Strange quark stars in binaries: formation rates, mergers and explosive phenomena

Grzegorz Wiktorowicz[1], A. Drago[2], G. Pagliara[2], and S. Popov[3]

[1]University of Warsaw
[2]University of Ferrara
[3]Lomonosov University

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Introduction

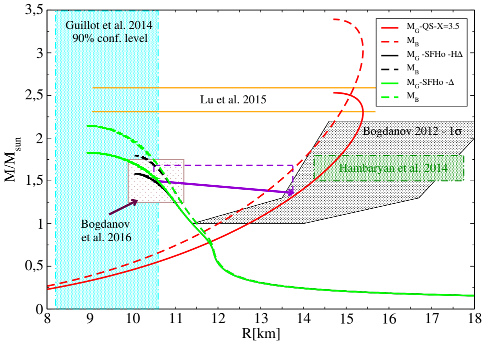
Strange Quark Star

Compact stars composed entirely of a mixture of deconfined up, down and strange quarks

Why binaries?

- $M_{\mathrm{NS,ZAMS}} \gtrsim 8\,M_{\odot}$
- most of the massive stars form in binaries (e.g. Sana et al. 2012)
- interactions allow for a formation of a NS/QS from a wider range of masses

Every NS with a mass $M_{\mathrm{NS}} \geq M^H_{\mathrm{max}}$ transforms into a QS
→ *Two families scenario (Drago et al. 2015)*
→ $M^H_{\mathrm{max}} = 1.5$ *or* $1.6\, M_\odot$
→ *mass of barions is conserved.*



- occurs rapidly
- about $0.1\!-\!0.15\, M_\odot$ gravitational mass difference
- mass of barions conserved

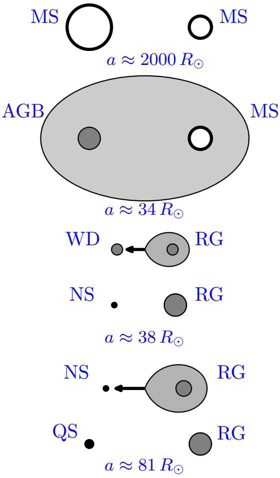
Grid of models

- solar and sub-solar metallicities
- different values of $M^H_{\rm max}$
- $N_{\rm binaries} = 2 \times 10^6$

There are three "ways" of forming a QS

1. **Direct formation** - No interaction but heavy primary and/or secondary
2. **Accretion** - QS formed as a result of accretion onto a NS
3. **Mass loss** - Massive progenitor ($M \gtrsim 22\,M_\odot$) loses mass, thus avoiding a direct collapse into a BH.

Typical QS formation route

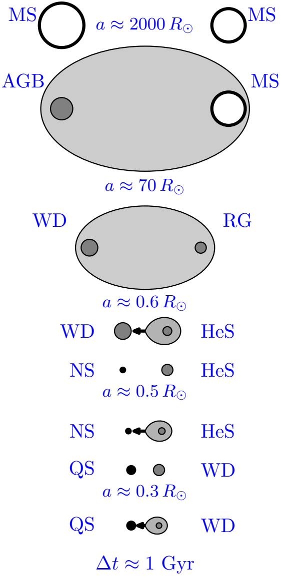


age [Myr]	phase	$M_{\rm a}[M_\odot]$	$M_{\rm b}[M_\odot]$
0	ZAMS	7.2	1.2
53	CE	6.7(1.3)	1.2
5700	MT	1.3(1.4)	1.2(1.0)
5700	NS	1.3	1.0
5700	MT	1.3(1.5)	1.0(0.5)
5700	QS	1.4	0.5

- most systems disrupt during QS formation ($90 \div 97\%$)
- QS formation rate from accretion is $11.6 \div 23.9$ Myr^{-1} MWEG^{-1}
- scenario typical for all tested metallicites and $M^H_{\rm max}$ values

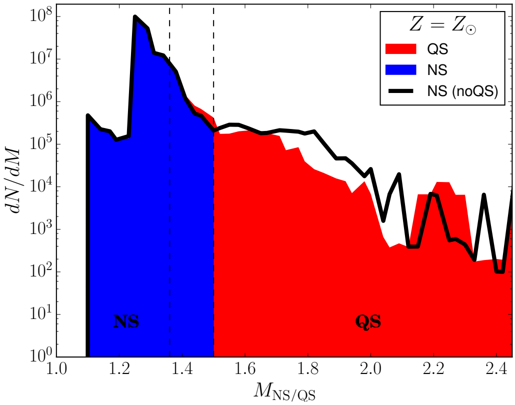
QS in LMXB

age [Myr]	phase	$M_a [M_\odot]$	$M_b [M_\odot]$
0	ZAMS	7.6	4.0
47	CE	7.1(1.3)	4.0
180	CE	1.3	4.0(0.7)
190	MT	1.3(1.4)	0.7(0.6)
190	NS	1.3	0.6
190	MT	1.3(1.5)	0.6(0.3)
210	QS	1.4	0.5
210	LMXB	1.4(1.5)	0.3(0.1)

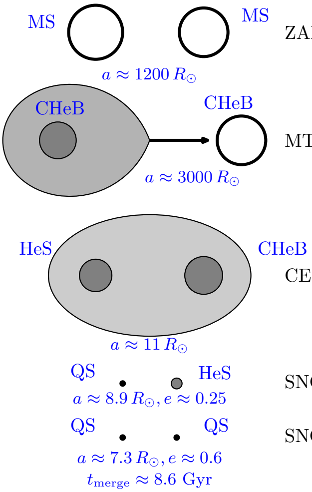


- different than typical route
- harbor 3 – 18% of all QSs

Coexistance range



- only a small excess in coexistance range!
- a peak of distribution located outside of the range



age [Myr]	phase	$M_{\mathrm{a}}[M_\odot]$	$M_{\mathrm{b}}[M_\odot]$
0	ZAMS	24	23
8.9	MT	23(8.4)	23(30)
9.2	CE	8.2	29(8.1)
9.3	SNQS	8.1(1.7)	8.0
9.4	SNQS	1.7	7.9(1.7)

! Only for moderate metallicity ($Z \approx 10\% Z_\odot$)

! Low merger-rate (12 Myr^{-1} for MW)

$\Rightarrow$ low strangelets pollution

- QSs form mostly through **accretion onto a NS**
- most of QSs exist as **single stars**.
- Statistics of NS mass measurements are too low to reject (or prove) the presence of "two families".
- The rates of double QS mergers are to low to trigger the deconfinement of all NS into QS.