The nature of Ultraluminous X-ray Sources

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Motivation

Study the evolution of a large population of binaries in order to investigate the formation scenarios of ULXs.

- only binaries
- no IMBH
- population synthesis

Population synthesis with the StarTrack code

Grid of models

- accretion physics (EL or unlimited accretion)
- beaming models
  (King 2009, saturation, constant beaming, no beaming)
- metallicity ($Z_\odot - 1\% \, Z_\odot$)

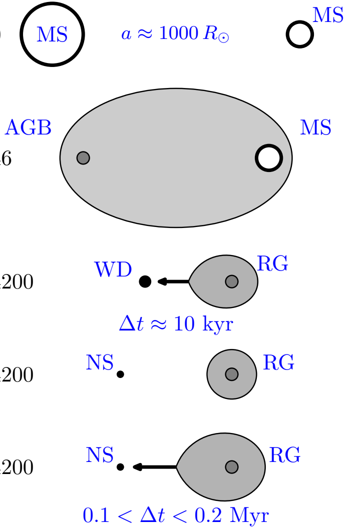
Models

- 2×10^7 binaries for each model from
  the initial XRB parameter space.
- evolution tracked from the ZAMS till
  the disruption, merger, or age of 10 Gyr.

Not included:

- NS magnetic fields
- rotation
- wind-fed ULXs

A typical NSULX formation



age [Myr]	phase	$M_a [M_\odot]$	$M_b [M_\odot]$
0	ZAMS	7.6	1.3
46	CE	7.3(1.3)	1.3
4200	MT	1.3(1.4)	1.3
4200	ECS	1.4(1.3)	1.3
4200	ULX	1.3	1.3(1.0)

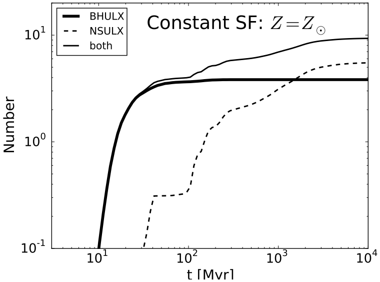
NSULXs dominate

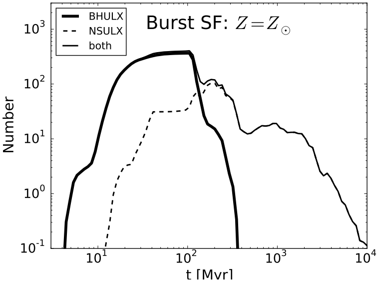
- post-burst populations
- old solar-metallicity populations

ULX formation sequence

ULXs appear in stellar populations **sequentially**
after the beginning of star formation:

1. $t \approx 4-40\,\mathrm{Myr}$ BH – MS ($5.6-11\,M_\odot$),
2. $t \approx 6-800\,\mathrm{Myr}$ NS – MS ($0.9-1.5\,M_\odot$),
3. $t \approx 430-1100\,\mathrm{Myr}$ NS – HG ($0.6-1.0\,M_\odot$),
4. $t \approx 540-4400\,\mathrm{Myr}$ NS – RG ($\sim 1.0\,M_\odot$);





Summary

- ULX with **NS accretors** are a natural consequence of a binary evolution and will dominate old stellar populations.
- ULX populations are **non-homogeneous** – consist of systems with different accretors and donors and have go through a ULX phase at different ages.
- We obtained **a testable relation** between the companion type and age of the ULX