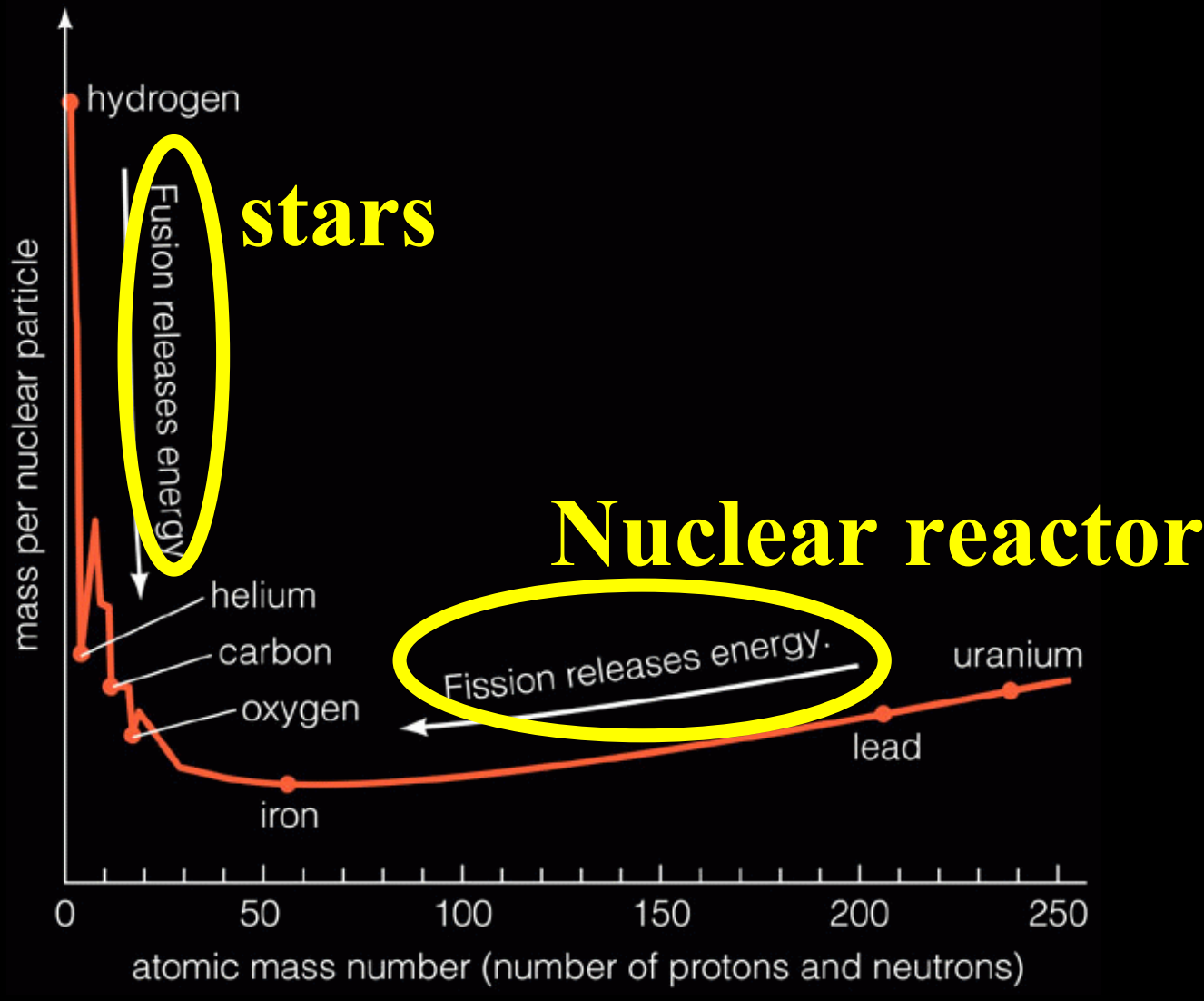
Nuclear energy



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TB | True-False Problem 4 | Difficulty: **2** | Time: **<1m**

True-False Problem 4

Description: (a) Nuclear power plants on Earth create energy in the same way as the Sun.

Part A

Nuclear power plants on Earth create energy in the same way as the Sun.

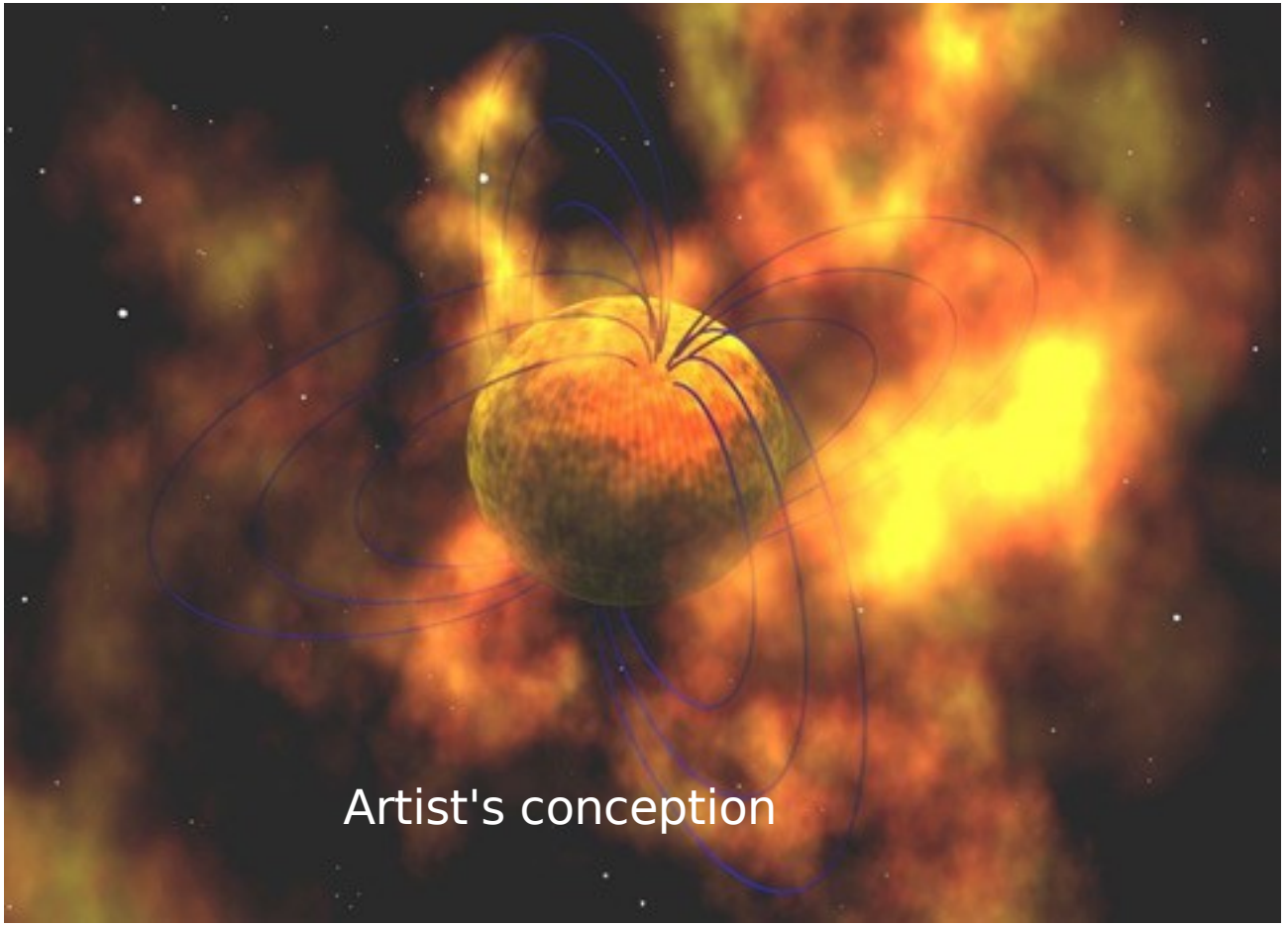
ANSWER:

- ○ True
- ◉ False

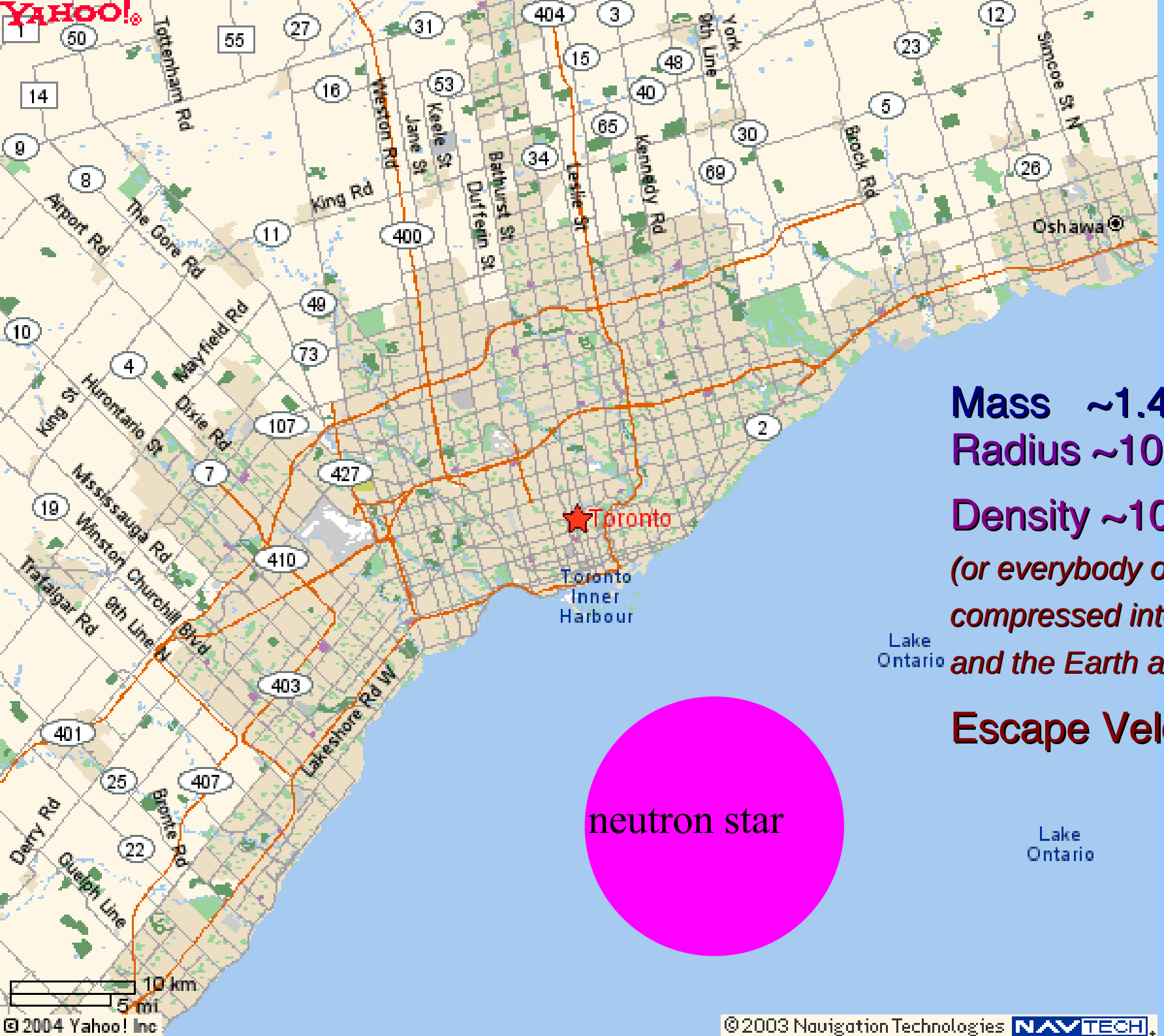
Answer Stats:	Students	% Correct	% Unfinished	% Req'd Solution	Wrong/student	Hints/student
Overall	168	90.5%	9.5%	0%	0.3	0
SCI199UOFT	44	100%	0%	0%	0.4	0

Wrong Answers for SCI199UOFT		
% Wrong	Answer	Response
100%	True	

In many cases, the star that goes supernova leaves behind its core ---------- a neutron star.



