Wednesday, April 20, 2016

Fifth exam and sky watch, FRIDAY, May 6.

Reading for Exam 5:

Chapter 9 – Sections 9.6.1, 9.6.2, 9.7, 9.8; Chapter 10 - Sections 10.1-10.4, 10.9; Chapter 11 - all except Section 11.6 (abbreviated, focus on lectures); Chapter 12 - all; Chapter 13 all; Chapter 14 - all

Astronomy in the news?

Goal:

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

Cygnus X-1

First X-ray source discovered in the direction of the constellation Cygnus.

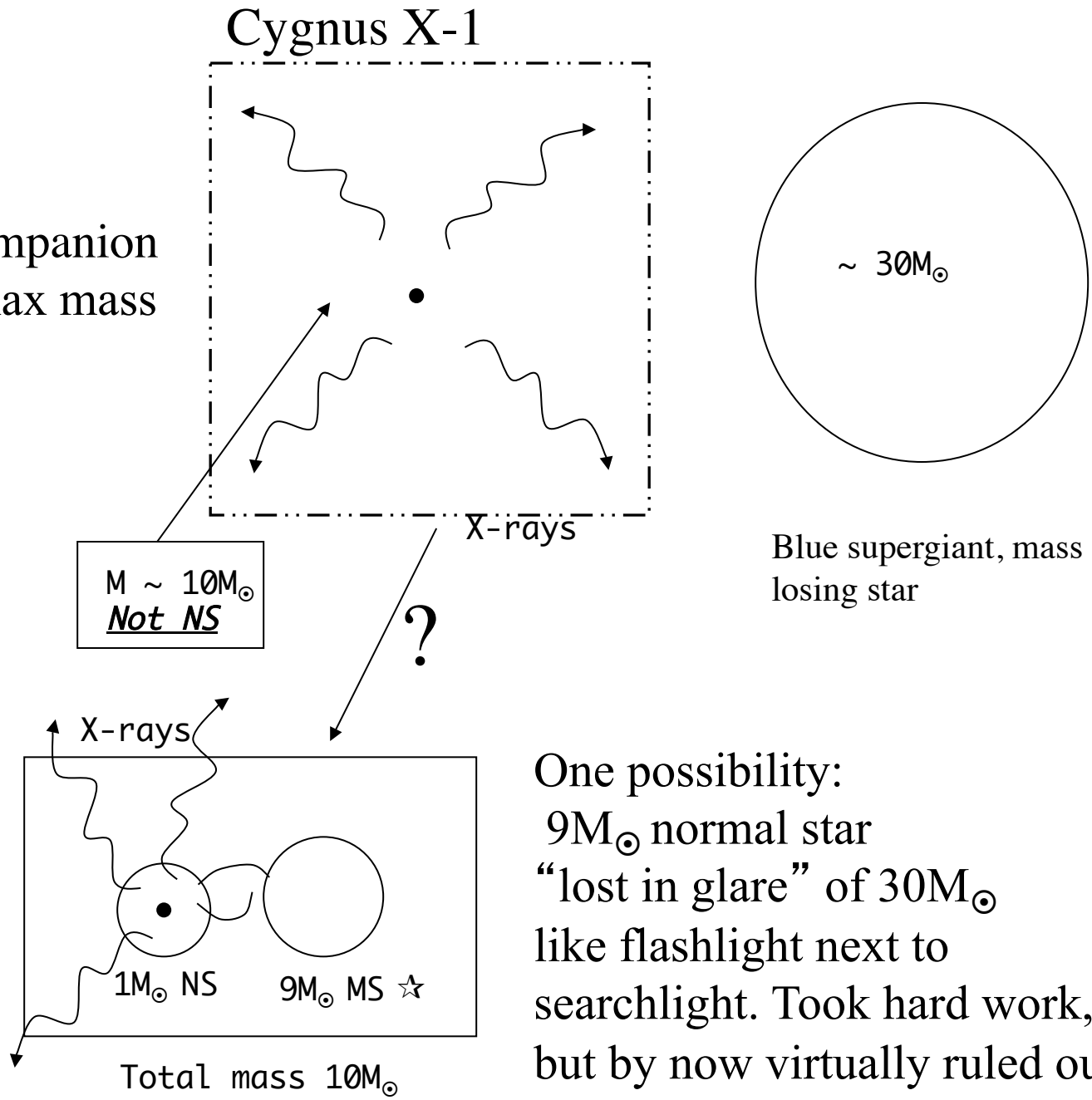
Discovered in 1970's by Uhuru Satellite (Swahili for Freedom).

