November 1, 2010

Reading: Chapter 10, Sections 10.1-10.4, 10.9.

Astronomy in the News?

Pic of the Day – Milky Way, Orion, Magellanic Clouds over volcano on Reunion Island in the Indian Ocean.
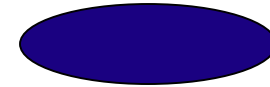
Goal:

To understand the full space-time associated with rotating black holes.

Rotating Kerr Black Hole

Mass and spin, but no electrical charge

Assume all mass is in the singularity, no mass anywhere else
(assumption necessary to solve equations)
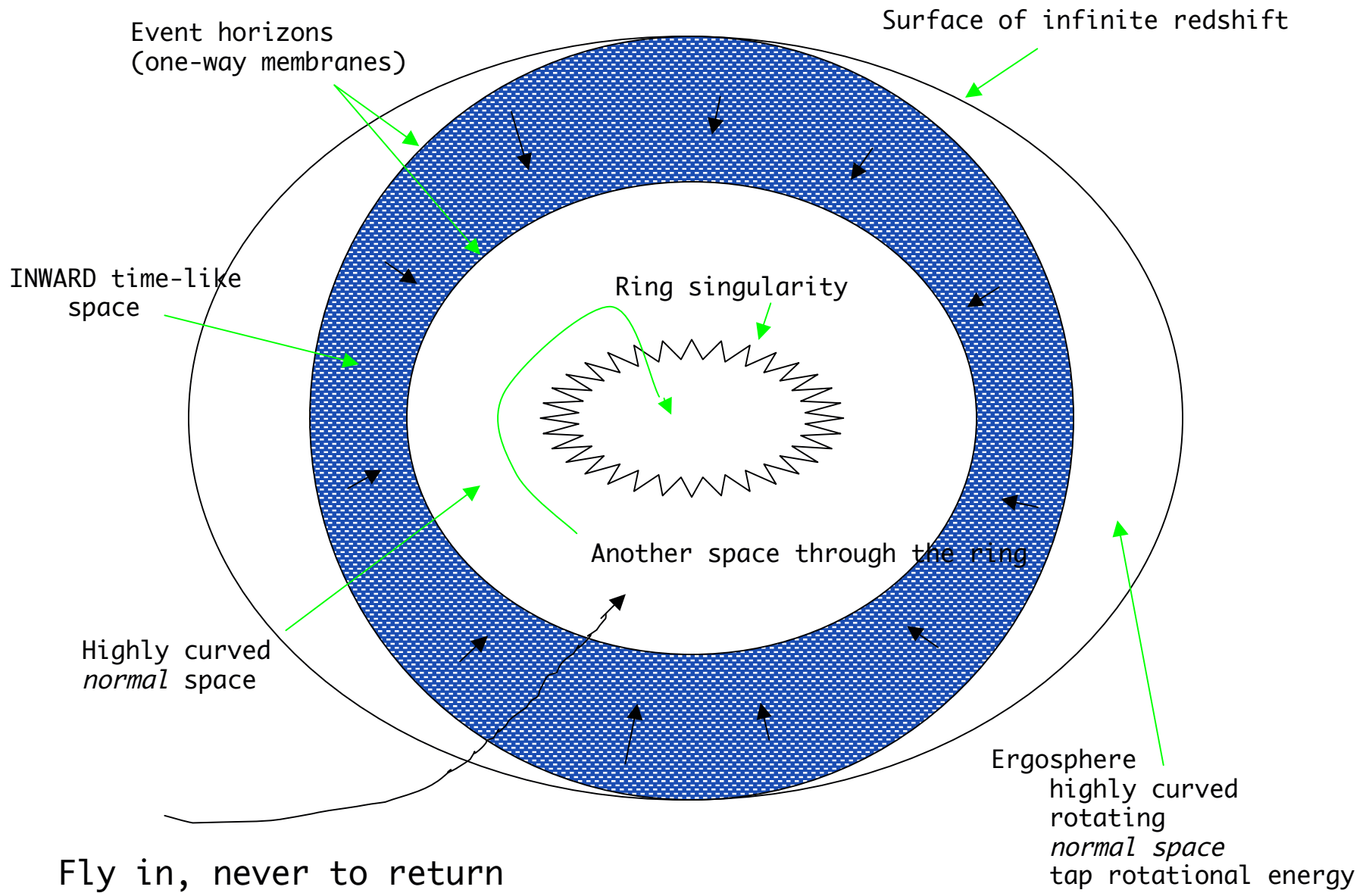
Find *singularity is a ring* (not a point)

