

Mass transfer binaries

- every star more massive than $8 M_{\text{sun}}$ expected to form a neutron star or black hole
- ~100 million in the Milky Way
- only *tens* of black hole candidates known (1000s of neutron stars as pulsars)
- need rare evolution of binary stars to form *observable* black holes

Binary stars

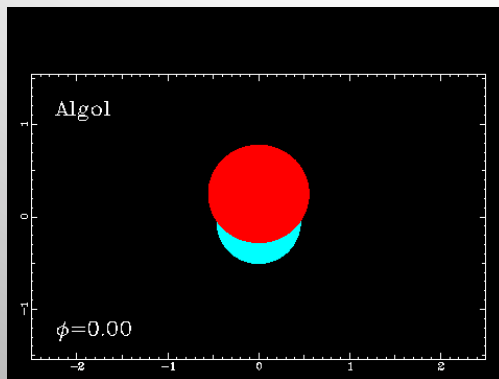
Most stars in the Solar neighborhood are part of binaries (2/3)

Separations range from almost touching “contact binaries” to thousands of times Earth-Sun distance

Majority are far enough apart that the stars evolve independently

Binary paradoxes

Some observed binaries have properties that are hard to understand in terms of the known evolution of single stars

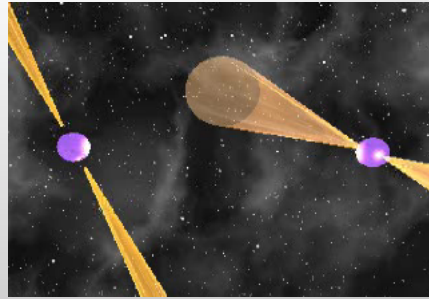


Algol

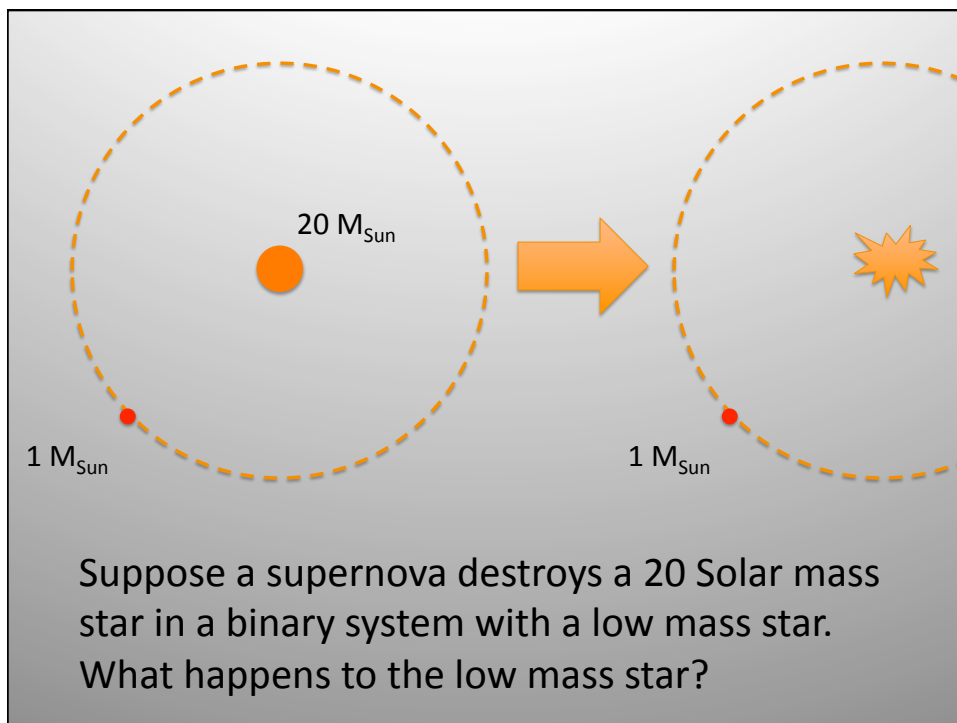
Massive blue star on the main sequence (fusing hydrogen in its core)
...in orbit with a less massive red star that is on its way to becoming a red giant

