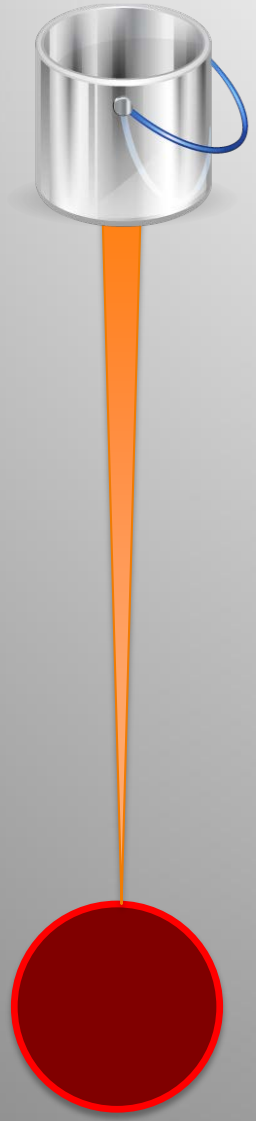
Accretion Disks

X-ray binaries: gas flowing from a “normal” star onto / into a neutron star or black hole

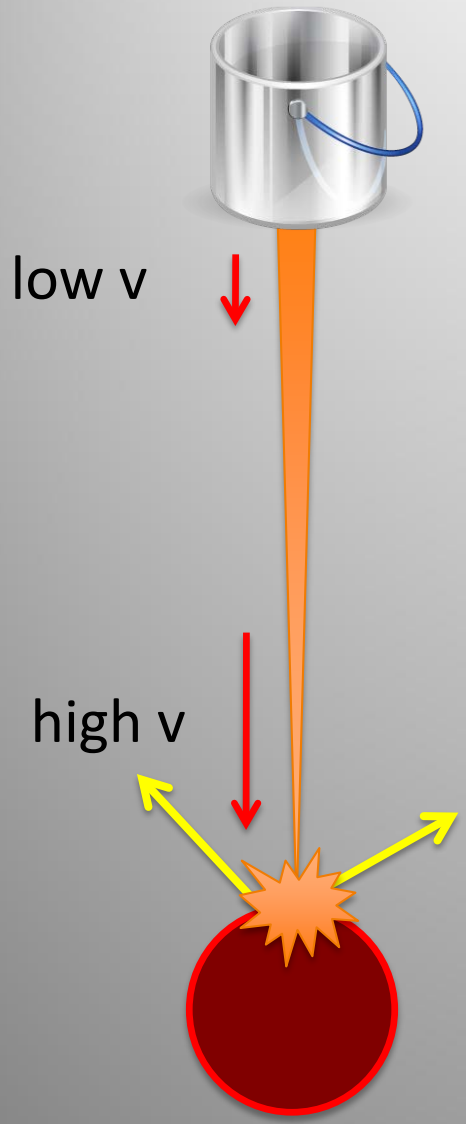
- how does this happen?
- why does it produce X-rays?

Radial accretion



Drop gas from great distance directly onto surface of a neutron star – what happens?