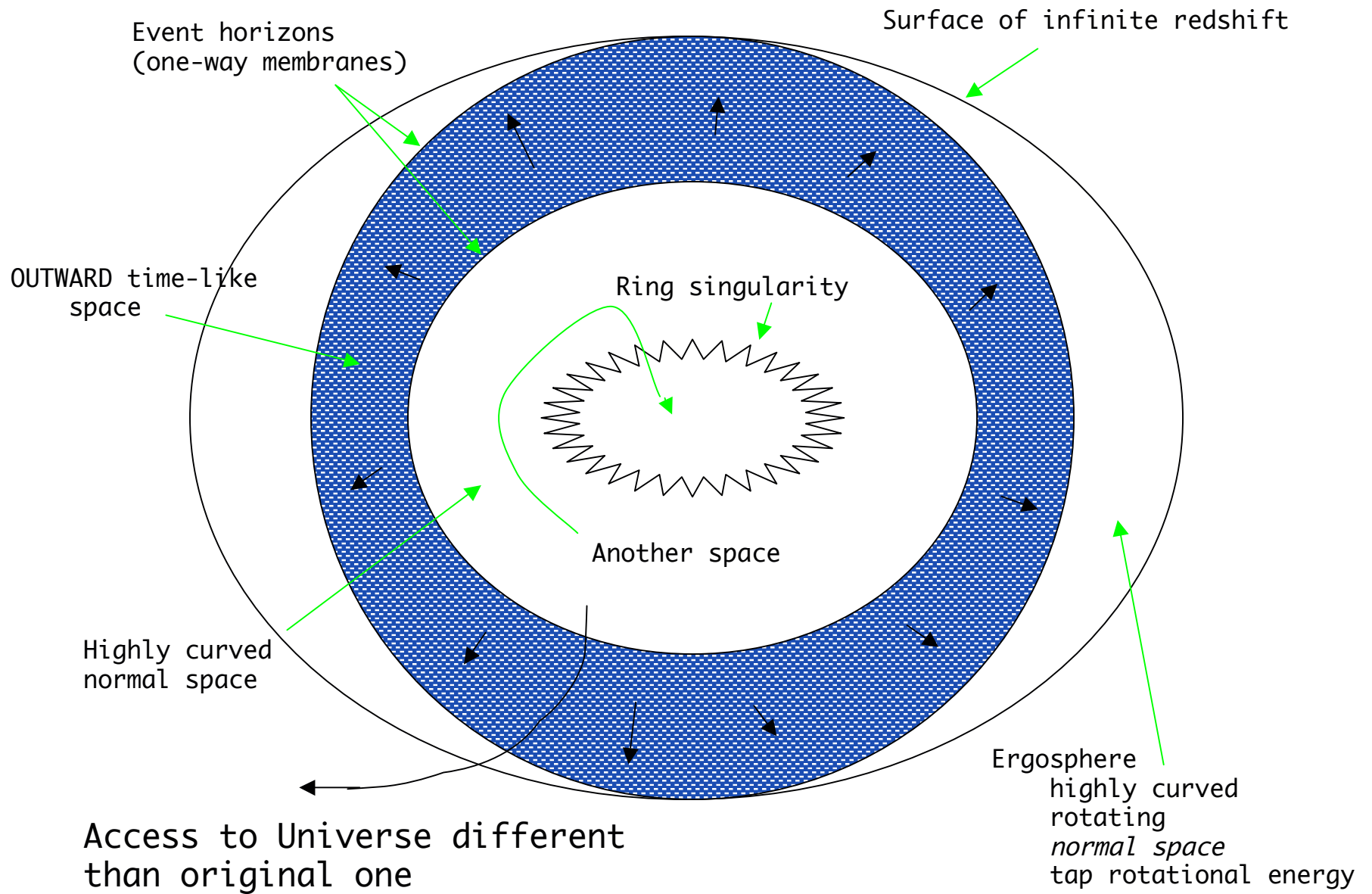0 thickness, ∞ density, still uncertainty problem