PSR J0737-3039

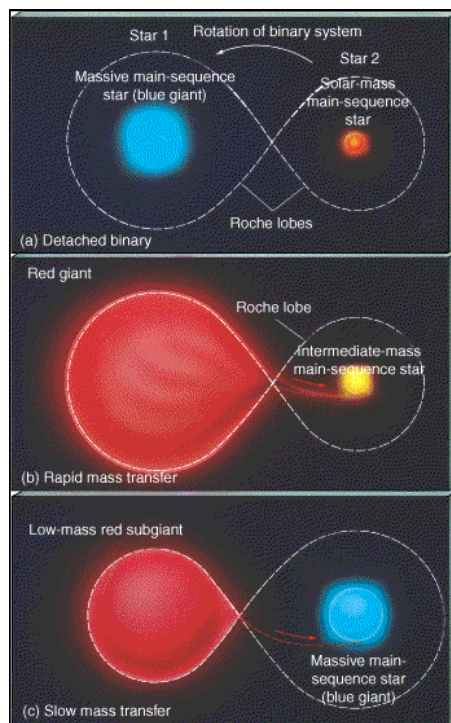
Binary pulsar in which
both neutron stars
are radio pulsars



Orbital period of 2.4 hours
Will merge from gravitational radiation in
85 million years



Resolution: stars in binary are (were) close enough together that mass can be exchanged between them as they evolve: no longer evolve as two isolated objects



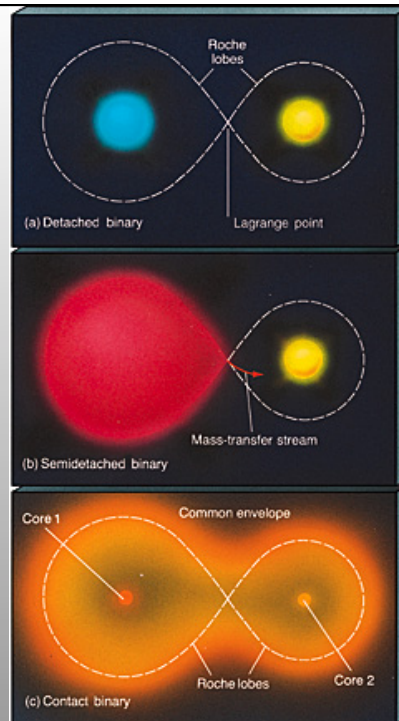
Algol: initially more massive star evolves faster

Swells to become a giant, transfers mass to companion

Now see a low mass giant with a more massive companion still on main sequence

If *both* stars swell up enough, the cores orbit with a mutual “common envelope”

Separation of the cores (one of which could be a neutron star) shrink as they interact with the gas in the envelope

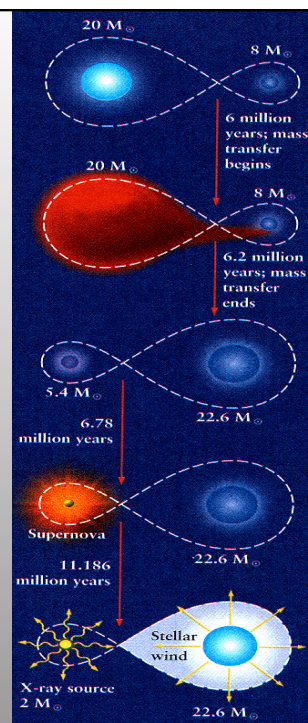


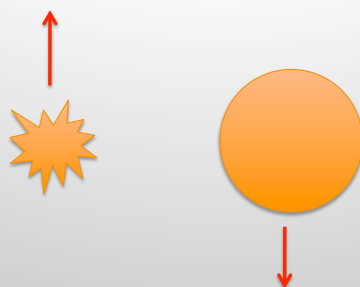
Can work out possible formation channels for observed X-ray binaries...

Can be complicated!

When the final state involves *two* compact objects, even more complicated!

Uncertain how many double black hole binaries exist...





Enough mass transfer: the star that explodes as a supernova is the *less massive* at the time of explosion – easier to keep the binary from being disrupted

Two roles for mass transfer in binaries:

1. Typically need mass transfer to *form* a close binary with a normal star in orbit about a compact object (a neutron star or black hole)
2. Need further mass transfer *on to* the compact object to produce observable X-ray emission via *accretion*