Radial accretion



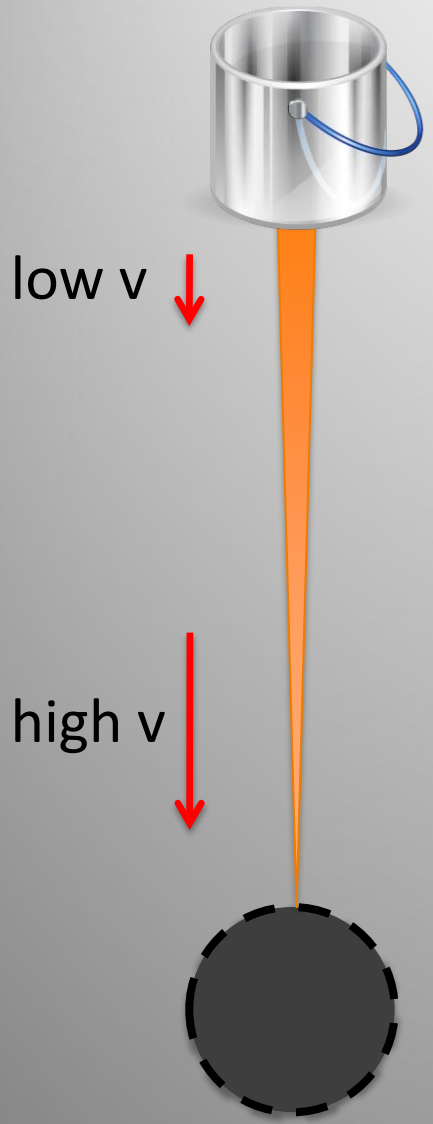
Gravitational energy

Kinetic energy

Heat

Radiation

Radial accretion

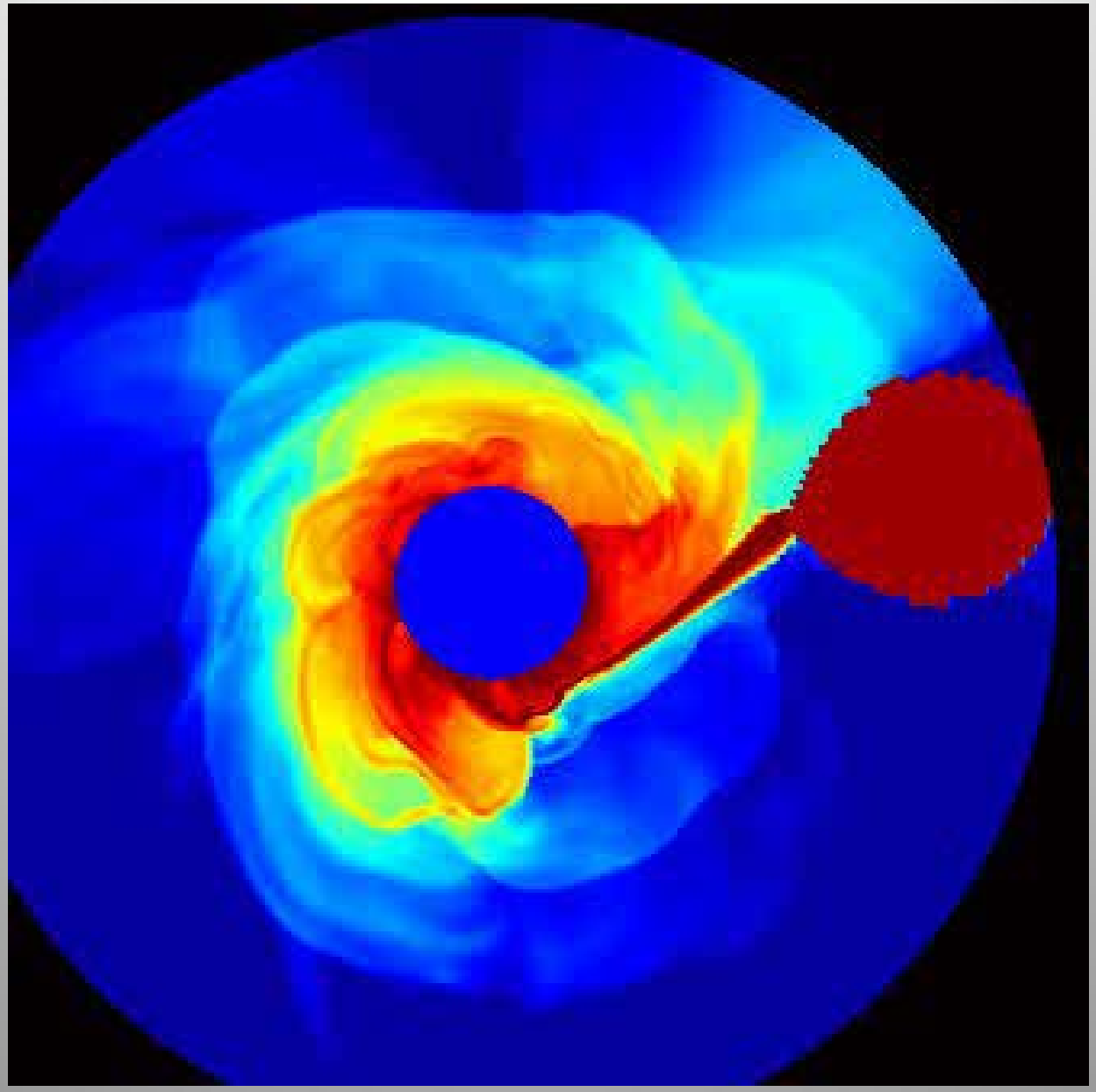


What about a black hole?

