High-Mass X-Ray Binaries

Astrophysics of Interacting Binary Stars

Presentation by Aleksi Mattila

High-mass X-ray Binaries

HMXBs are binary systems of a neutron star or a black hole and a massive companion star

Formation of a HMXB requires two massive stars (> 12 $M_\odot$)

If the mass ratio is too small, accretion by Roche-lobe overflow is unstable

- Mass is usually accreted from the stellar wind

Hard X-rays

- Photon energy 15 keV or more

There are three different types of HMXBs

- Be X-ray Binaries (BeXBs)
- Supergiant HMXBs
- Wolf-Rayet X-ray Binaries (WRXBs)

Be X-ray Binaries

The largest group of HMXBs

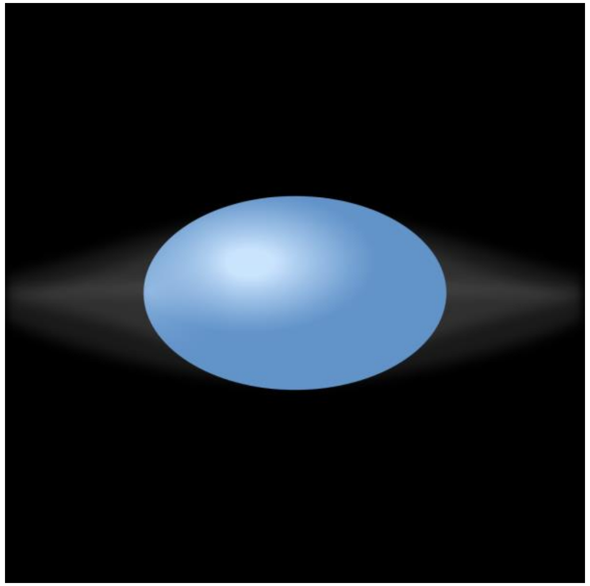
A Be star donor and usually a neutron star

- Be stars have masses of 8-20 $M_\odot$

Long orbital periods

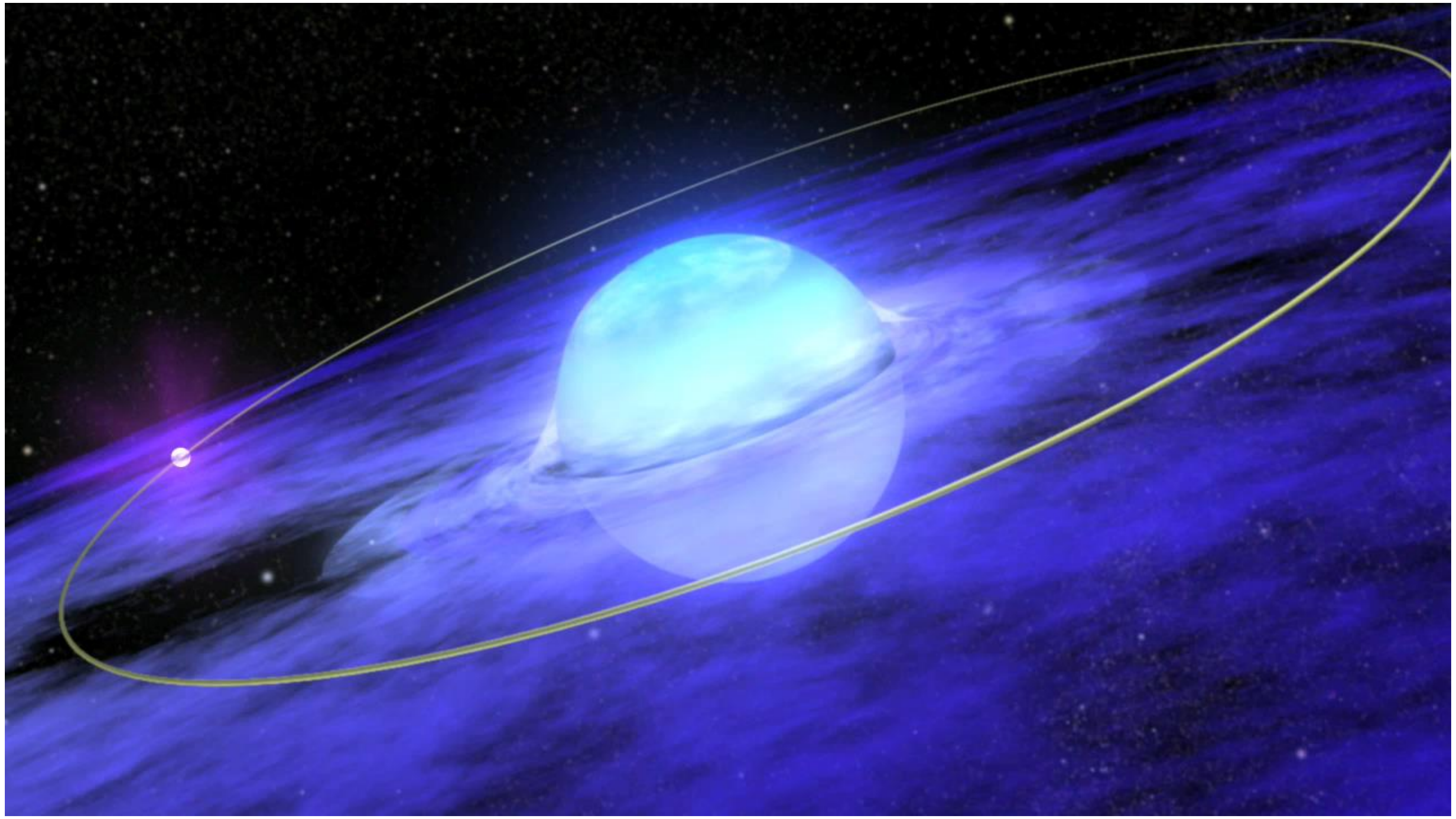
- Can be quiet for decades, then flare up for weeks or months

