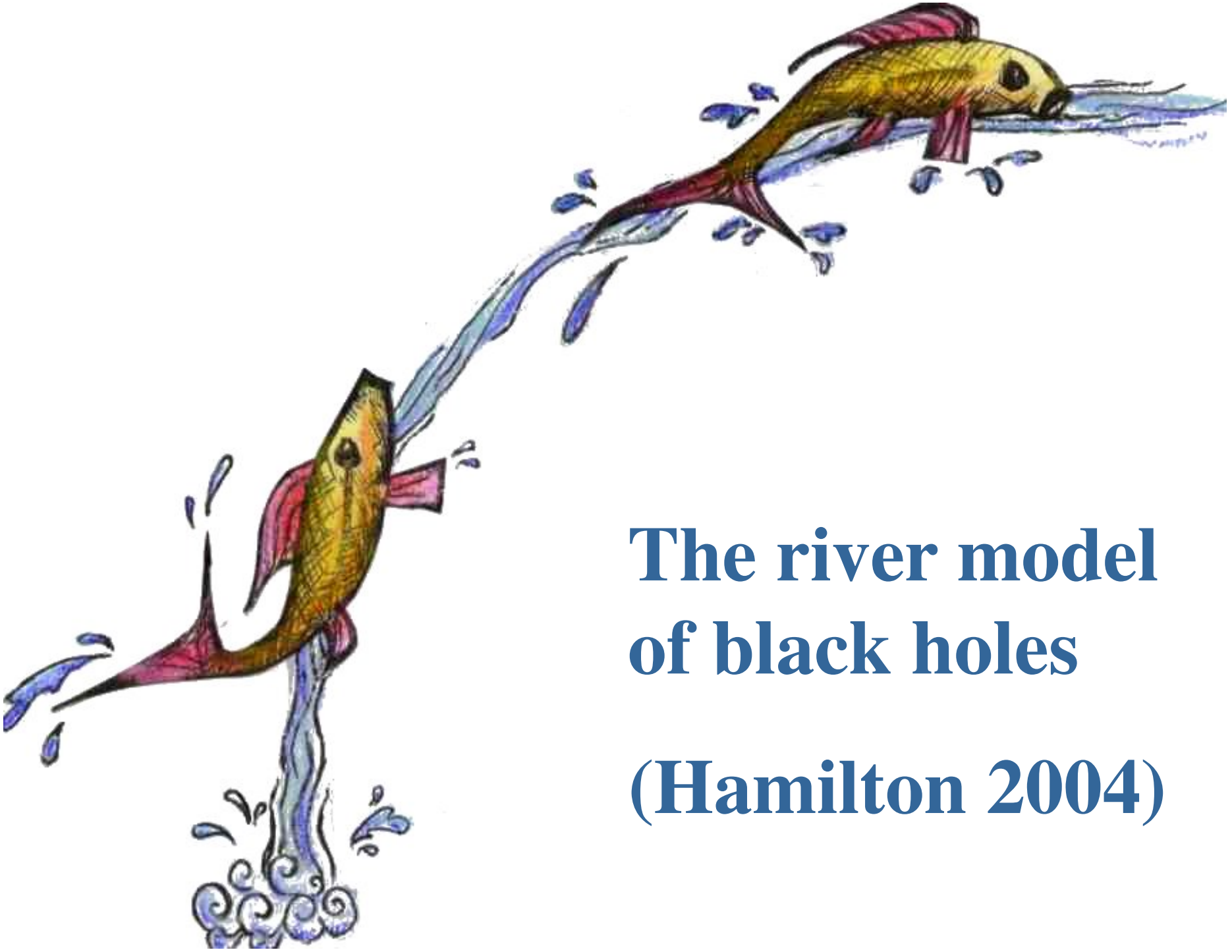
A:

1. Mass
2. Angular momentum
3. Charge



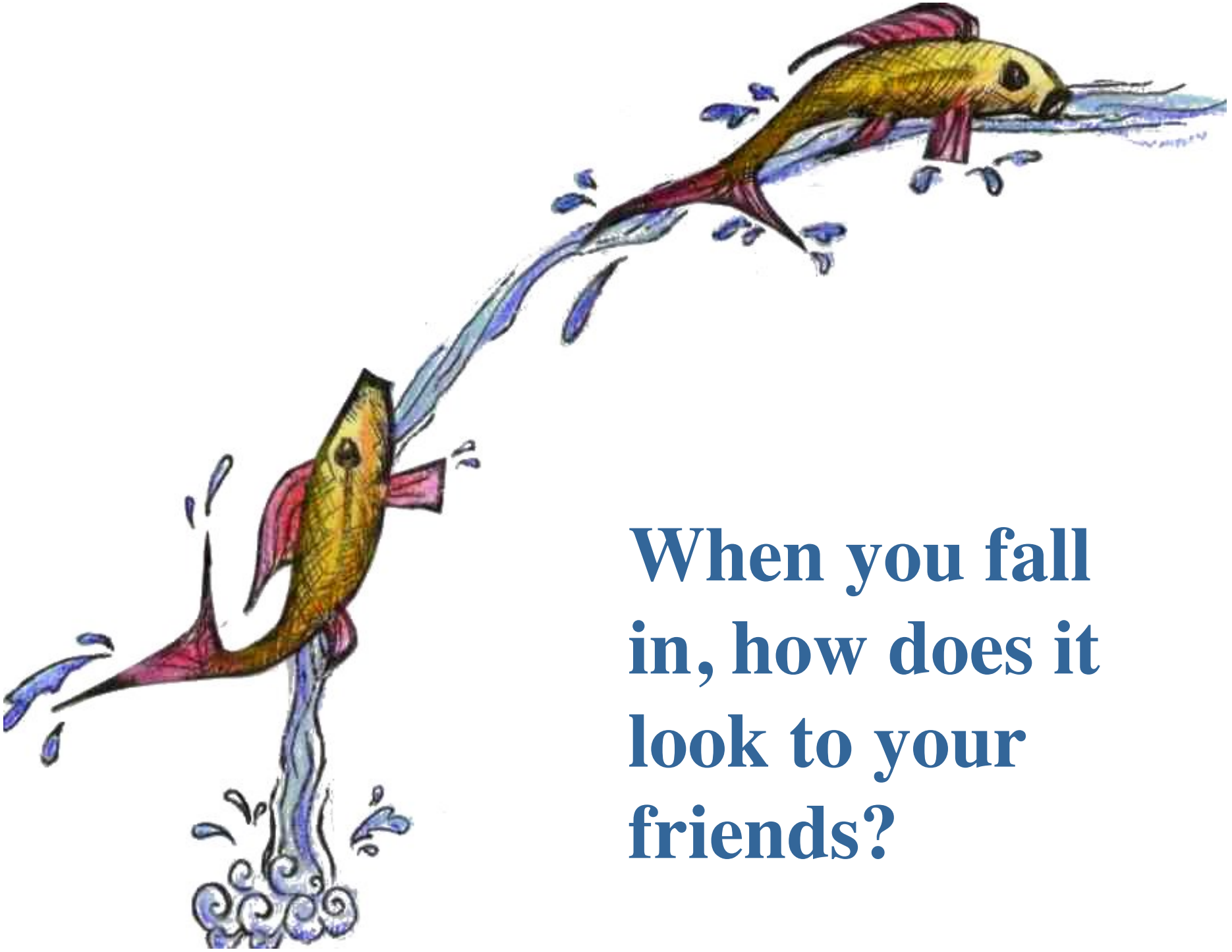
But what is a black hole *really*?

River model gives great intuition!

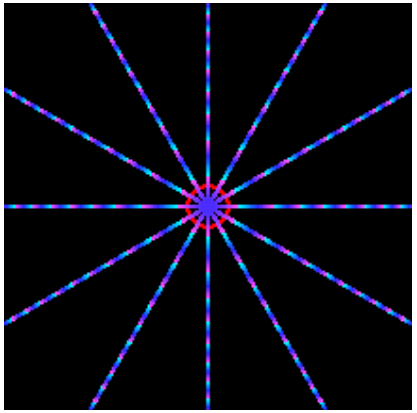


The river model of black holes

(Hamilton 2004)



When you fall in, how does it look to your friends?