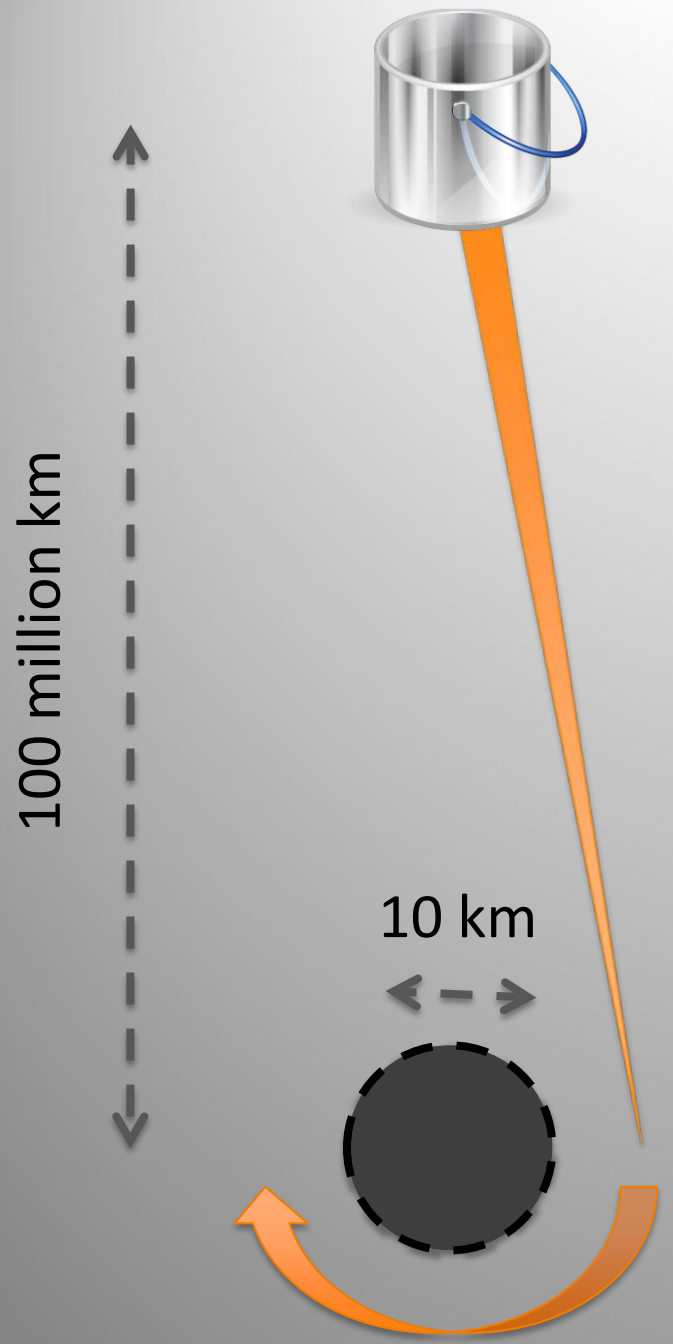
Gravitational energy

Kinetic energy

Matter *and* energy "lost" through event horizon



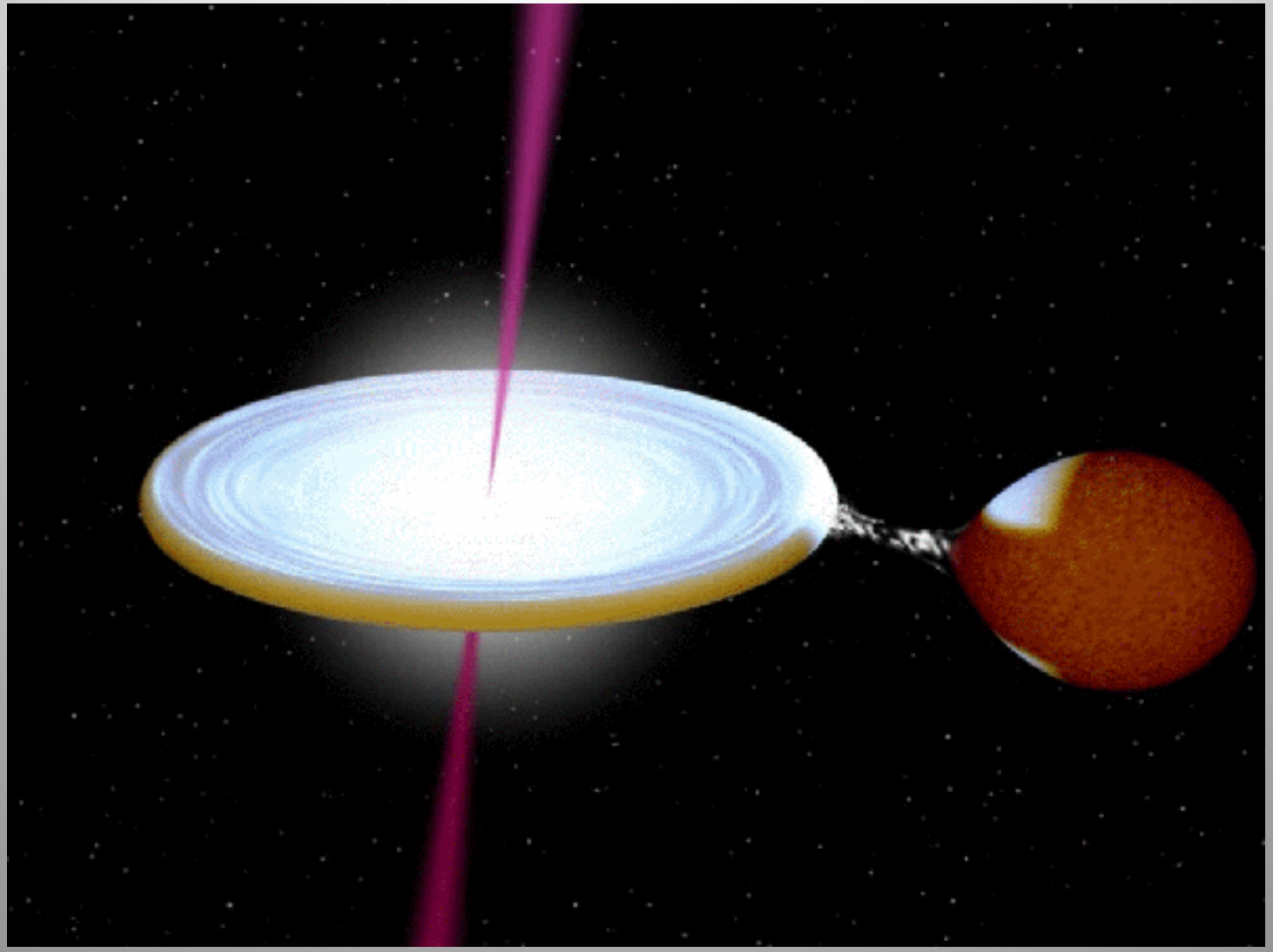
Simulation
by J. Blondin



Radial / spherical accretion never happens in binary systems with compact objects – too small a target