First and still most famous stellar-mass binary black hole candidate.

Can't see this system with the naked eye, but can find constellation Cygnus - look for it for sky watch!

Optically dark
X-ray emitting companion
$\geq 10M_\odot$ >> NS max mass
$\Rightarrow$ BH

Could nature be tricking us? All we really know is that there is a $10M_\odot$ "thing" emitting X-rays



One possibility:
$9M_\odot$ normal star
"lost in glare" of $30M_\odot$
like flashlight next to searchlight. Took hard work, but by now virtually ruled out.

Expect only two or three systems like Cygnus X-1 in our Galaxy.

Bright, massive, short-lived companion

Maybe only one, and we found it!

Surprisingly, most binary black hole candidates have small mass main sequence companions, typically ~ 1/2 solar mass.

Observe ~45 such systems and guess there may be ~1000 in the Galaxy

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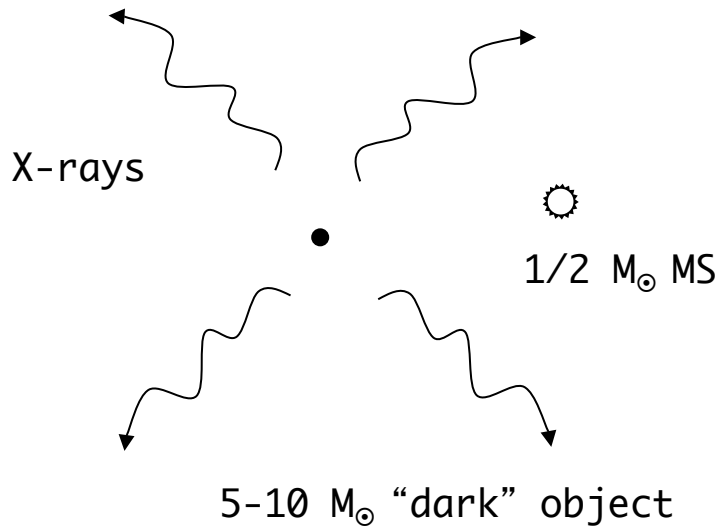


For systems with small mass companions cannot hide a 3rd star in the system

$\Rightarrow$ excellent black hole candidates.

Evidence still circumstantial but virtual proof of black hole

Not sure how these binary systems form.

Would have expected massive stars that can make black holes in core collapse to have massive companions, like Cygnus X-1.

Need to have black hole very close to small mass companion, current separation smaller than size of the star that made the black hole.

Possibilities:

Black hole progenitor swallows small mass companion while a red giant?

Companion forms from left-overs of collapse that formed the black hole?

Proving Black Holes

Astronomers search for ways to directly determine that the dark object producing X-rays is a black hole, not a neutron star.

How would you identify a black hole of 1 solar mass?

Evidence that in some circumstances black holes, but not neutron stars, can produce very hot, rarified inner accretion regions, making gamma-rays, but few X-rays.

This is evidence that the object has **no surface**.

Black hole candidates in the directions of Sagittarius, Ursa Majoris, Perseus, Scorpius, Ophiuchus, Vulpecula, Monoceros, Lupus, Cygnus (2) (Find and observe the constellations for sky watch)

Cygnus X-1

AO620-00 = Nova Mon 1975 = V616 Monocerotis - one of the first and best studied with a small mass companion, black hole about 5 solar masses.

V404 Cygni - somewhat evolved companion, but one of the best cases for a black hole with "dark" mass of about 12 solar masses.

Two candidates in the Large Magellanic Cloud:
LMC X-1, LMC X-3

Total number of such systems known, about 45.

Now, a whole new way!