A neutron star is extremely compact. Even electrons are squeezed into the nuclei to make neutrons. Neutrons resist further collapse by 'degeneracy pressure'.


Mass ~1.4 $M_\odot$
Radius ~10 km
Density ~10^{15} g/cm^3
(or everybody on Earth compressed into a sugar cube, and the Earth a 10-m ball)
Escape Velocity ~½c
neutron star
Toronto
Toronto Inner Harbour
Lake Ontario
Lake Ontario
Oshawa
10 km
5 mi
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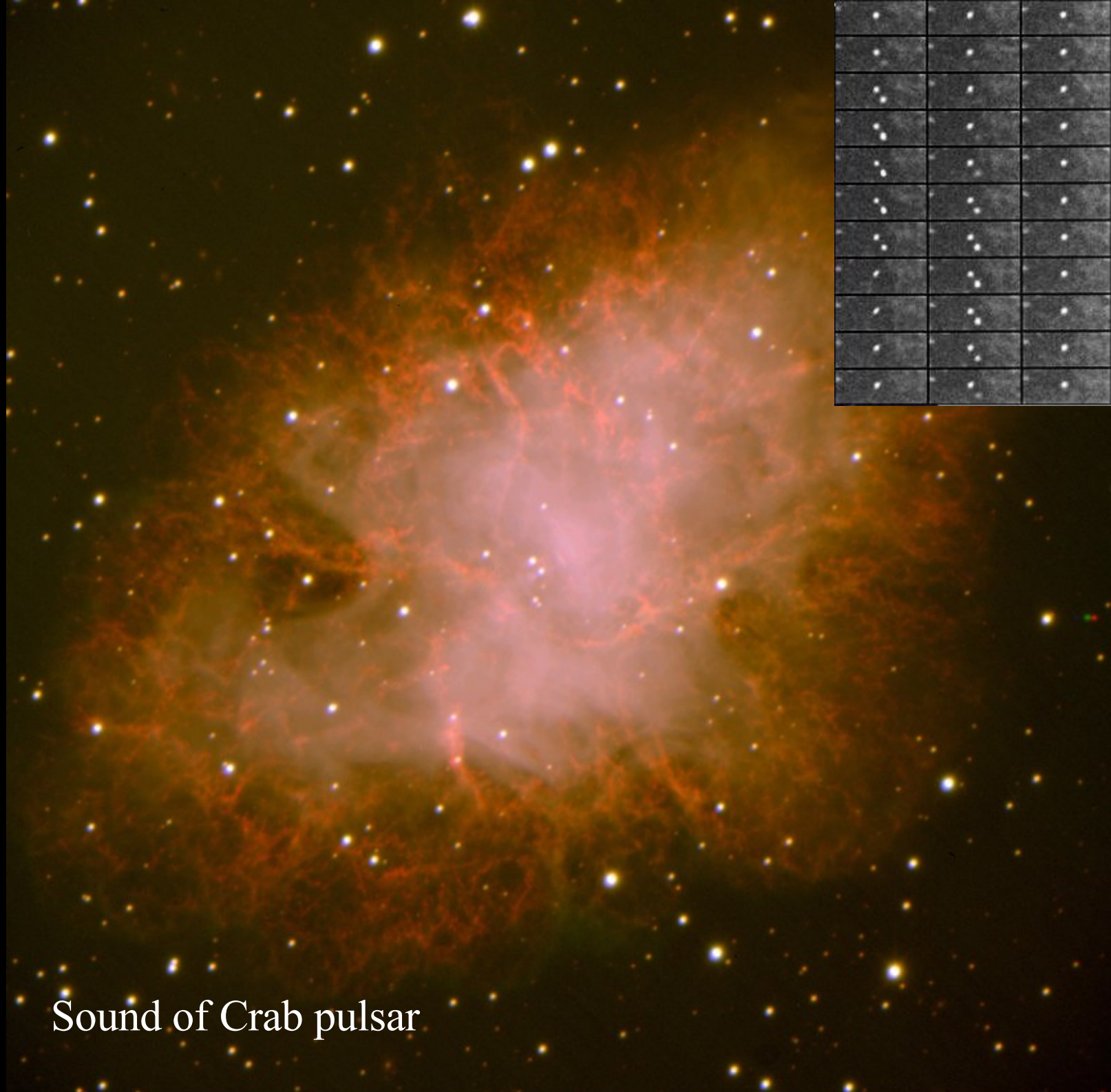
Crab



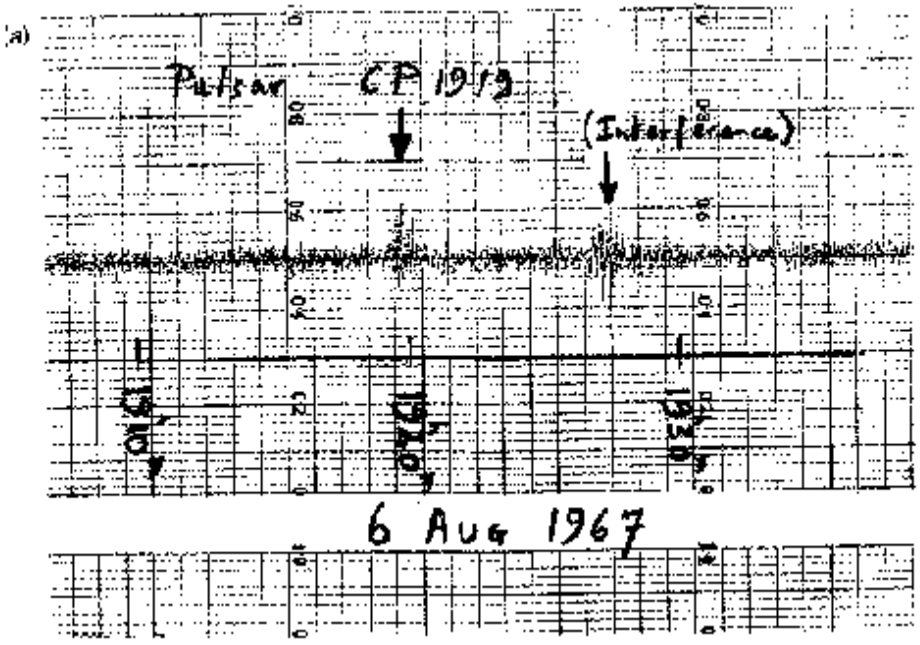
Sound of Crab pulsar

A few thousand pulsars have now been discovered

(compared to 100 billion white dwarfs...
higher mass stars are born more rarely)

The first one: 1967, Ms. Jocelyn Bell Burnell, Prof. Antony Hewish

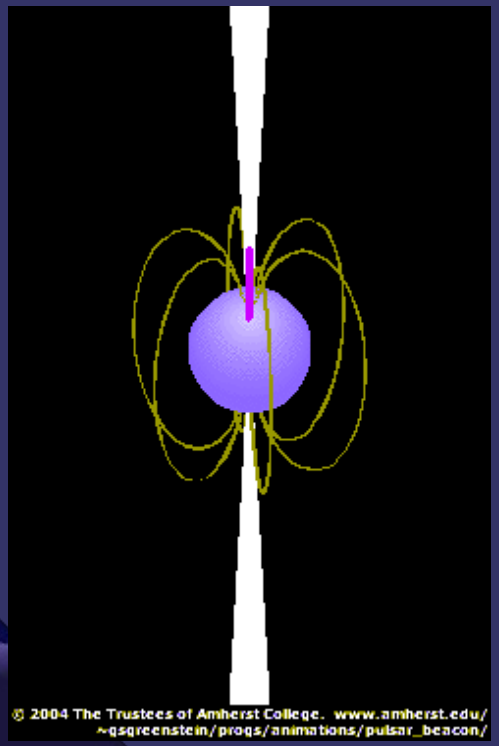
little green man?

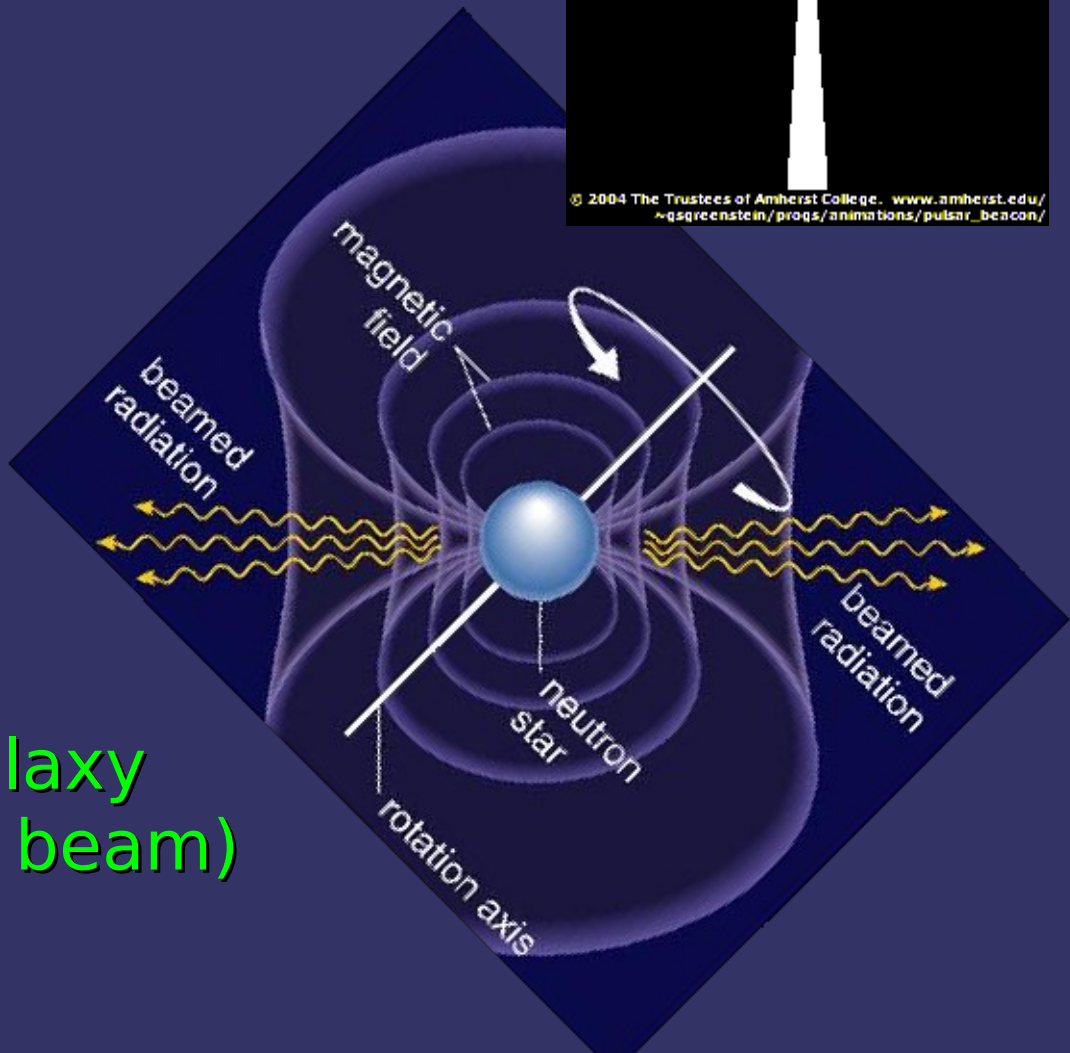


Nobel prize in Physics awarded: 1974, Prof. Hewish

A neutron star is extremely dim.
But they are also cosmic lighthouses.