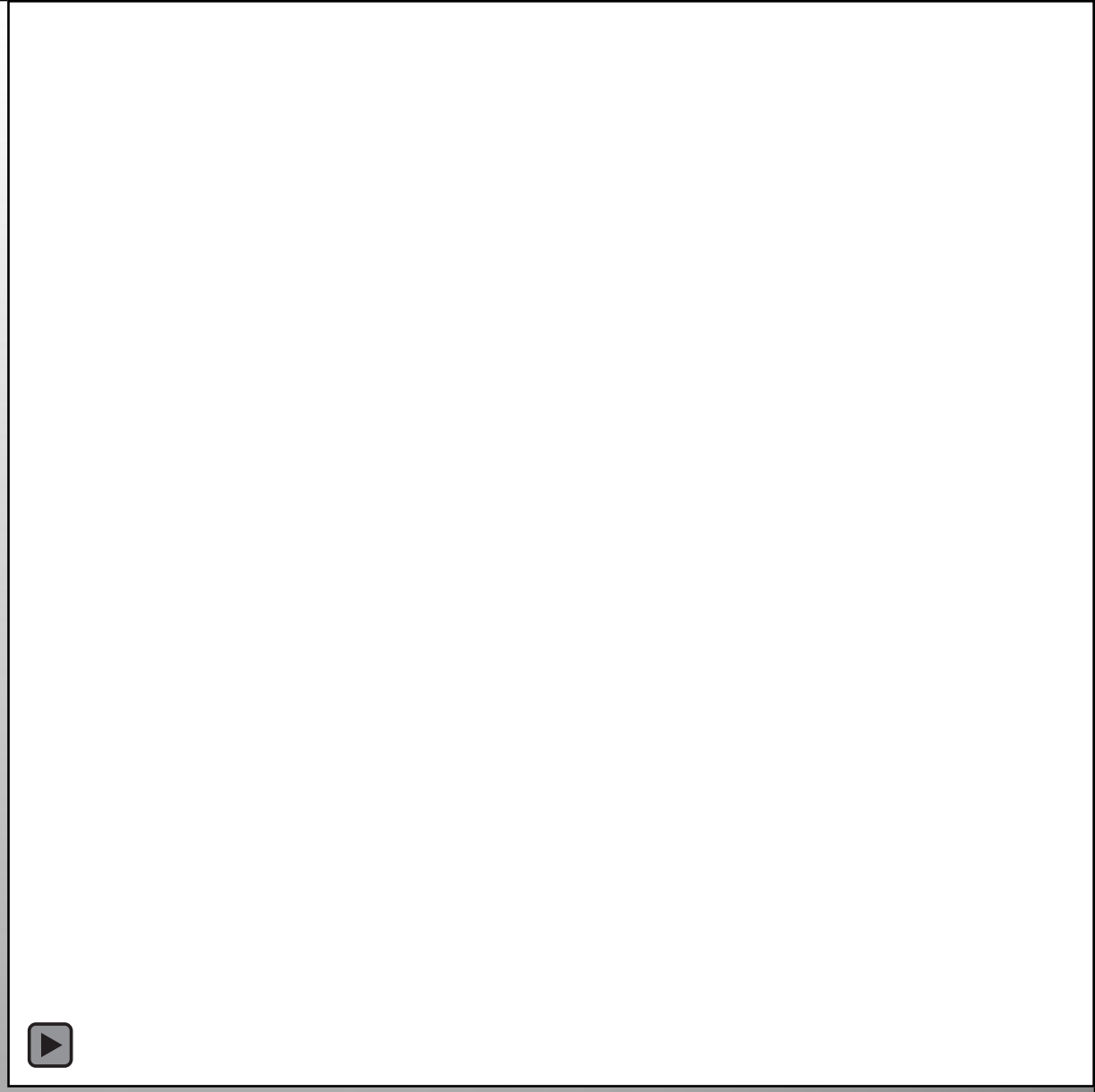
Gas misses

Gas almost *never* falls straight into a black hole



…too much “swirl” (angular momentum)