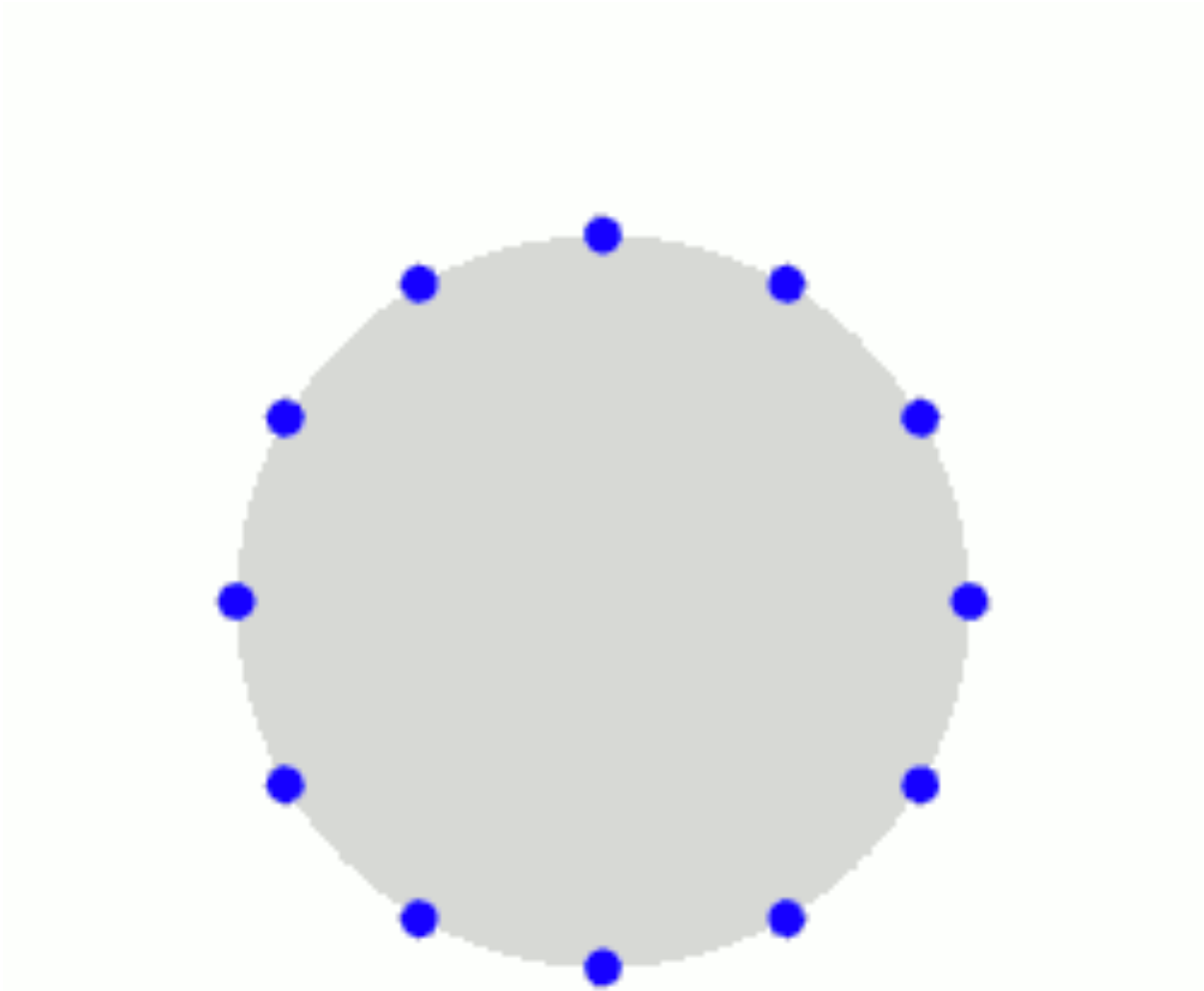
The LIGOrevolution
(**Laser Interferometer Gravitational-Wave Observatory**)

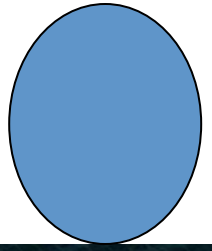
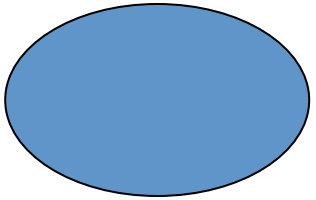
Livingston, La