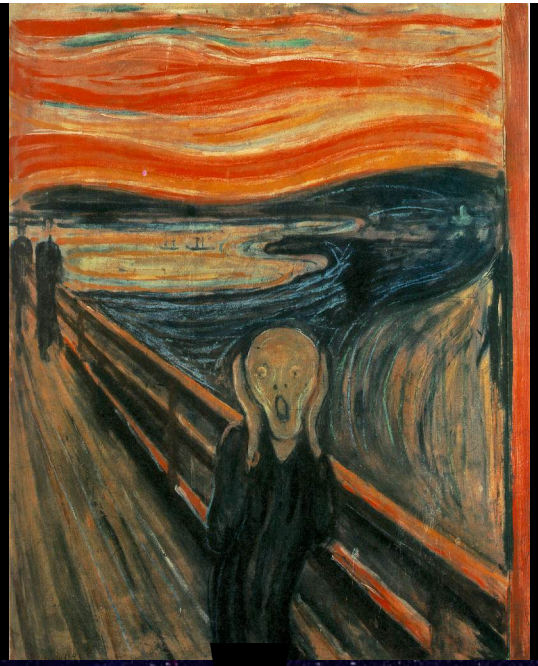


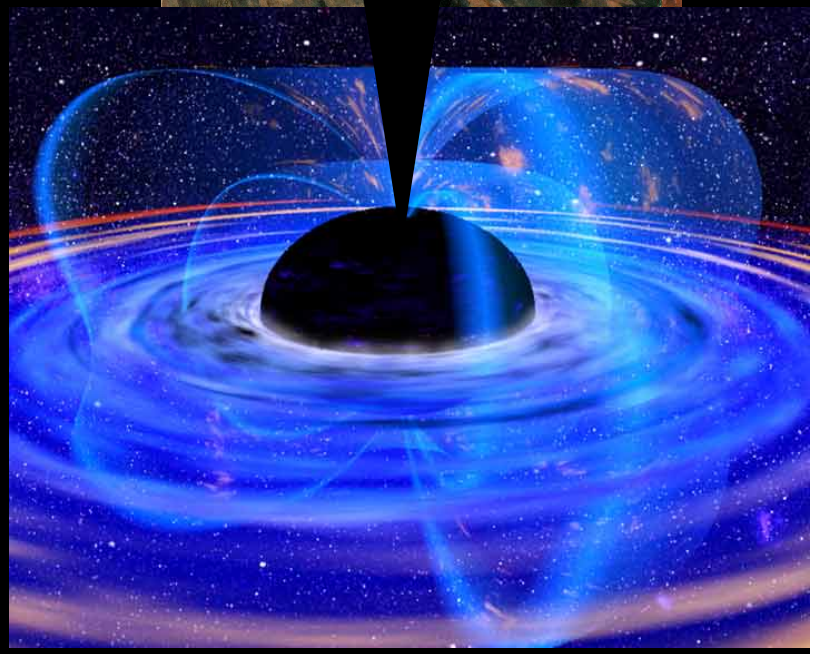
The river model explains

- Event horizon & interior (not singular, compare to Niagara swim)
- Tidal forces
- Why t breaks down at horizon
- Why “excess radius” near horizon

- Escape velocity
- Newtonian calculation for death plunge

How would you die?





Evidence for black holes, part I

Astrophysical evidence for black holes:

1) Supermassive BH's in centers of most (all?) galaxies:

- existence of quasars, huge jets

- stellar motions => 10^6 - 10^9 solar masses

- orbiting gas disks => size less than 0.4 lightyears (can't be stars)