Forms an *accretion disk*

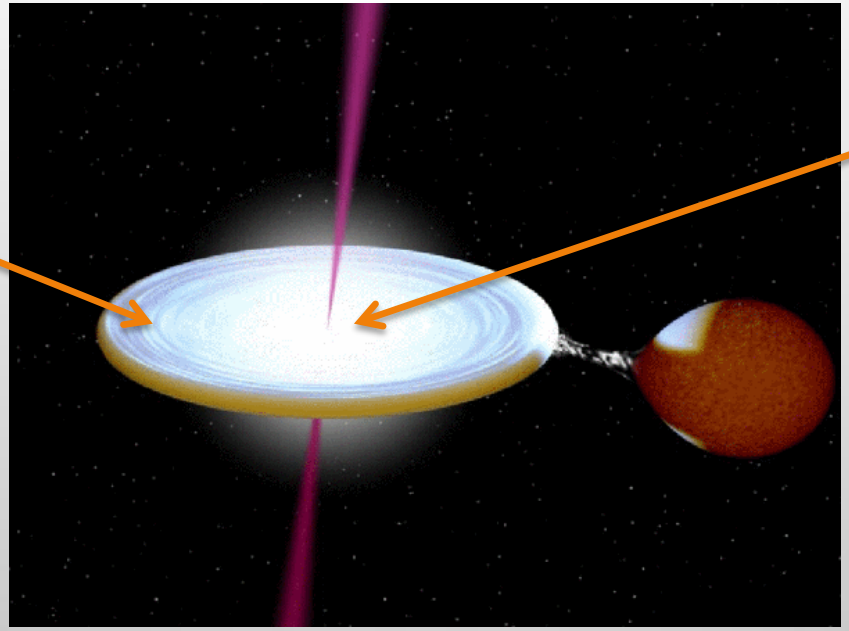


Simulation:Michael Owen, 2007

Forms an *accretion disk*

Like a gaseous whirlpool

"low" velocity, lots of angular momentum

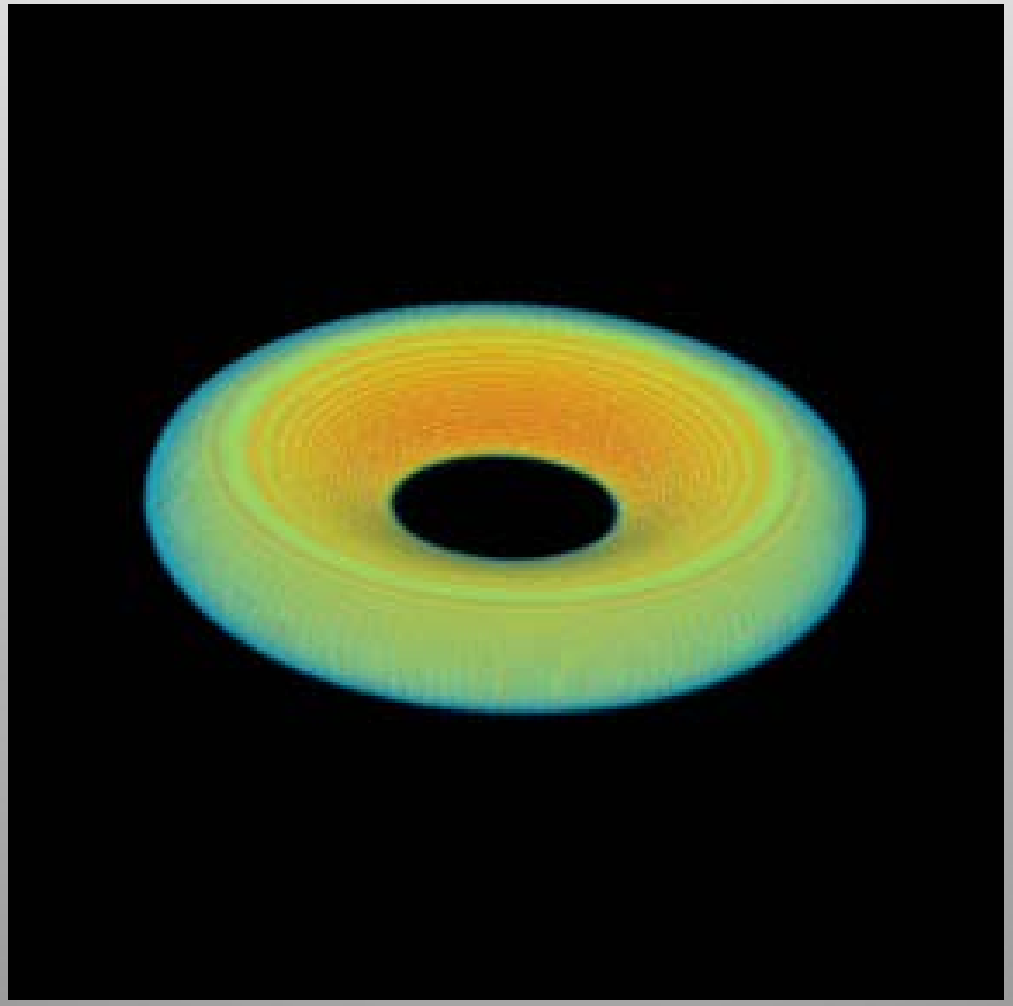


high velocity, less angular momentum

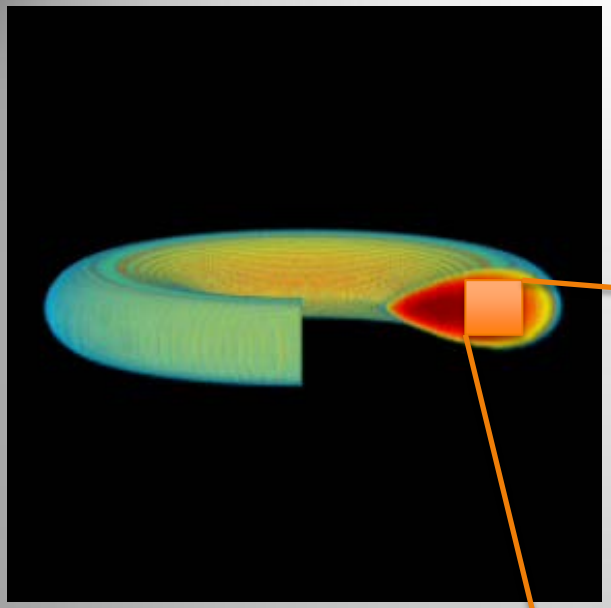
Gas must give up angular momentum to spiral toward the black hole