The compact object accretes mass from a ring around the Be star



Be star Achernar

Be X-ray Binaries



Walt Feimer,
NASA/Goddard Space
Flight Center

Supergiant HMXBs

Relatively rare

- Supergiants have short lifespans

Donor is an O or B star that's close to filling its Roche-lobe

- Masses of 20-50 $M_{\odot}$

Compact object is almost always a neutron star

Continuous X-ray sources

Accretion of matter from the stellar wind

- In some cases, RLO begins

Orbital periods usually under 2 weeks

Wolf-Rayet X-ray Binaries

Very rare

Binary system of a WR star and a black hole

Very short orbital periods, about 1 day or less

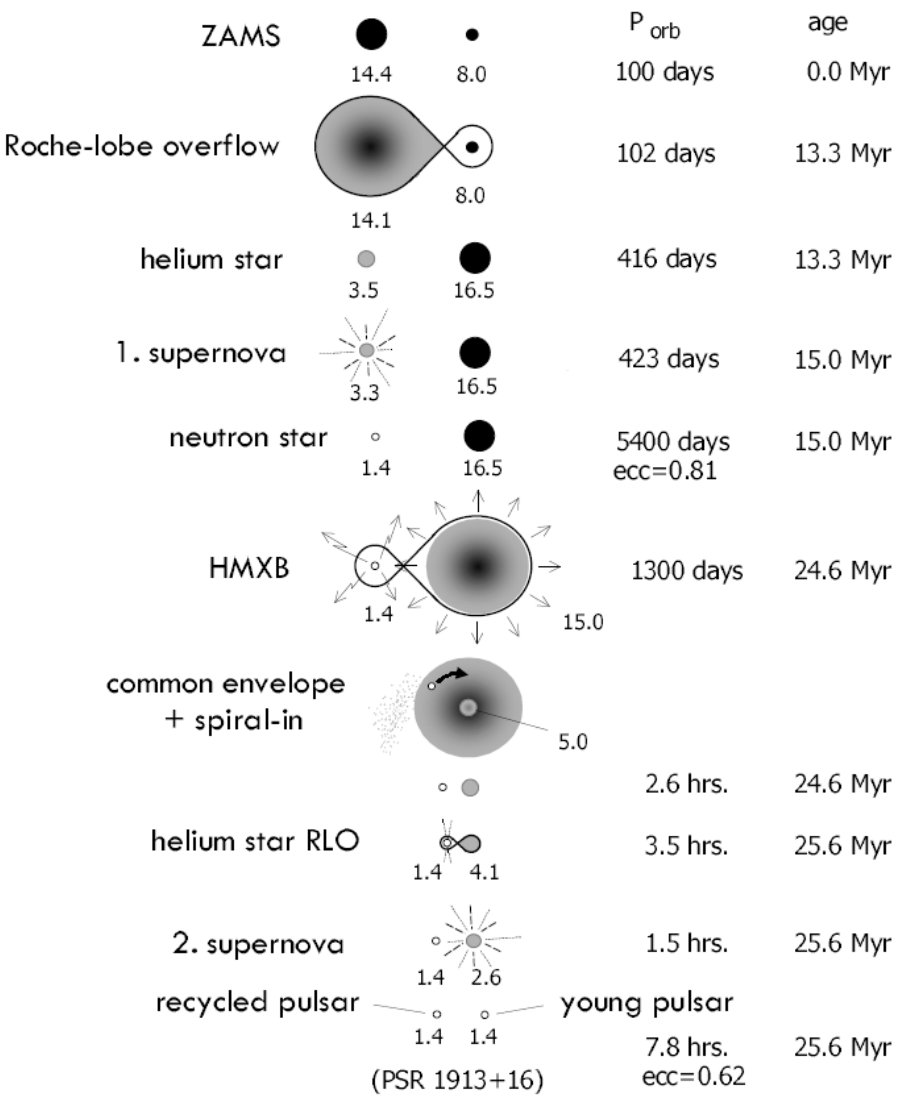
Accretion from strong stellar wind from the WR star