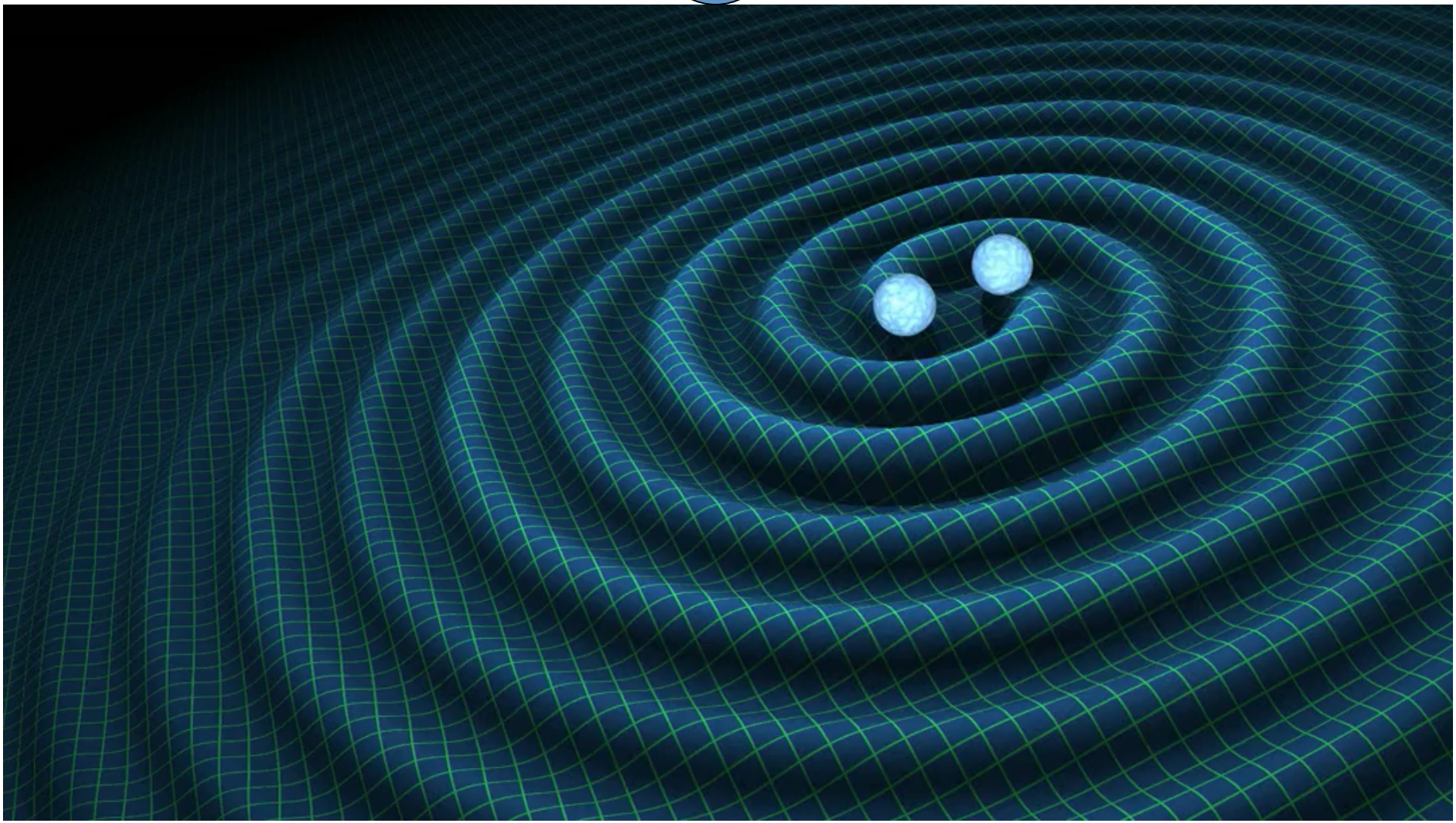
Hanford, WA

Gravitational waves from two inspiralling, merging black holes a billion light year's away.