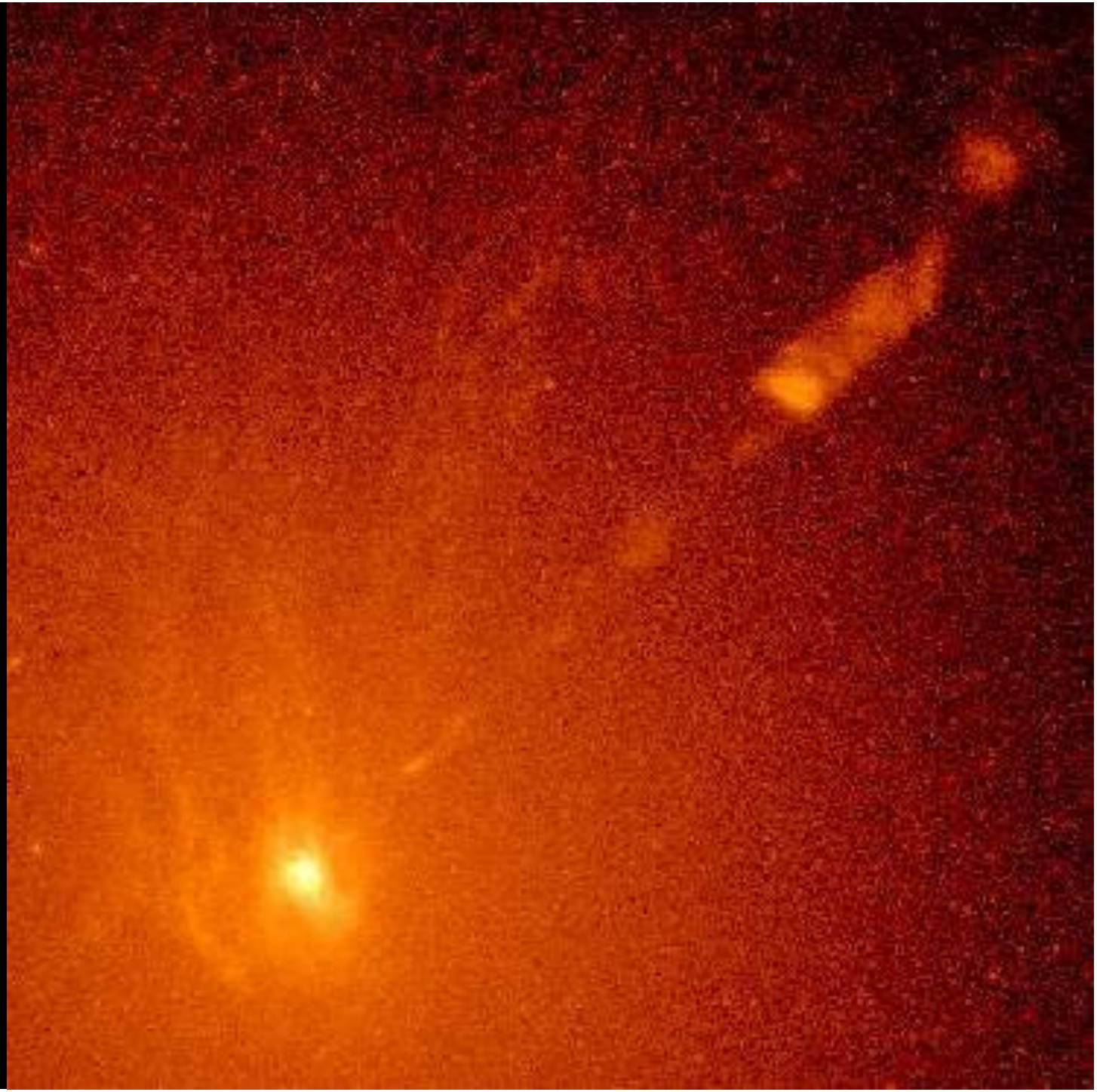
- devoured star incident => size less than 0.4 A.U.

- X-ray spectra reveal disk extending in to 6-20M!