- Mass loss rate of $10^{-5}\ M_{\odot}$/yr

Born from other HMXBs

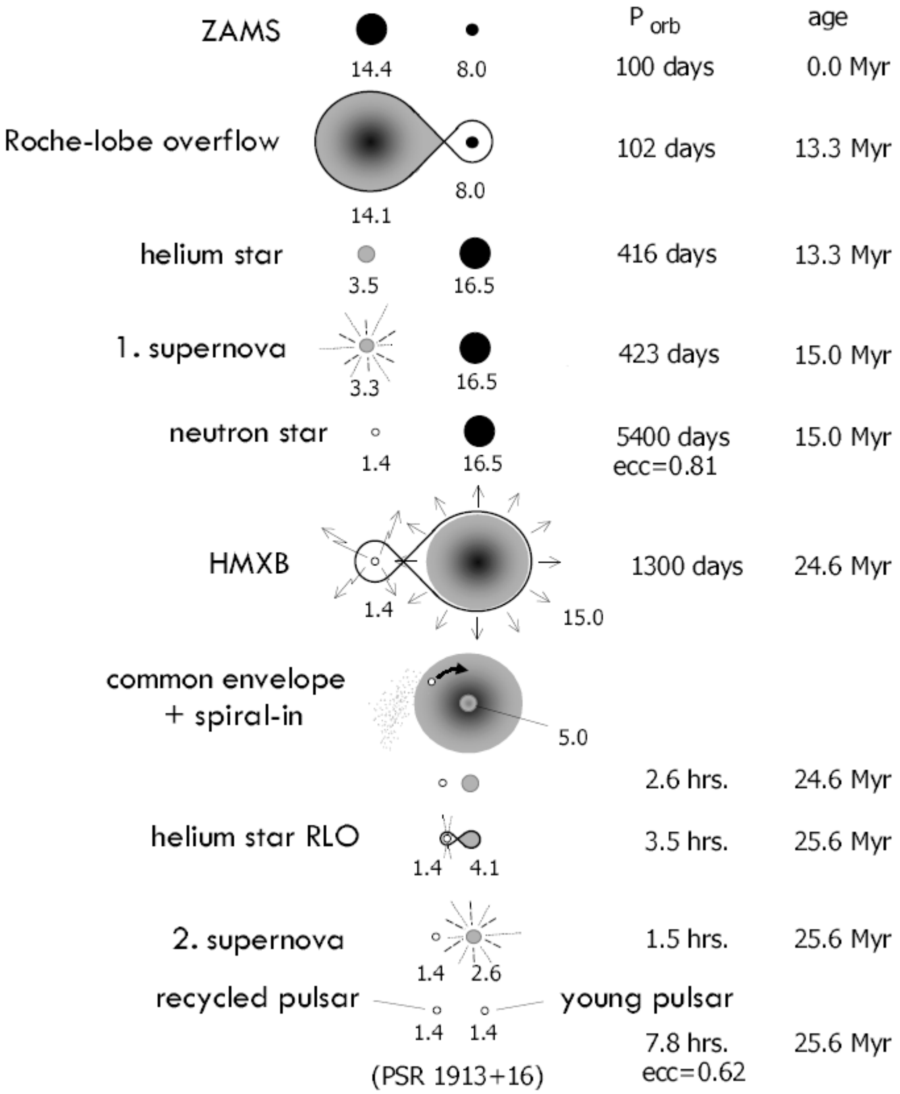
Progenitors of double black hole systems and black hole-neutron star binaries

Cygnus X-3. X-rays in white, radio in red and blue
X-ray: NASA/CXC/SAO/M.McCollough et al,
Radio: ASIAA/SAO/SMA



Evolution of a HMXB

1. Zero-age main sequence stars
2. Roche-lobe overflow
3. He-star
4. Supernova
5. Neutron star
6. High-mass X-ray binary



Evolution of a HMXB

7. Common envelope
8. Neutron star + He-star
9. Helium star Roche-lobe overflow
10. Second supernova
11. Double neutron star

Evolution of a HMXB

Formation of a HMXB requires two massive stars

- But the other can be less massive if it gains enough mass to undergo a supernova

In a system with stable RLO most of transferred mass is ejected

- Relativistic jets and very strong wind. Mass loss rates of 10^{-6} and 10^{-4} $M_{\odot}$/yr respectively

Summary

HMXBs are binary systems of a NS or a BH and a massive star.

They are progenitors of binary black holes and neutron stars

- Close double neutron stars are products of wide NS-BeXBs
- Close double black holes are products of short-period WRXBs

Accretion disks are uncommon, most mass transfer happens through stellar wind

Sources

Van Den Heuvel, E. P. J. (2019). *High-mass X-ray binaries: Progenitors of double compact objects*

Tauris, T. M. and Van Den Heuvel, E. P. J. (2003). *Formation and Evolution of Compact Stellar X-ray Sources*