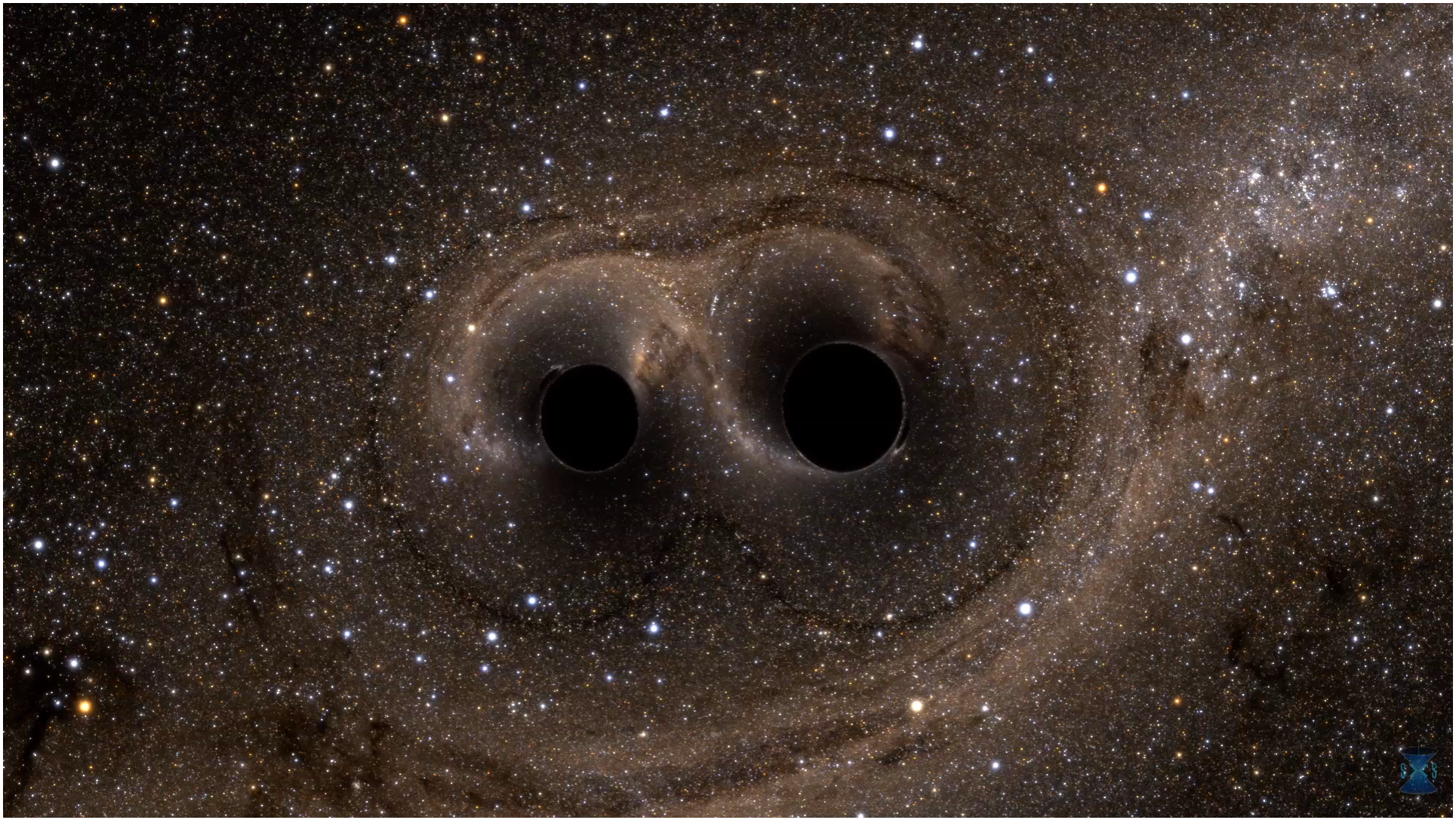
Affect of gravitational waves on a ring of particles