M87
AGN

+

jet



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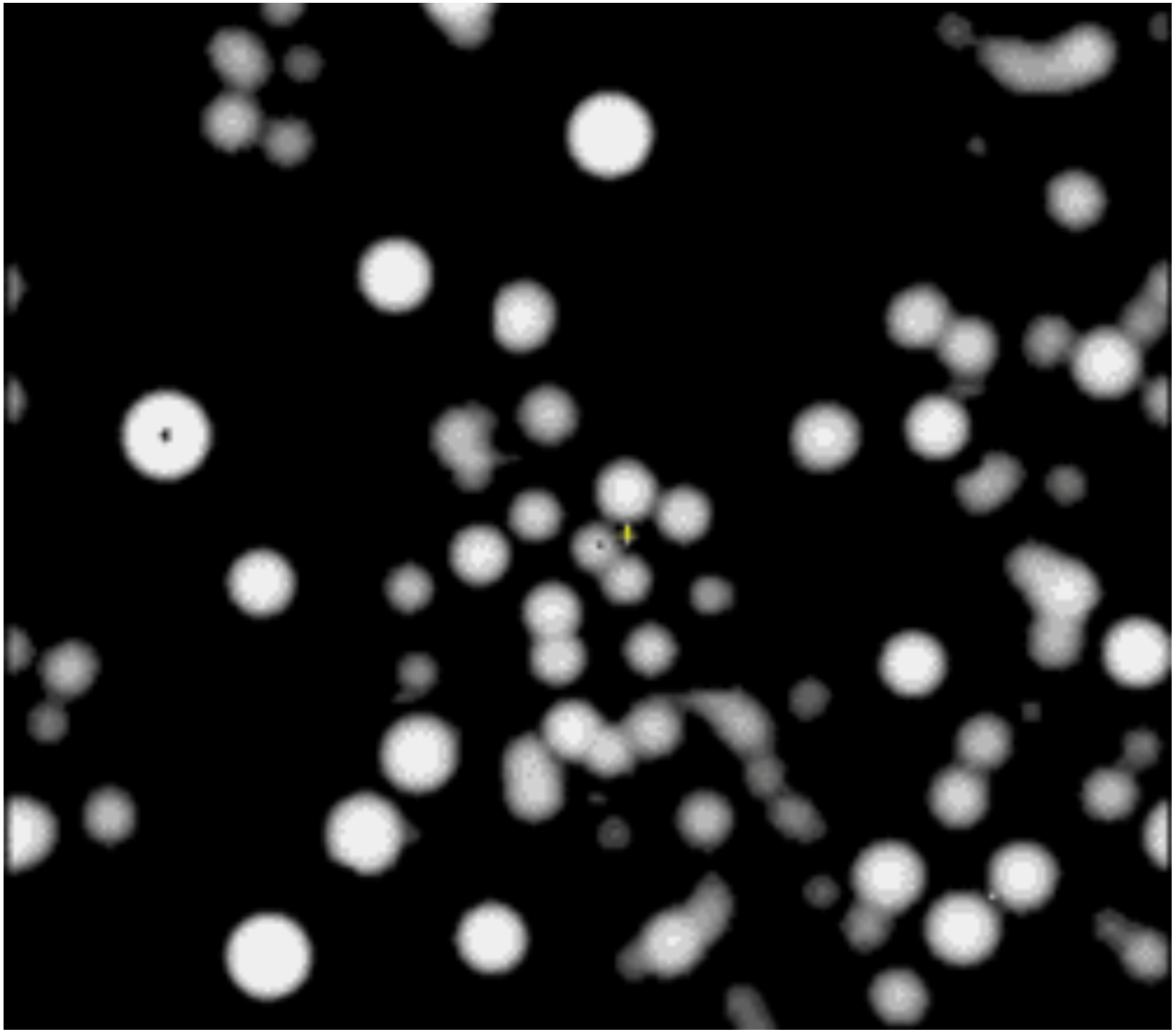