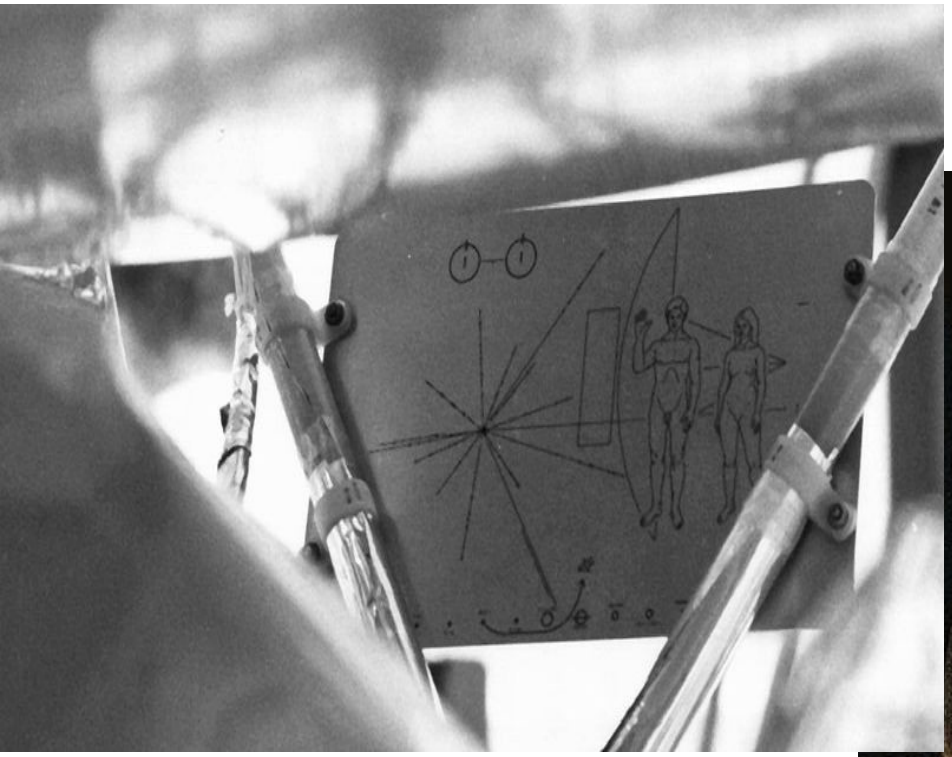
strong magnetic fields + fast spin
= coherent, intense radio beams
-- pulsar



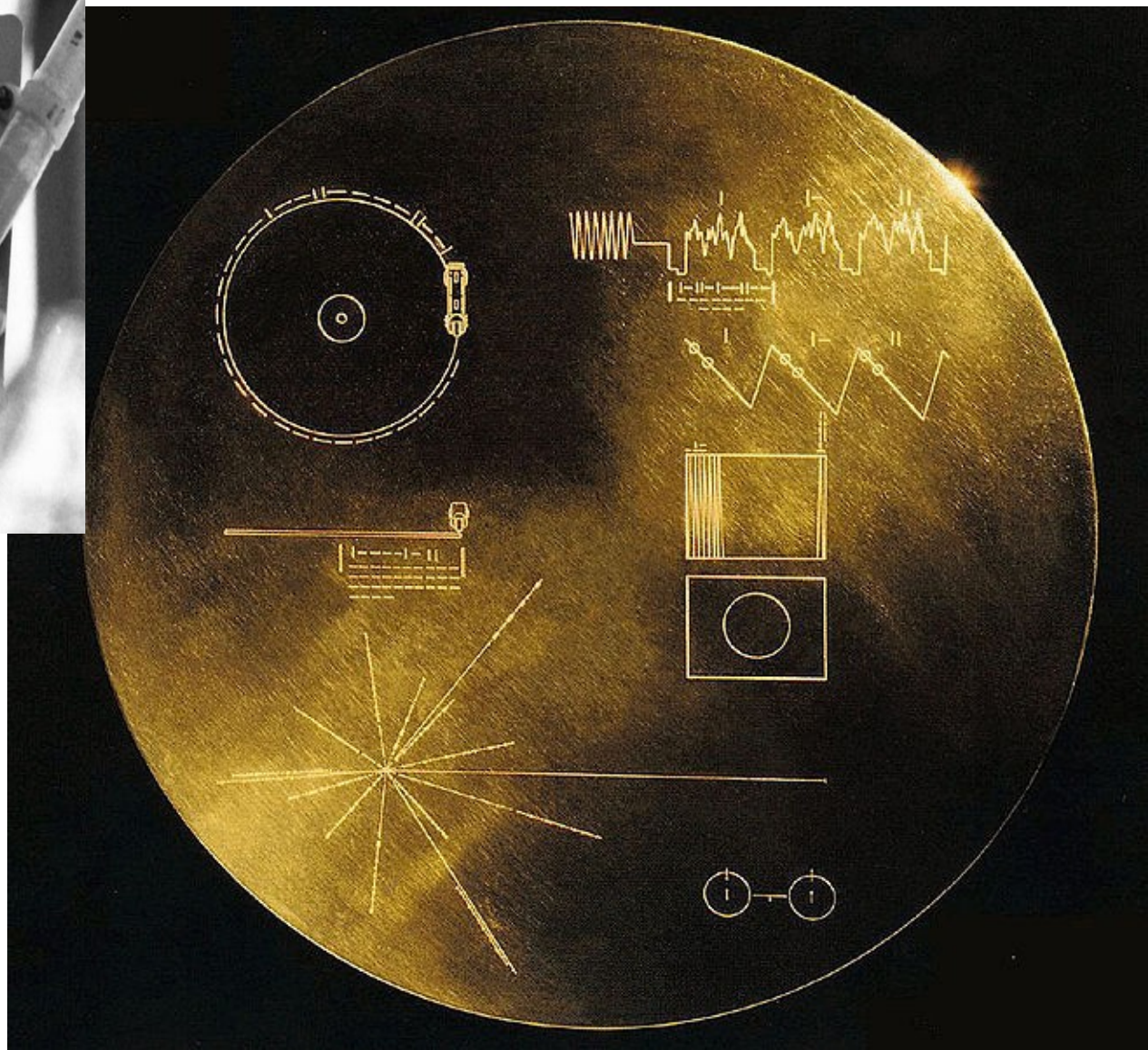


Visible in only part of the galaxy
(ones that sit along its beam)

How do we communicate to aliens our location in the Galaxy?



"The Message Plaque"
pioneer 10/11 (1972)



"The Golden Record"
Voyager I/II (1977)

SN 1987A

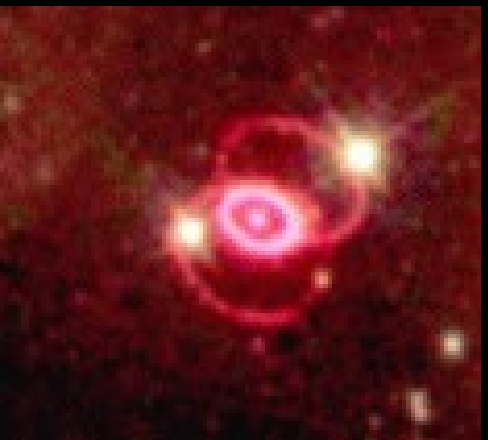

1994


1997


2000


2003

What's left behind by SN1987A?



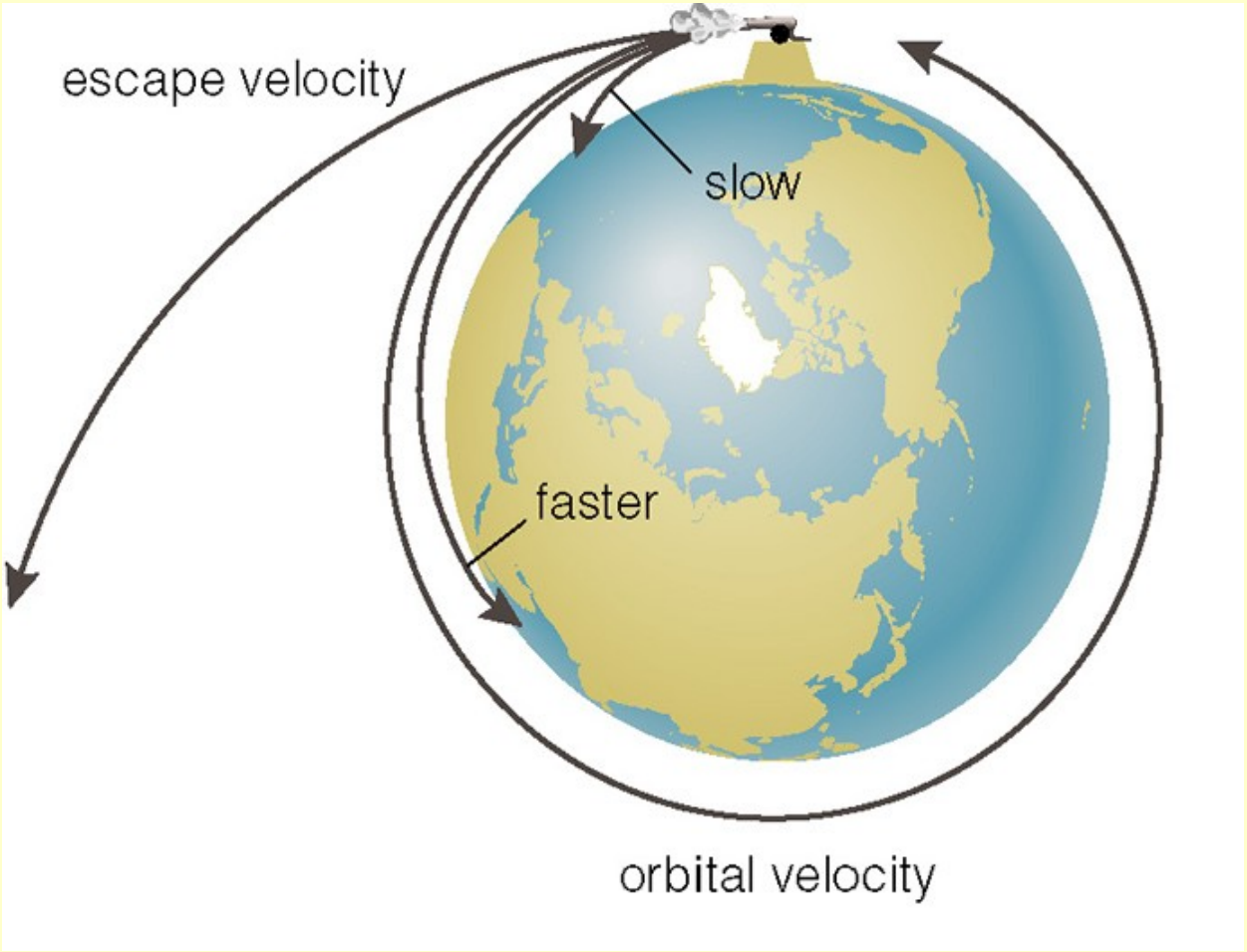
Likely a BLACK HOLE.

Some supernova events, however, leave behind a

black hole

an object that even light cannot escape.