Infinite Universes!

(implicitly spread through hyperspace)

Cross-sectional view of rotating Kerr black hole

Event horizons
(one-way membranes)

Surface of infinite redshift

INWARD time-like
space

Ring singularity

Another space through the ring

Highly curved
normal space

Fly in, never to return

Ergosphere
highly curved
rotating
normal space
tap rotational energy

In future

Event horizons
(one-way membranes)

Surface of infinite redshift

OUTWARD time-like
space

Ring singularity

Another space

Highly curved
normal space

Ergosphere
highly curved
rotating
normal space
tap rotational energy

Access to Universe different
than original one

Are Different Universes Real?

In Real Universe:

Light falls into the black hole

Photons are Doppler blue shifted, accelerated to higher energy,
compacted into a thin shell: **Bluesheet**
 the energy/mass of the blue sheet warps the space
 changes the mathematical, hence the physical solution

So, probably not in this case, but stay tuned…

One Minute Exam

In the mathematical solution for a rotating black hole:

➡ The surface of infinite redshift is identical to the event horizon.

⬅ You can escape the black hole back to the universe from which you entered.

⬆ There are exactly two universes.

⬇ The space entered through the ring singularity is different than the space surrounding the singularity.

Chapter 10 - Finding Black Holes for Real

We know that massive stars evolve to form iron cores that absorb energy and collapse. A compact object must be left behind.

Some explode and leave rotating, magnetic pulsars

Some explode and leave highly magnetic magnetars

Some explode but leave black holes or completely collapse to leave black holes

We don't know which massive stars do which! Tendency to think that more massive stars are more prone to making black holes, but the rotation of the star, the presence of a binary companion, and other factors may influence the outcome.

We do know that black holes exist, so some stars make them.

Goal:

To understand how we search for real black holes and why binary systems with mass transfer and accretion disks are so important.

Black Holes for Real

There may be 1 - 100 million black holes in the Galaxy made by collapsing stars over the history of the Galaxy.

That means that the nearest black hole may be only a few tens of light years away. How do we find them?

Black holes made from stars are really black! (Negligible Hawking radiation).

Those alone in space are not impossible to find, but very tough. None yet identified.

Look for binary systems, where mass accretion occurs.

Will not see the black hole, do not yet have the technology to "see" a black spot.