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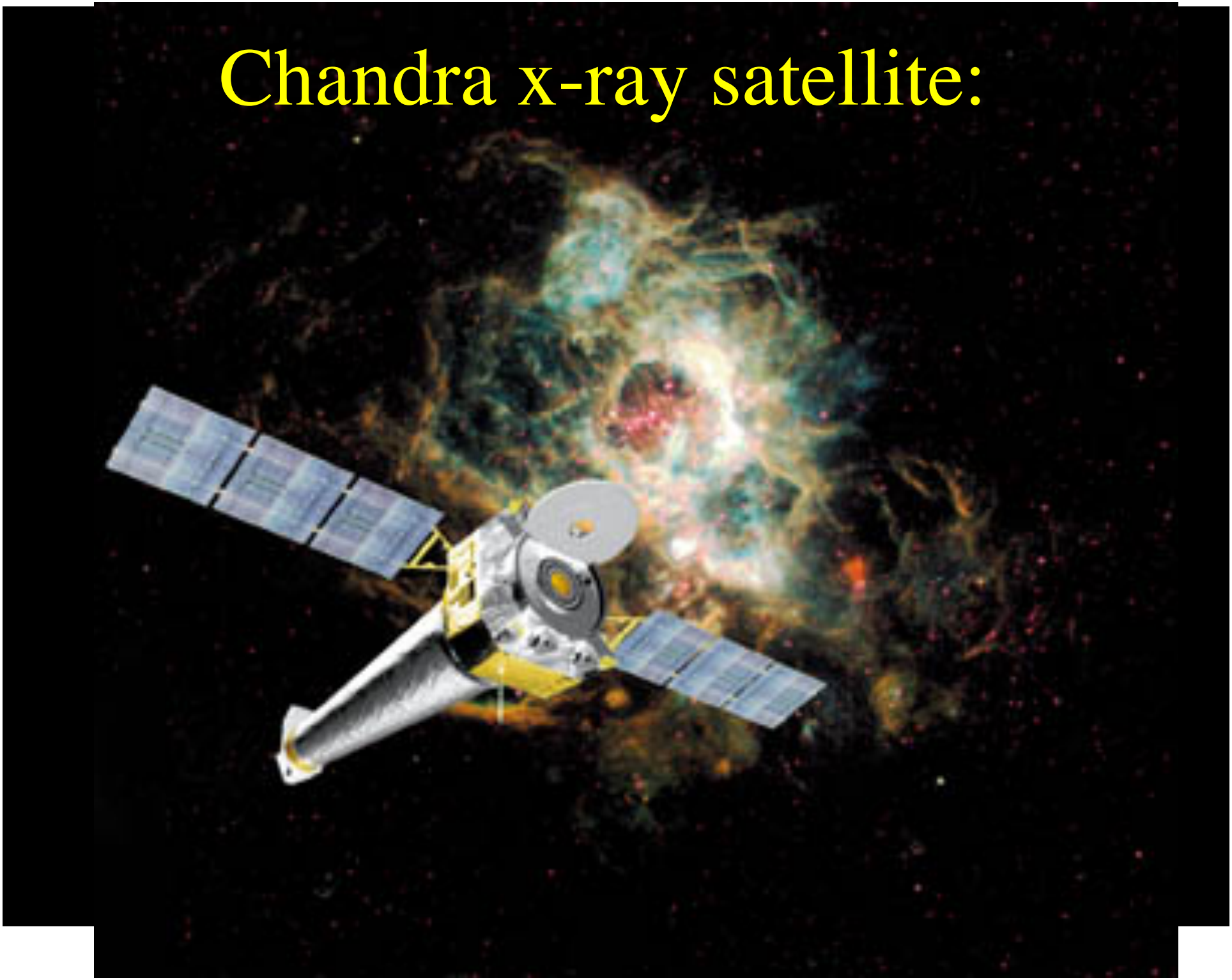