(Escape velocity > speed of light c)



escape velocity:

on Earth: 11.2 km/s

on the Moon: 2.3 km/s

Comet Halley: 2 m/s

...

a black hole: 300,000km/s

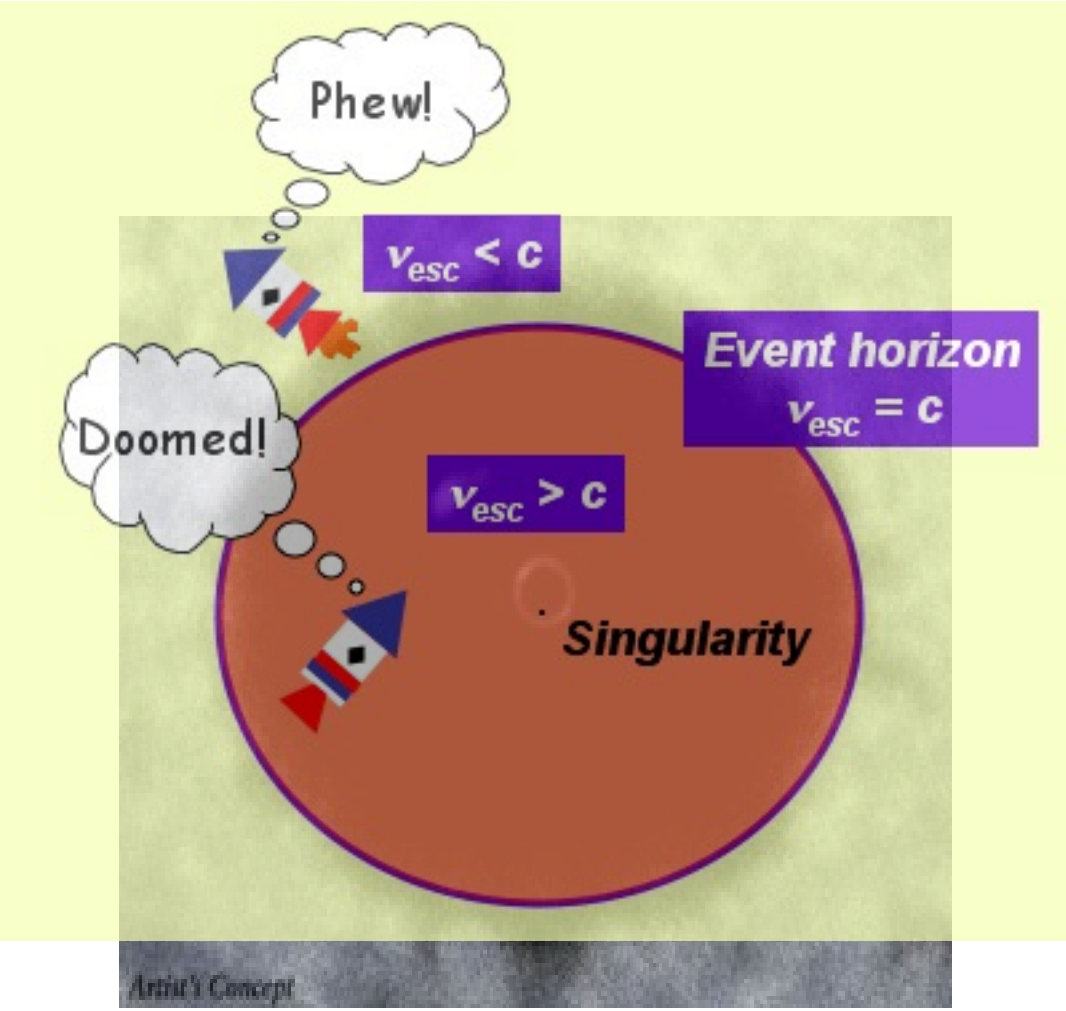
black holes are some of the most bizarre objects in the universe.

1) How big is a black hole?

The actual size of a black hole ---

In practice, we define a black hole 'size' as the point of no-return

'event-horizon'



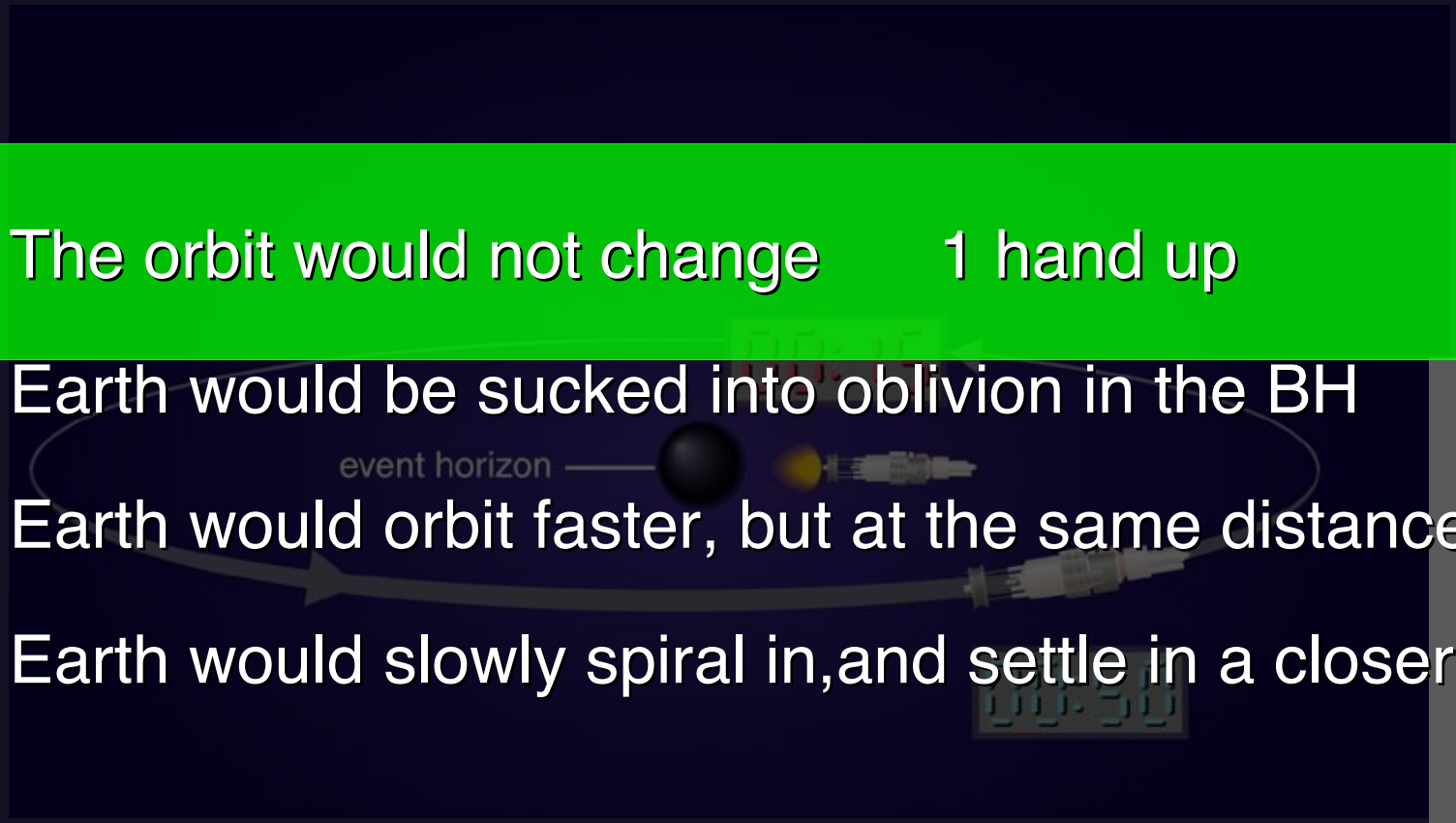
Morbid Quiz: Imagine the Sun were replaced with a one solar-mass black hole. What would happen to Earth in its orbit?

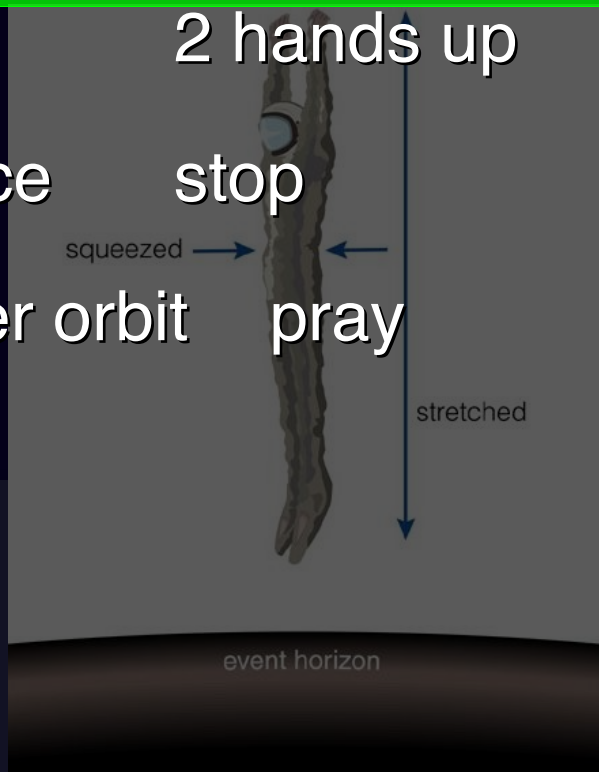
The orbit would not change — 1 hand up

Earth would be sucked into oblivion in the BH — 2 hands up

Earth would orbit faster, but at the same distance — stop

Earth would slowly spiral in,and settle in a closer orbit — pray





2) Does a black hole have to be very massive?

No. There could (in principle) be black holes as light as a bacteria, or as massive as a galaxy.

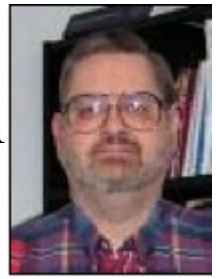
Astronomically, we have not seen anything lower than a few solar masses, and anything higher than a billion solar masses.

This says something about how these black holes were formed...

Center of each galaxy may have one massive black hole.

First Evidence for a Black Hole: Cygnus X-1 (1971)

Prof. Tom Bolton



Doppler Shifts of the B star compar

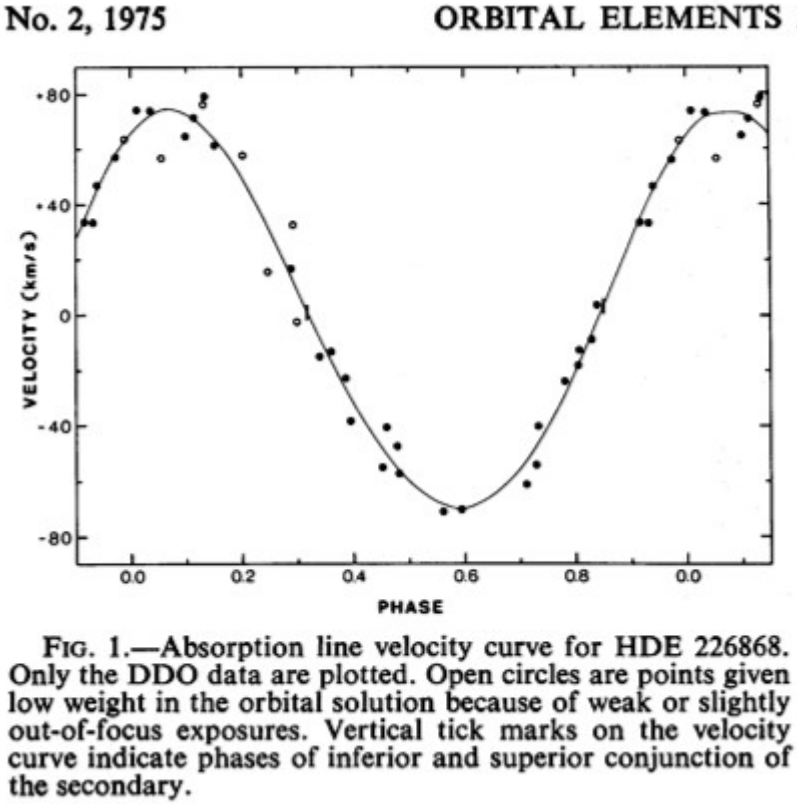
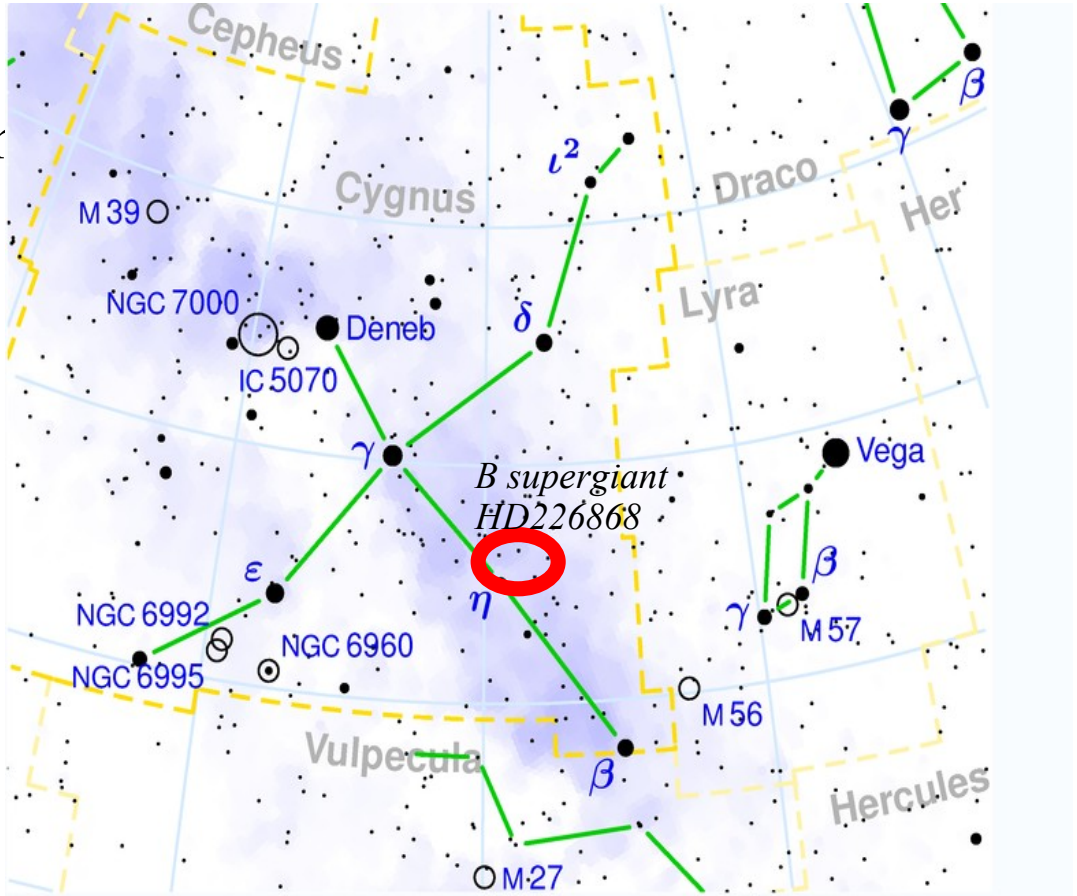