"Friction" (viscosity) between gas orbiting at different speeds transfers angular momentum, also generates *heat*

“Friction” thought to be due to tangled magnetic fields within the disk



Simulation: John Hawley



Flow of energy in an accretion disk

Gravity

swirling closer to black hole

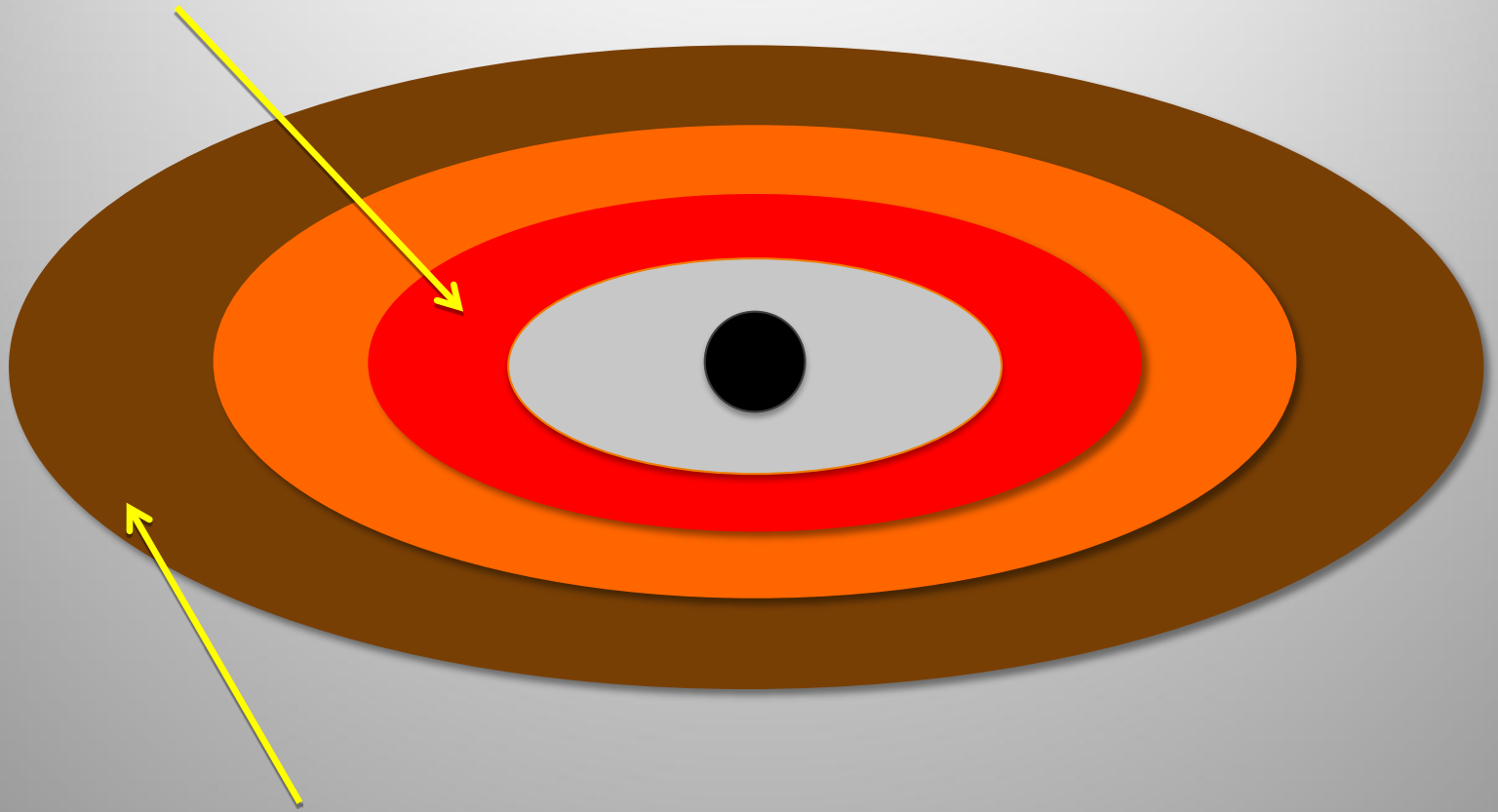
Kinetic energy
(of orbital motion)