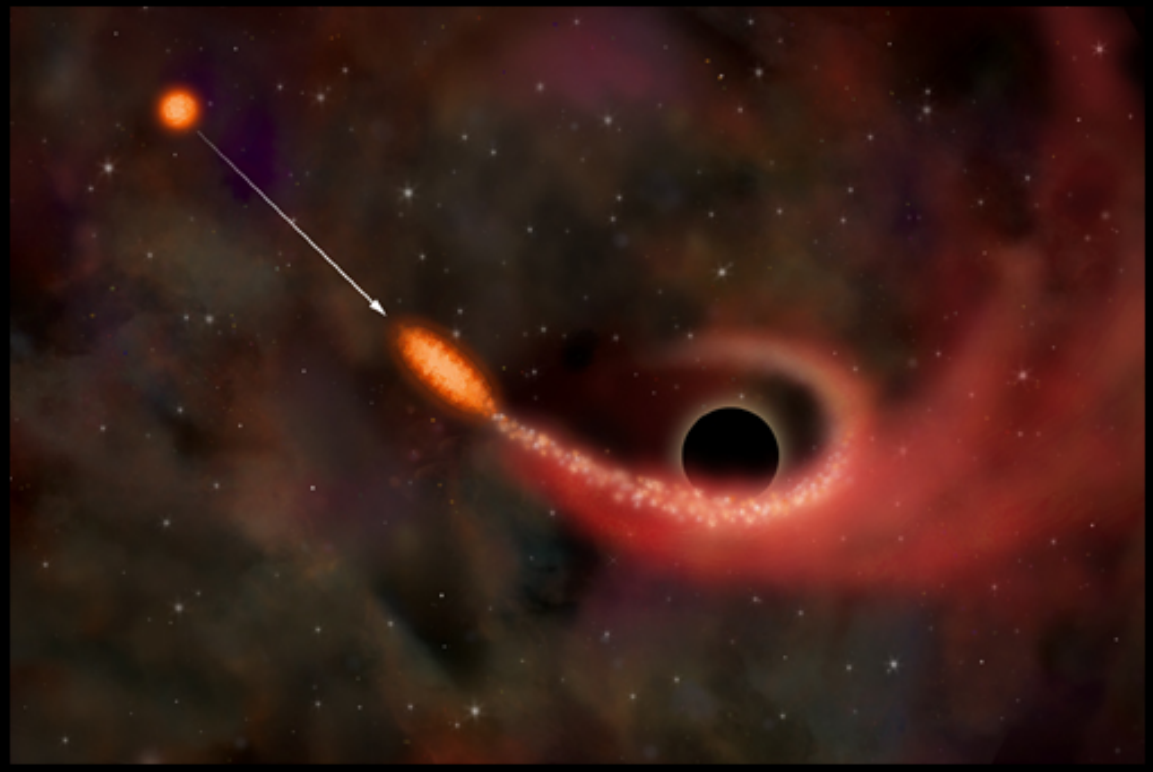
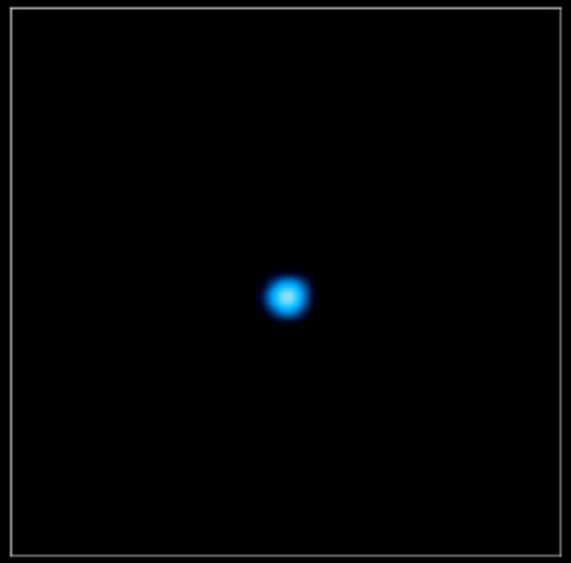
Chandra x-ray satellite:

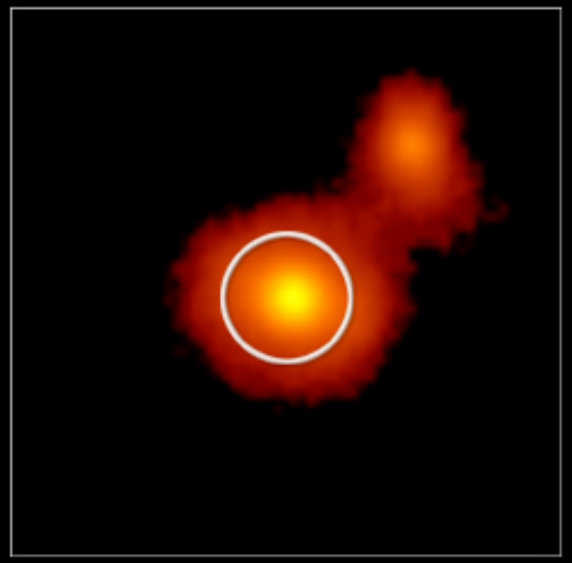


Star strays too close to Sagittarius A* supermassive black hole

(=>size<0.4au)

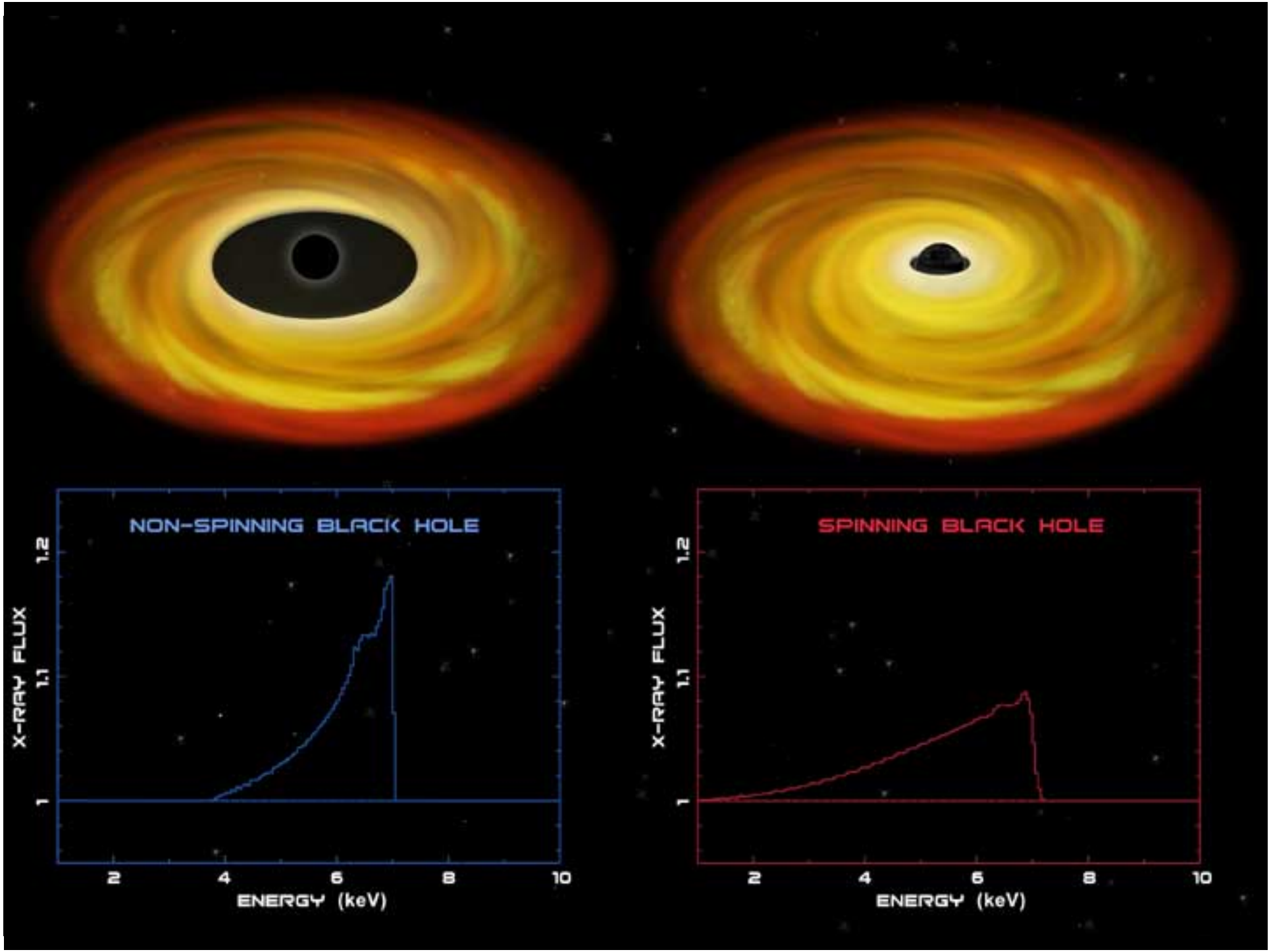






CHANDRA X-RAY

ESO OPTICAL


NON-SPINNING BLACK HOLE
X-RAY FLUX
1
1.1
1.2
2
4
6
8
10
ENERGY (keV)
SPINNING BLACK HOLE
X-RAY FLUX
1
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Evidence for black holes, II

Astrophysical evidence for black holes:

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Astrophysical evidence for black holes:

2) Stellar mass BH's:

- Stars orbiting massive invisible companion

- Maximum neutron star mass is 3 solar masses

- Best example: V404 Cygni
partner mass = 12±2 solar masses.

- Older example: Cygnus X1 (StarryNight!)

- X-ray variability puts upper limit on size

- Appears that no "surface"