FIG. 1.—Absorption line velocity curve for HDE 226868. Only the DDO data are plotted. Open circles are points given low weight in the orbital solution because of weak or slightly out-of-focus exposures. Vertical tick marks on the velocity curve indicate phases of inferior and superior conjunction of the secondary.



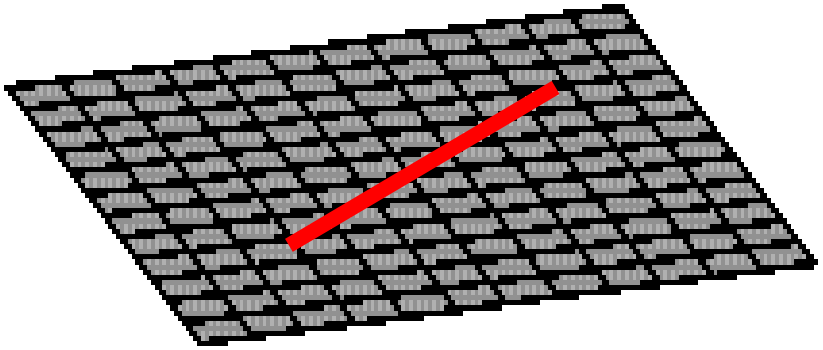
Steven Hawking Lost the Bet!

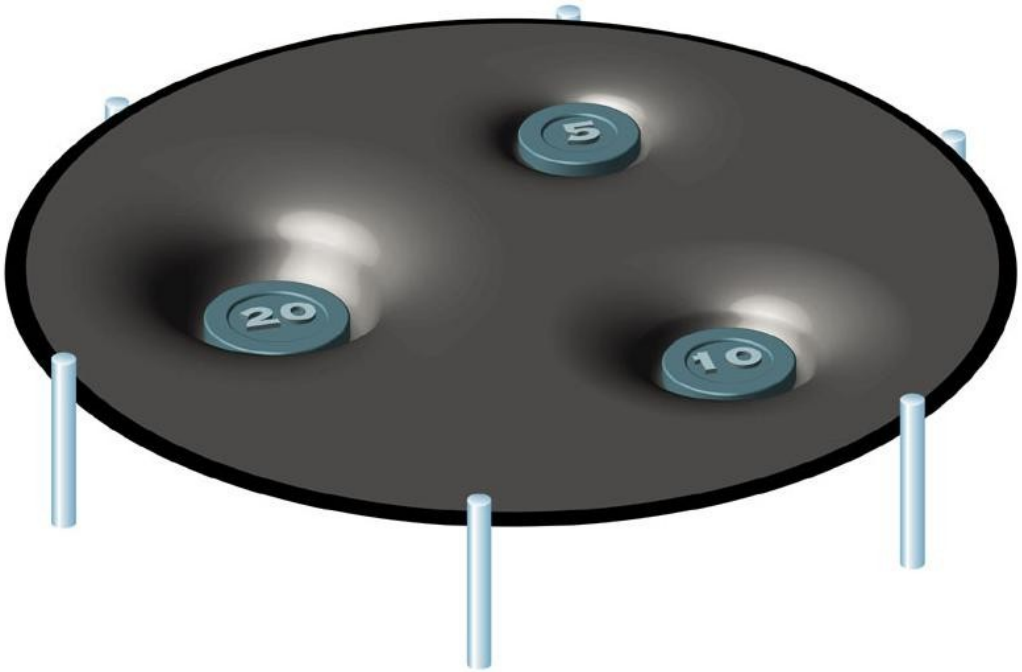
3) Space-time distortion by a black hole (actually, any mass)

space around us is mostly flat. The shortest path

(also one that taken by photons)

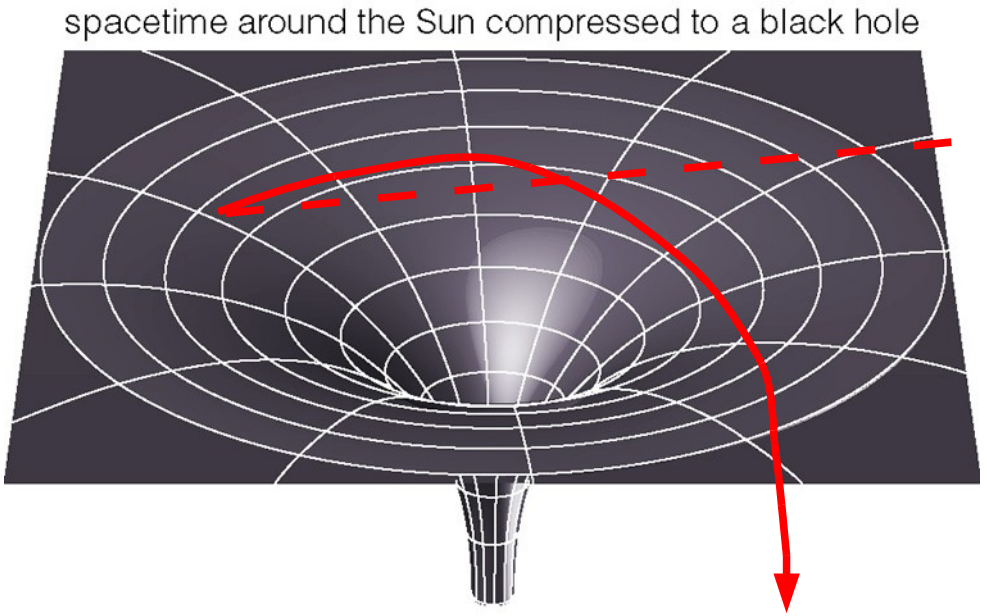
from A to B is by drawing a straight line between the two.





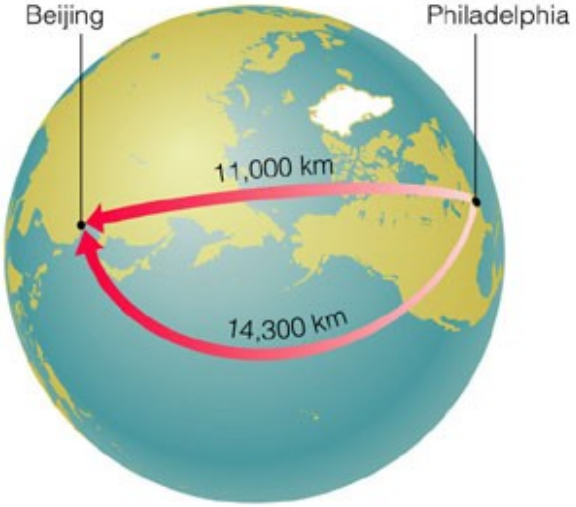
However, presence of
a massive body distorts
the space around it.
Such that the shortest path
is no longer a simple
straight line.

What does this mean? 'light bending'



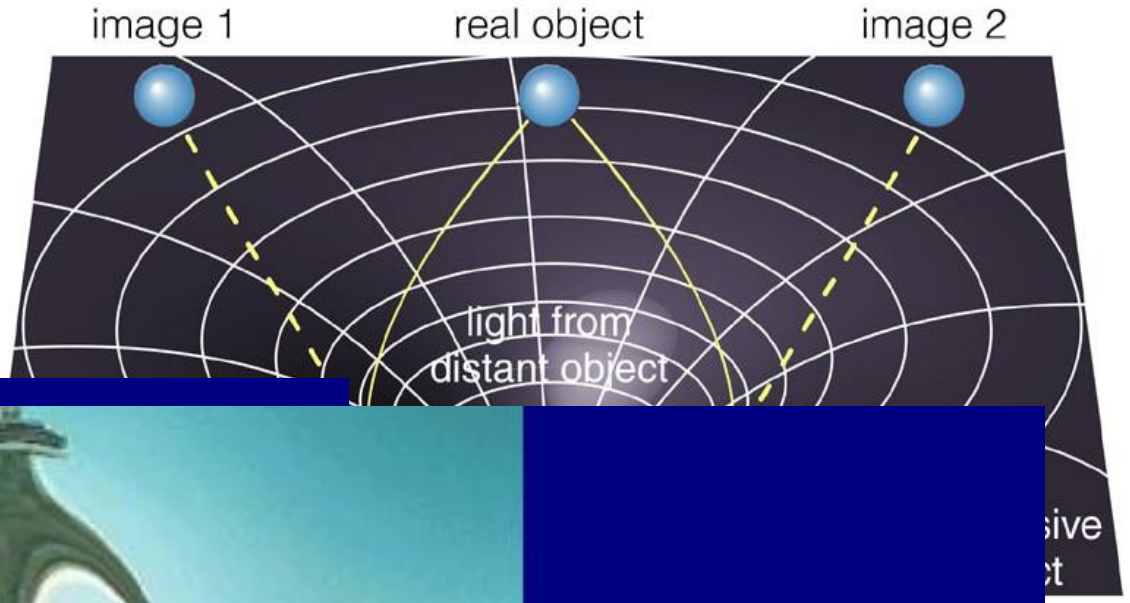
This is NOT a straight line

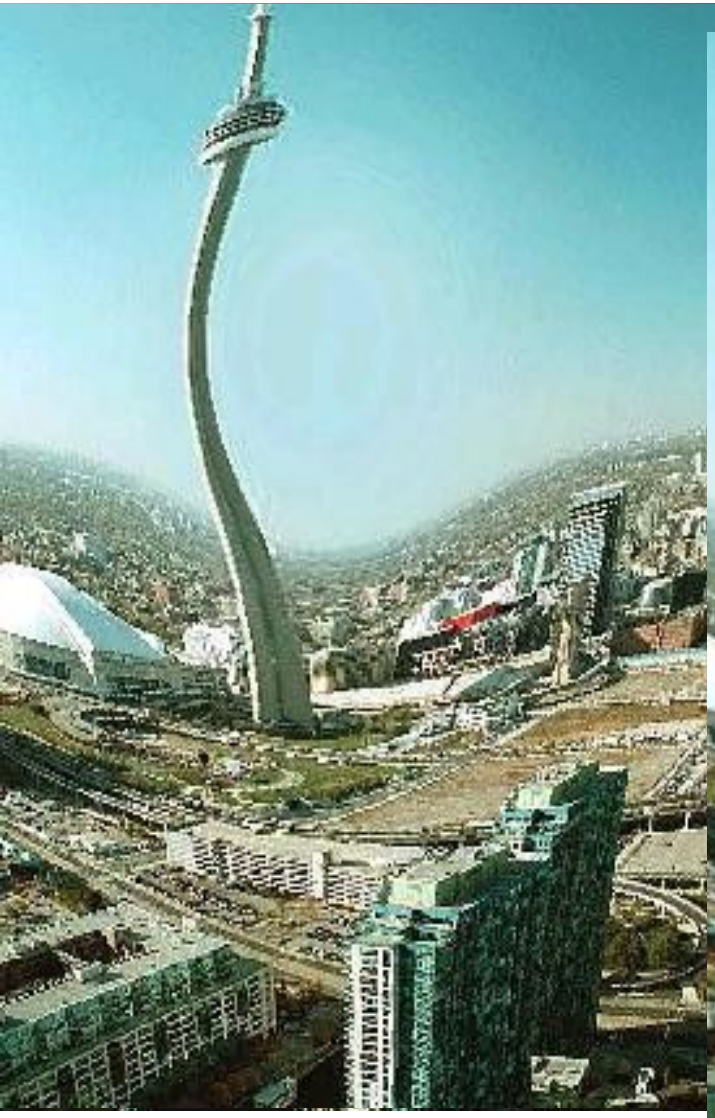
This is a straight line = shortest distance between two points, like the great circle on a sphere.