friction, turbulence

Heat

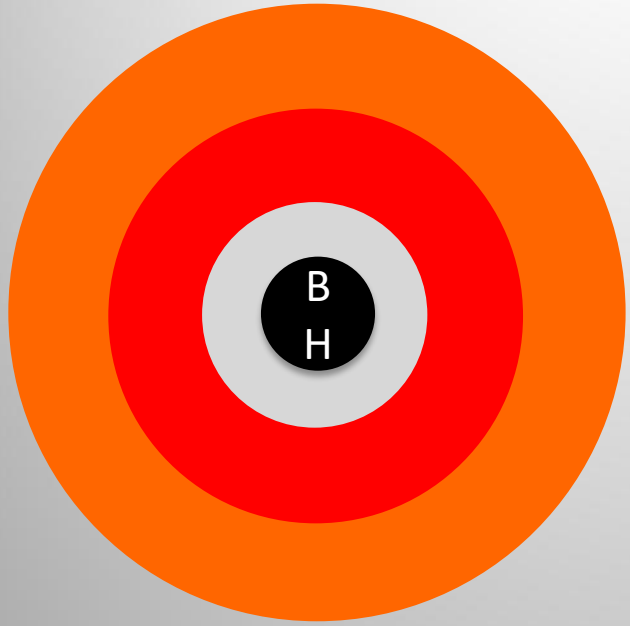
Radiation (X-rays)

Deepest potential well, highest speeds,
T ~ 10-100 million degrees (X-rays)

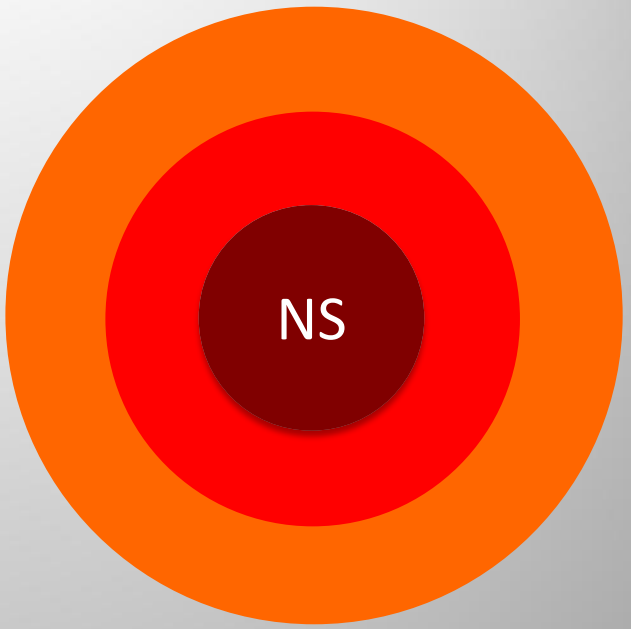


Slower, cooler, may emit UV or even visible light if far enough from hole

Black hole



Neutron star



Energy released *before* gas crosses the horizon

differences in principle between BH / NS disk accretion, but hard to measure

Identify as neutron star only if we see “surface” phenomena: pulsations, thermonuclear bursts