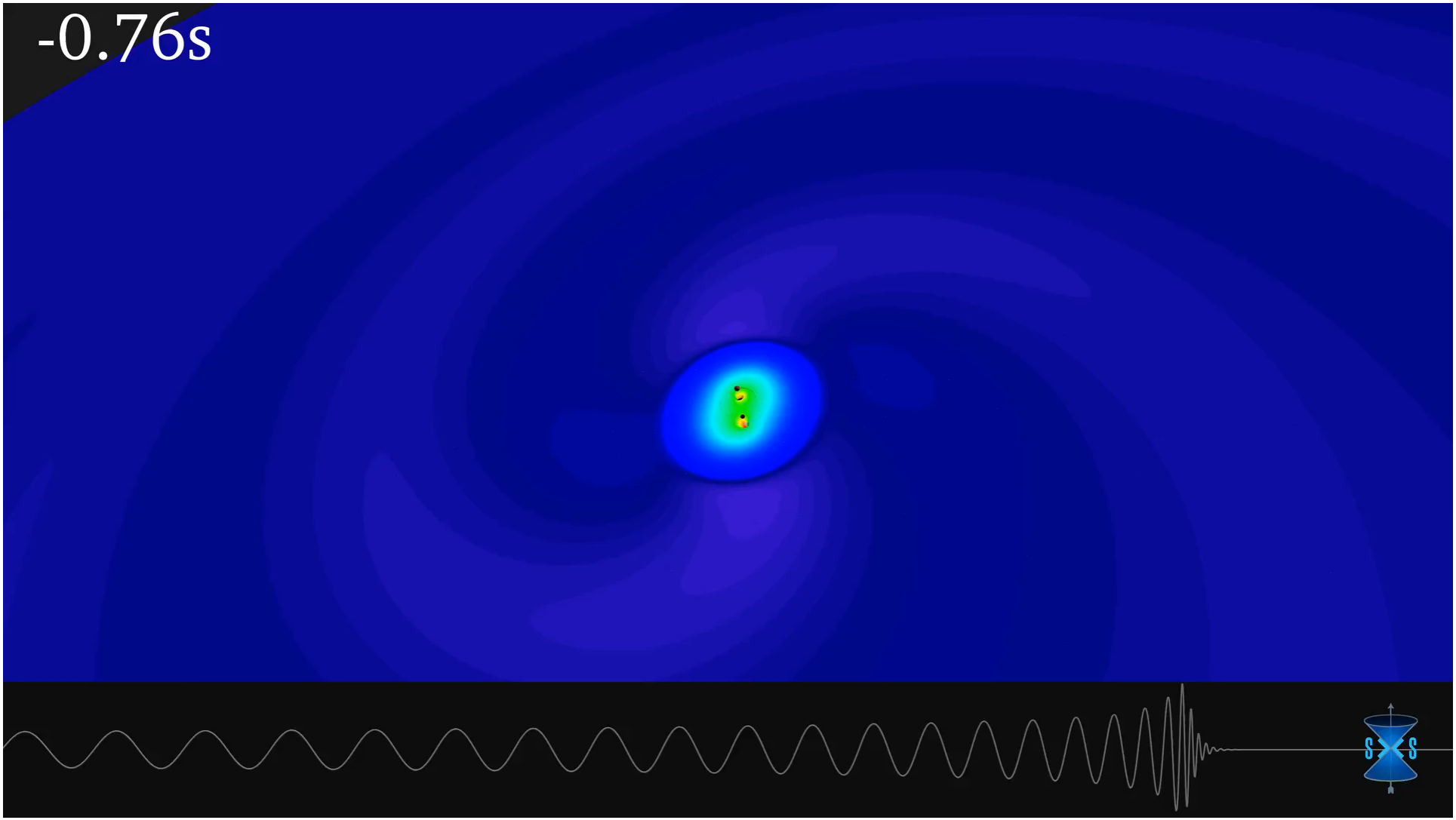
Peaks squish space like this  troughs like this 



Merging and ringdown of two black holes and their gravitational lens distortion of the star field behind them.

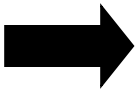


Inspiral and merging of two black holes and the corresponding behavior in an embedding diagram to show how the surrounding space itself is warped. Sound track of “chirp” is across the bottom.

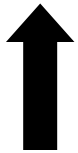


One Minute Exam

The best candidate for a binary star system with black hole is:


One with a 30 solar mass ordinary star companion


One with a 1/2 solar mass ordinary star companion


One with two black holes in orbit


Cygnus X-1