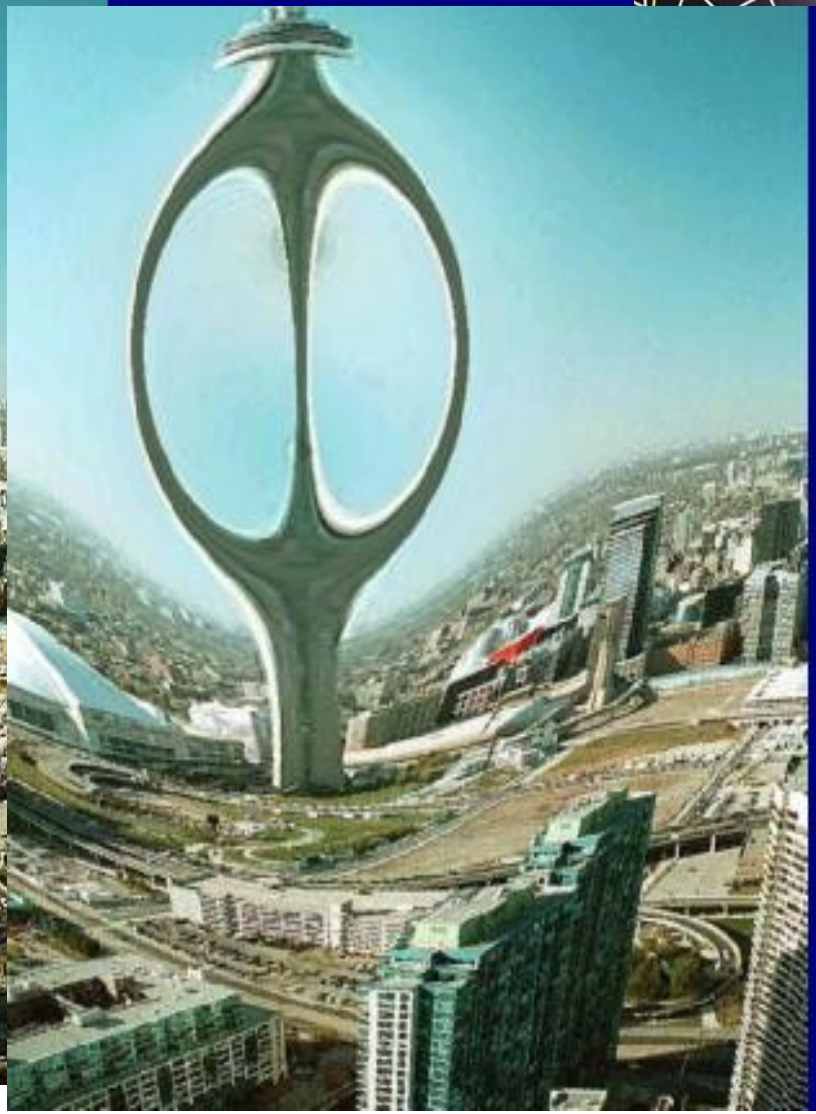


Light bending

watch a blackhole moving...

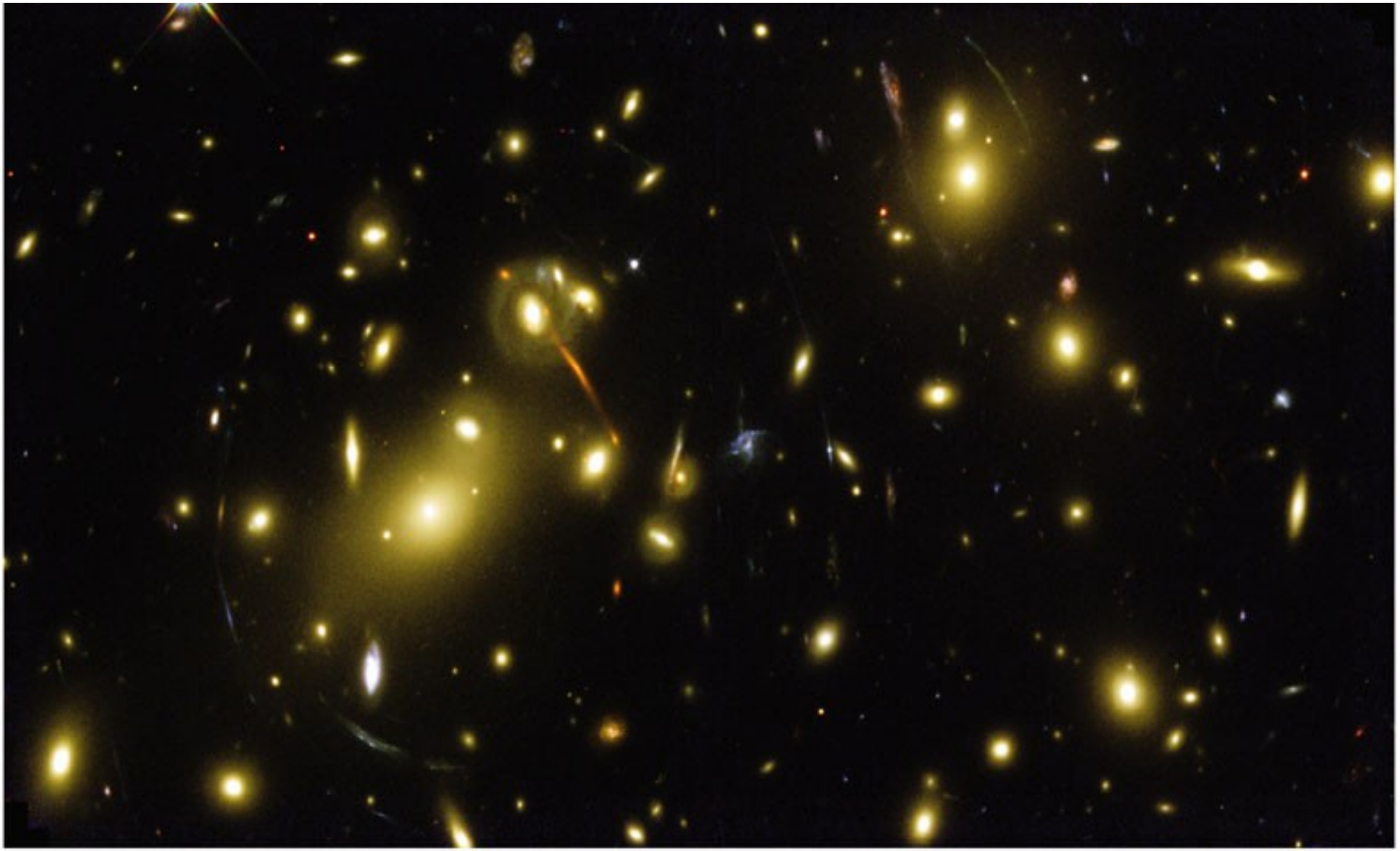






Strongly Lensed
CN Tower
(distortion and
multiple images)

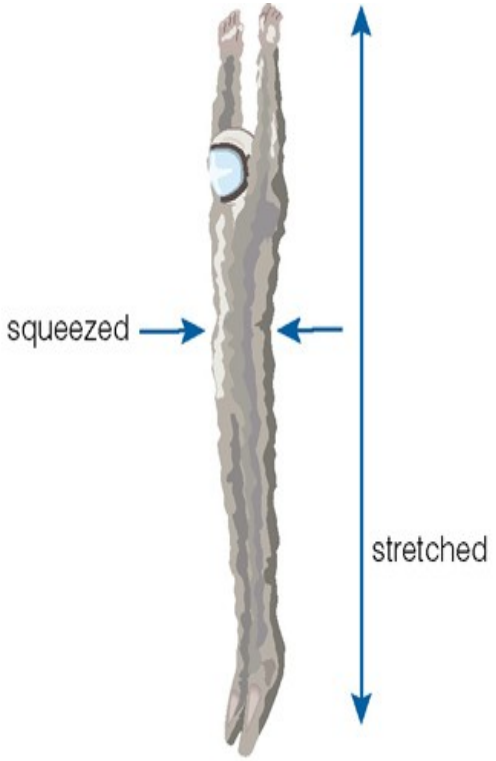
You see it in front of our eyes...



Gravitational lensing by a cluster of galaxies

4) gravitational time-dilation

Watch someone falling into a black hole...



1) Gravitational acceleration
on foot >> on head,
strong tidal stretching of the body

2) Let him carry a Morse code machine
as he is falling

... --- ...

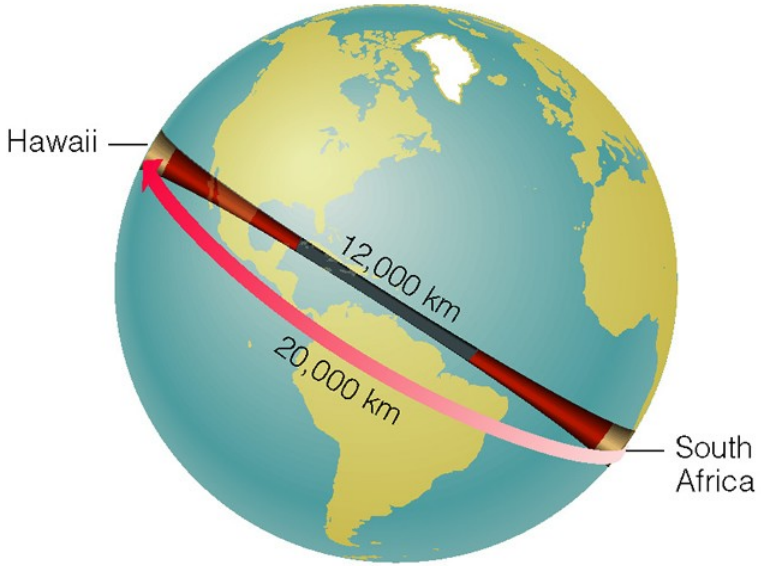
. . . - - - . . .

. . . -- -- -- . . .

. . . --- --- --- .

