Transients

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Talk Plan

Physical processes in binary evolution

Explosions from compact binaries:

- Short-duration gamma-ray bursts
- Long-duration gamma-ray bursts
- Gap transients

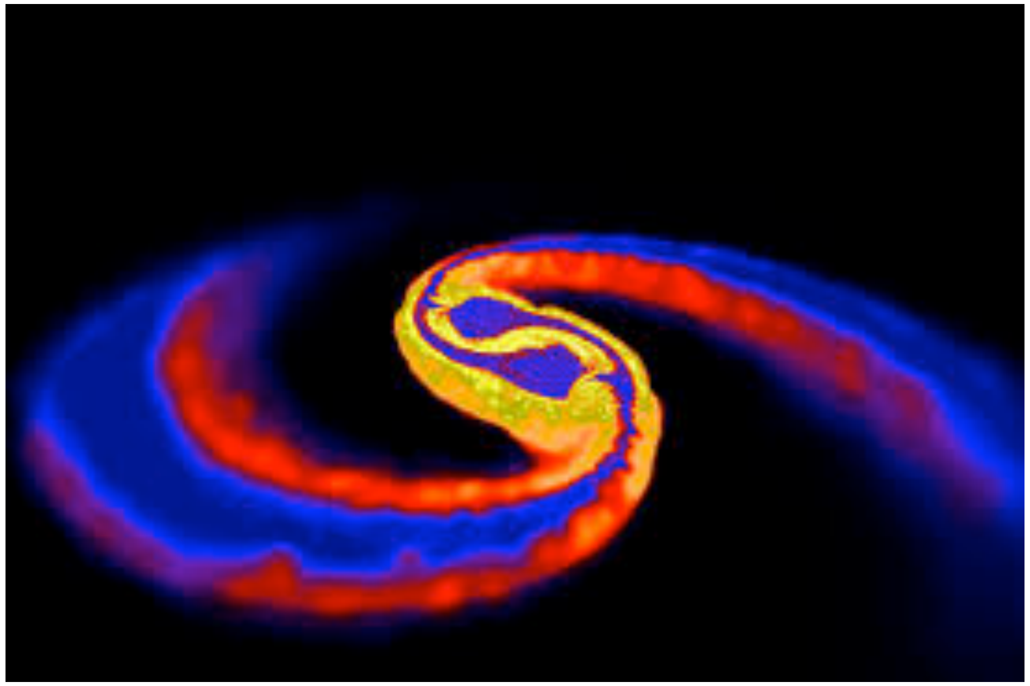
Fast Radio Bursts:

- What they are. How might they be made?