Can detect the **halo of X-rays** from orbiting matter, the accretion disk, near the event horizon that will reveal the presence and nature of the black hole. ***Look in accreting binary systems!***
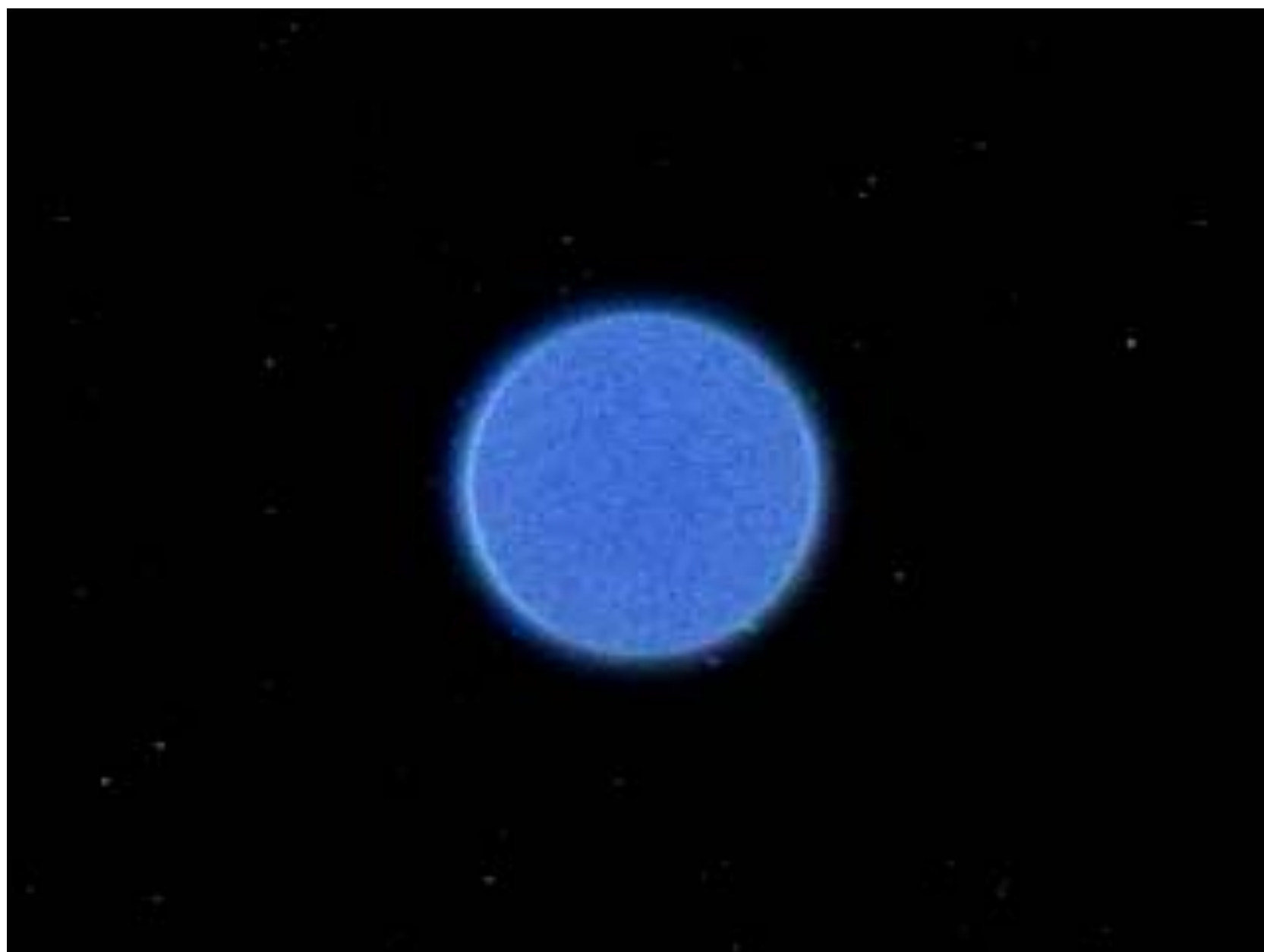
Goal is to get close-up study of strongly warped space
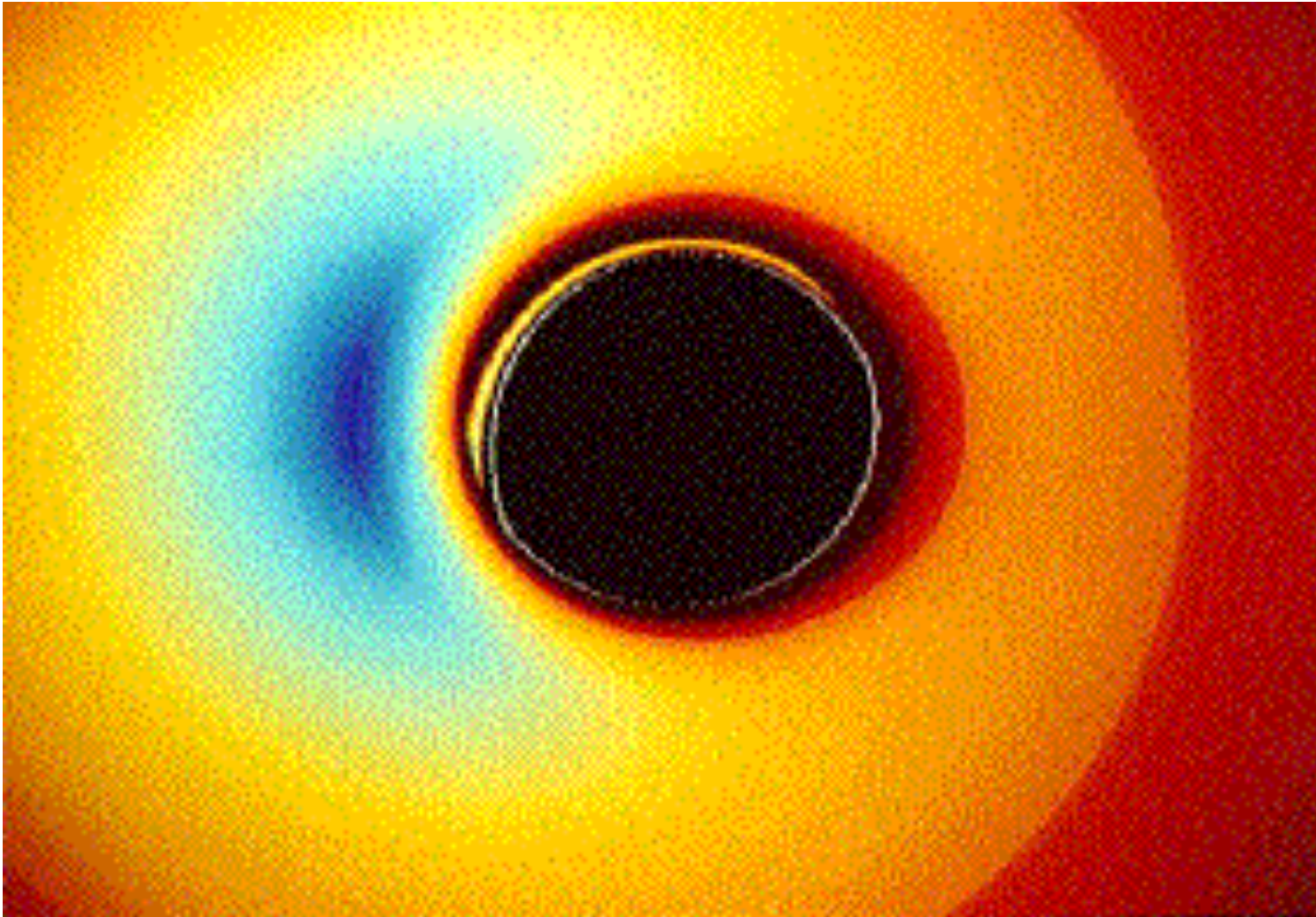
Perez and Wagoner, Stanford: computer simulation of
radiation from inner black hole accretion disk

Black holes are so weird and so important that the standards of evidence have to be high!

Current evidence is still primarily circumstantial, but very strong:

Stellar mass black holes (several to ~ 10 solar masses), in binary systems in our Galaxy or nearby galaxies

Intermediate mass black holes (~ 1000 - 10,000 solar masses)??, in binary systems or stellar clusters in our Galaxy or nearby galaxies

Supermassive black holes (million to a billion solar masses) in the middle of our Galaxy and in the middle of many, many others.

Circumstantial arguments for presence of black hole in a binary system:

Only neutron stars and black holes have the high gravity necessary for intense X-rays.

Use Kepler's laws to measure the total mass of the system, astronomy to determine the mass of the mass-losing star, subtract to get mass of "unseen" companion emitting X-rays.

Maximum mass of neutron star is ~ 2 solar masses

Intense X-ray source with mass exceeding 2 solar masses is, by a process of elimination, a candidate black hole.