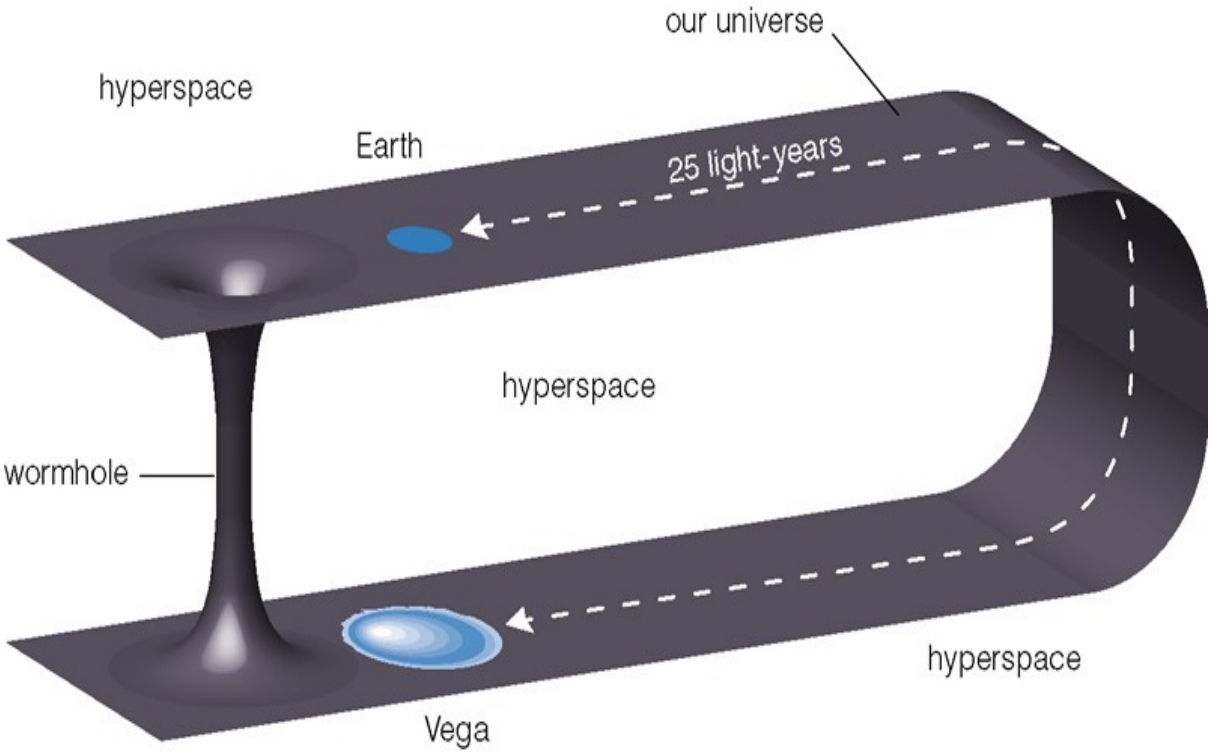
This is because photons are having a harder and harder time to climb out of the potential well...
he also appears redder and redder... and seems freeze...

5) So what are black holes good for?

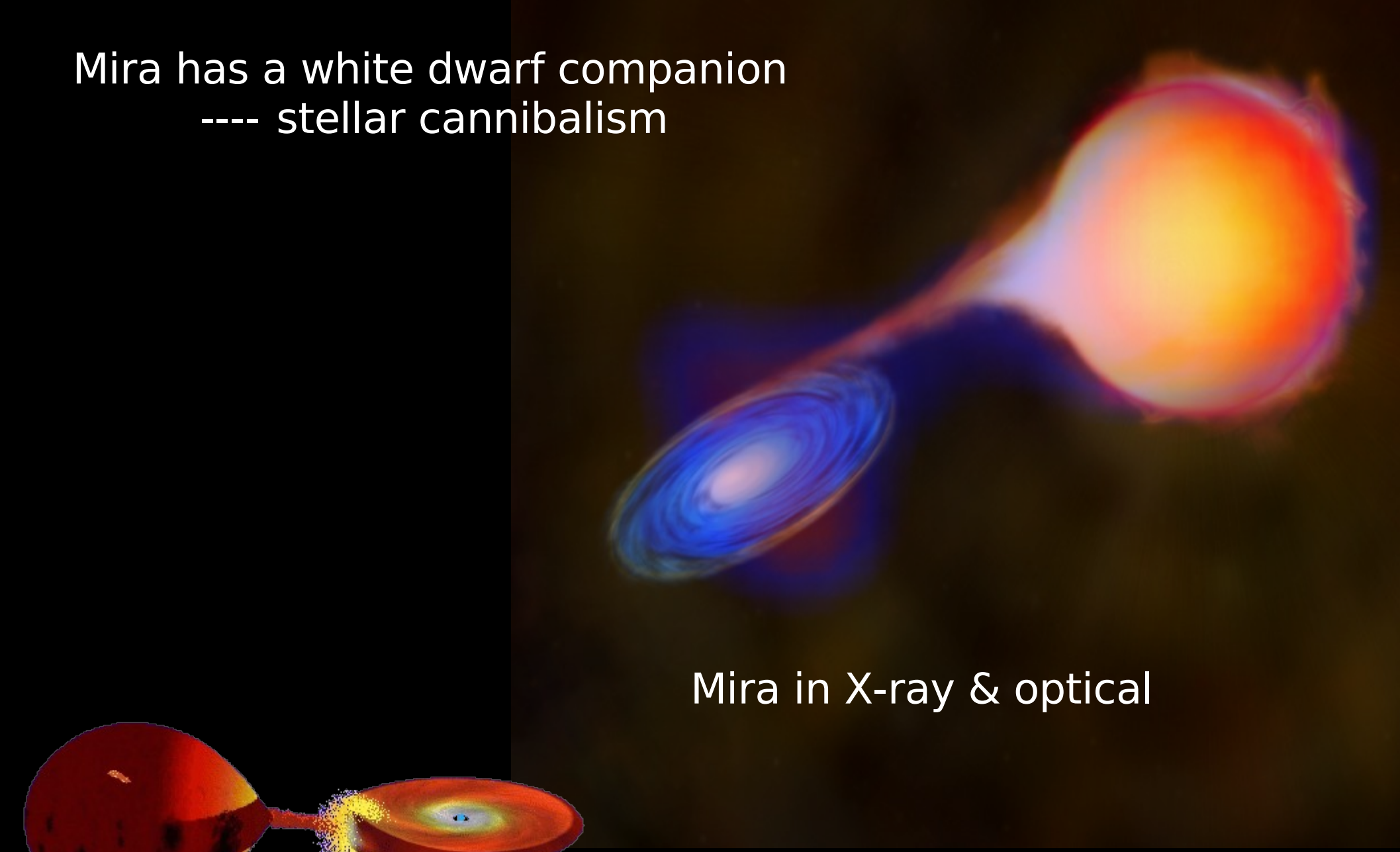


It's have conjectured that black holes may be useful for interstellar travel, to overcome the immense distance

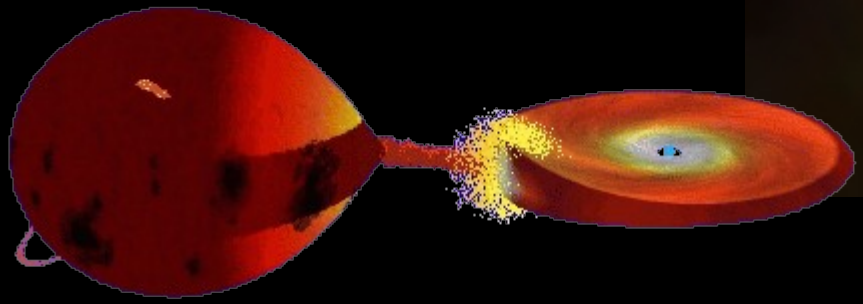
-- wormholes?



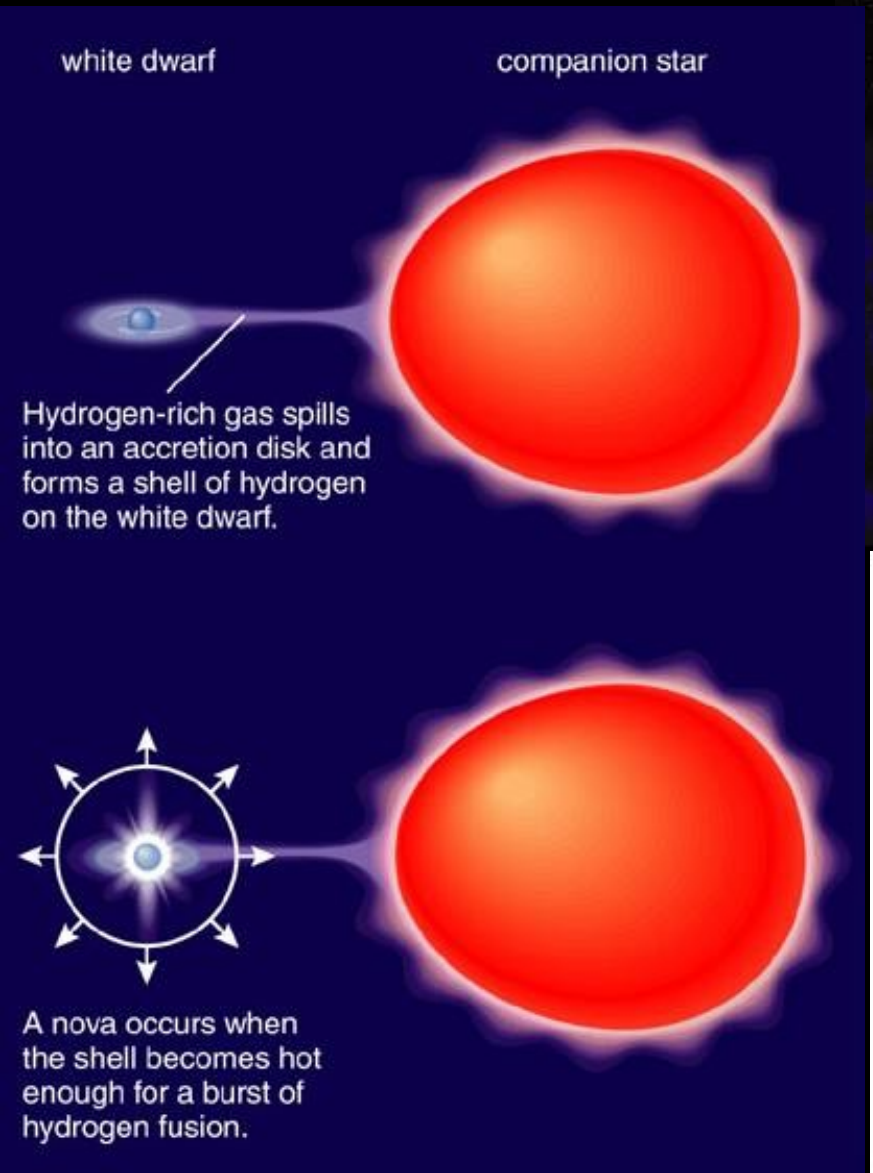
Mira has a white dwarf companion
---- stellar cannibalism

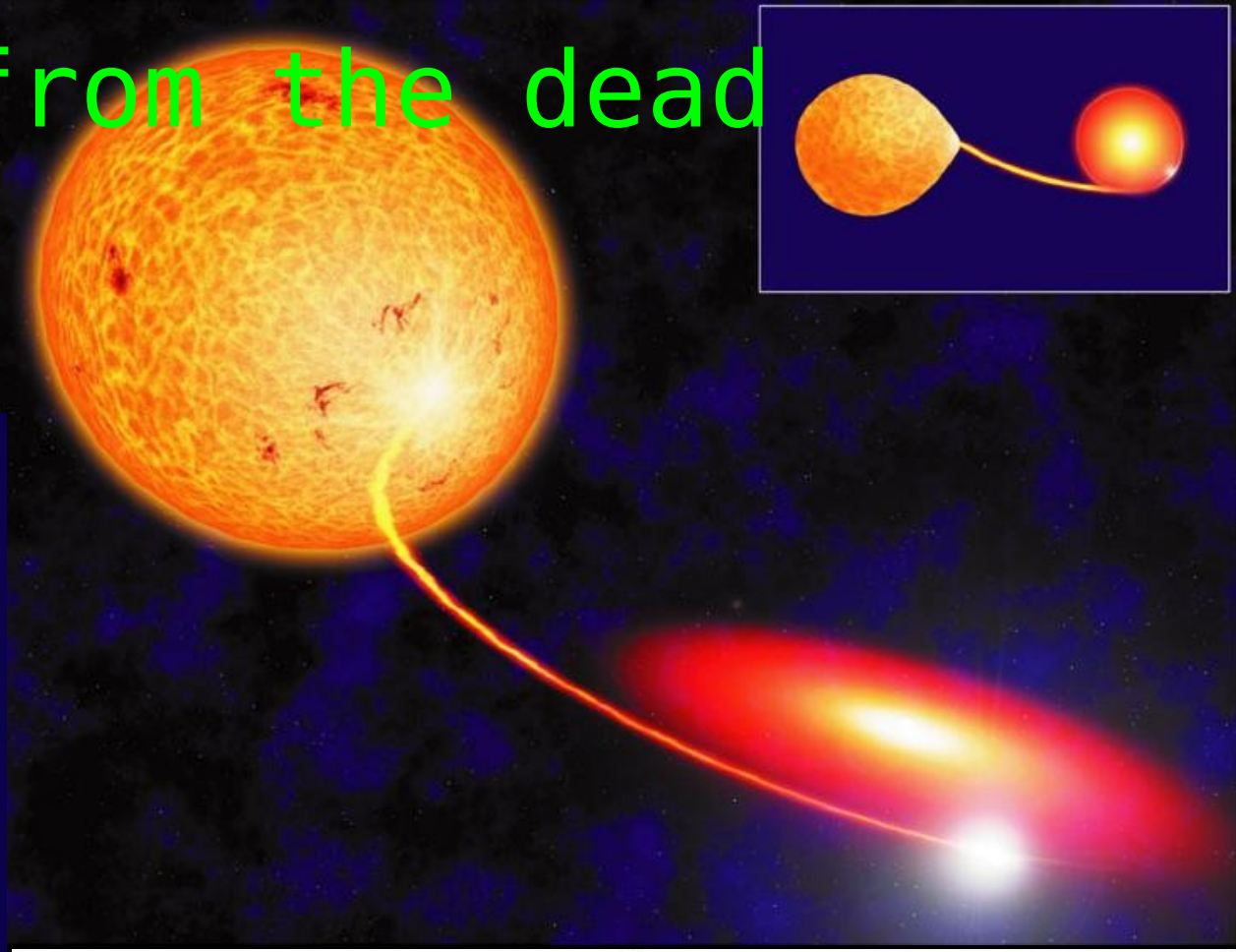


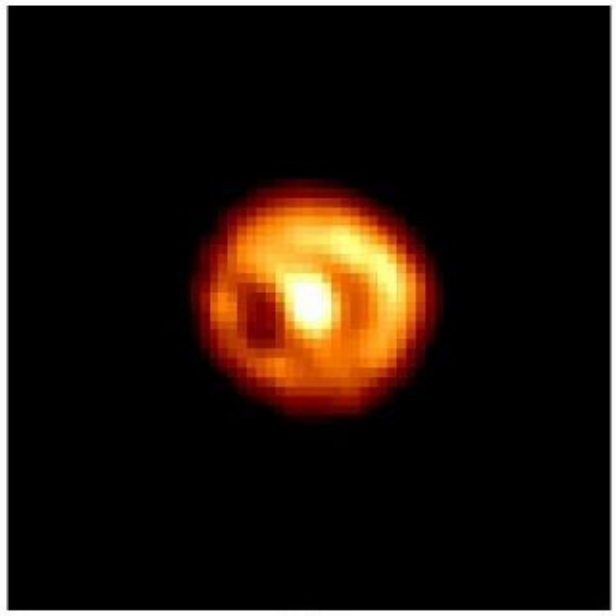
Mira in X-ray & optical

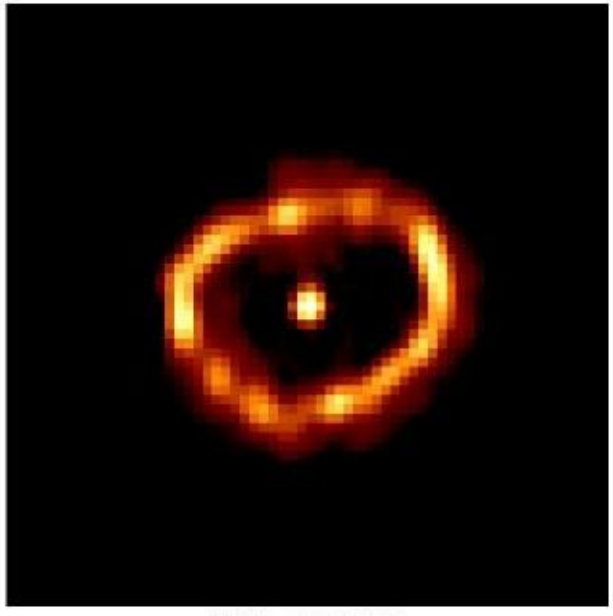


Novae: rise from the dead

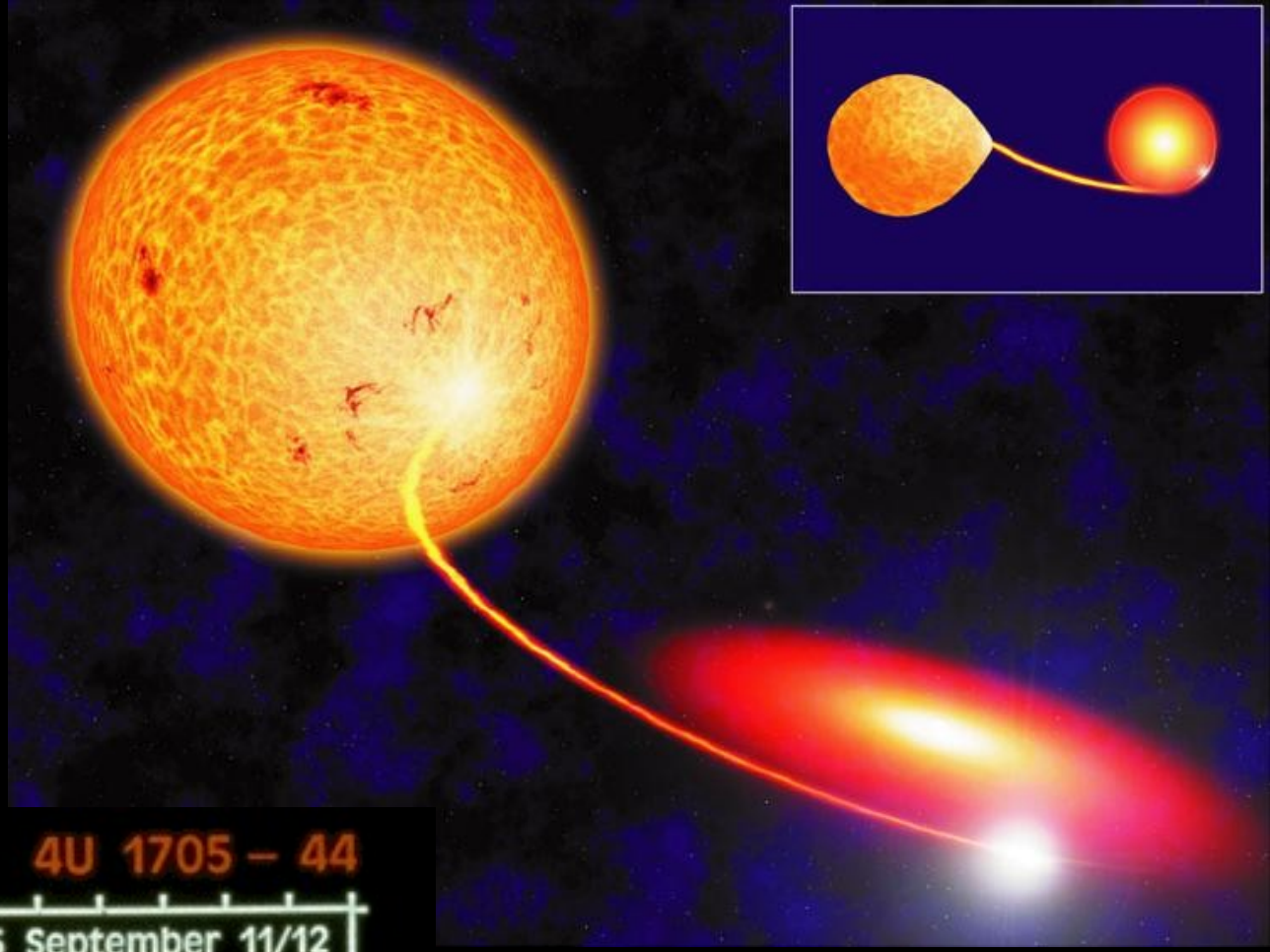


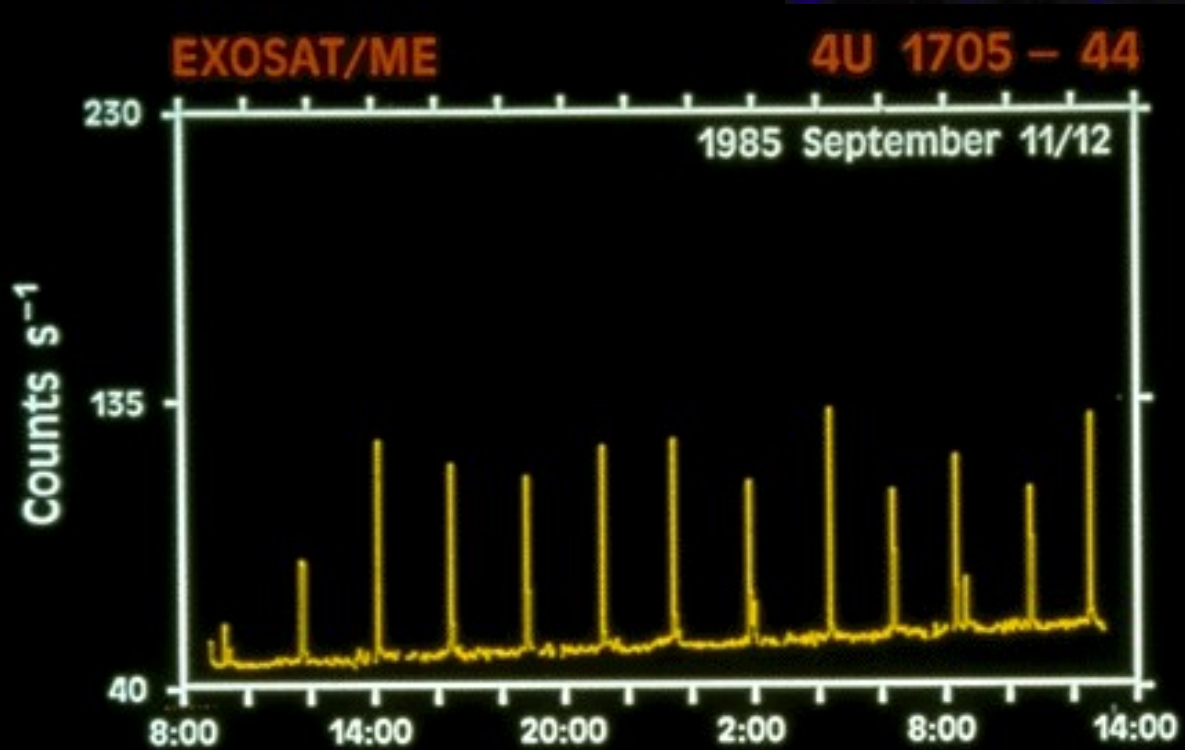






X-ray binaries





Instant Quiz: We do not see pulses from the neutron star RX J1856.5-3754. Could other civilisations see pulses?

RX J1856.5-3754

No, no pulses implies nomagnetic field	1 hand up
No, no pulses implies no radio emission	2 hands up
Possibly, they may see a radio beam that misses us	stop
No, the beam must be aligned with the rotation axis	pray