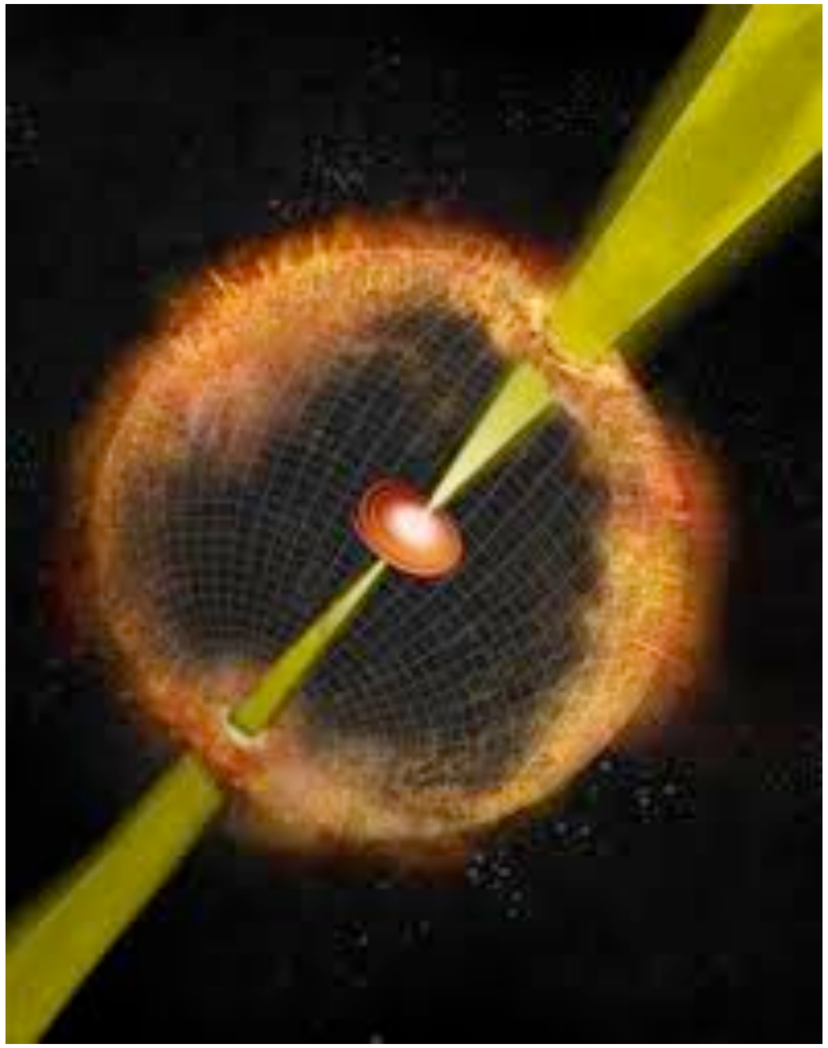
Gamma-ray bursts

Observation: a bright flash of gamma-rays, lasting for typically a few seconds, detected by space telescopes.

Energetics suggest that we are seeing the birth of an accreting, rapidly-rotating black hole.

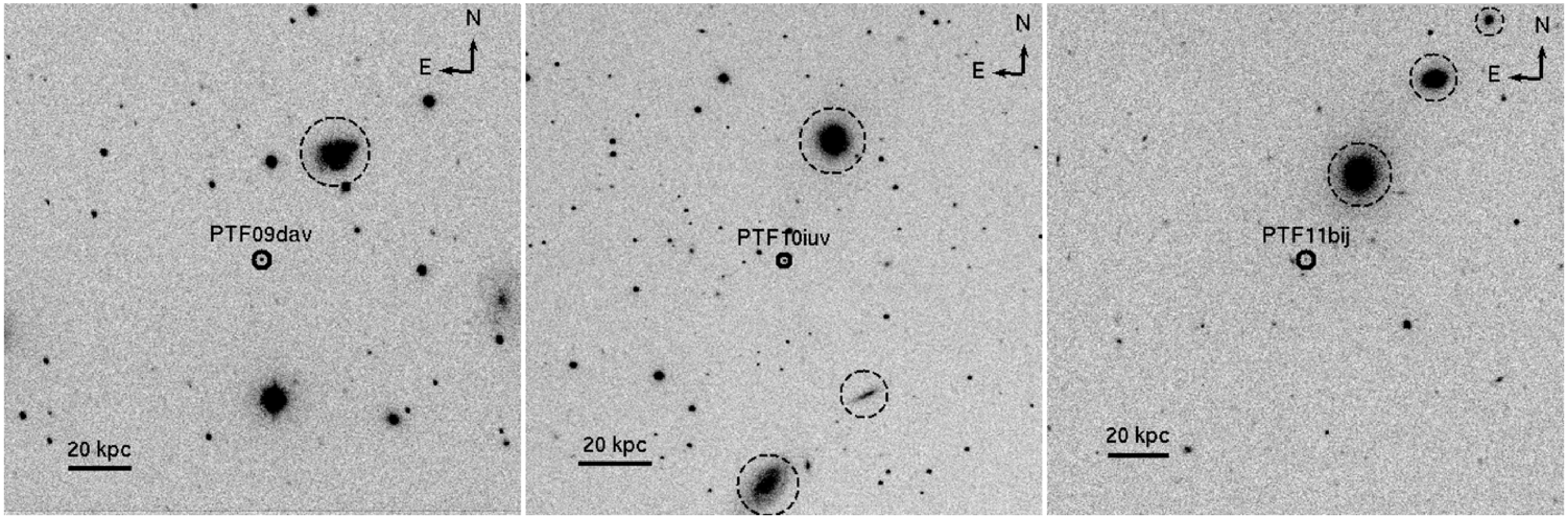


(Stephan Rosswog, Stockholm)



(Bill Saxton, NRAO)

Gap transients



Luminosities between those of novae and supernovae.

Thought to be formed from mass transfer in WD-NS binaries.

Spectra dominated by calcium (made by nuclear burning in accretion disc).

Offset from the host galaxies.

Kasliwal et al. (2012)

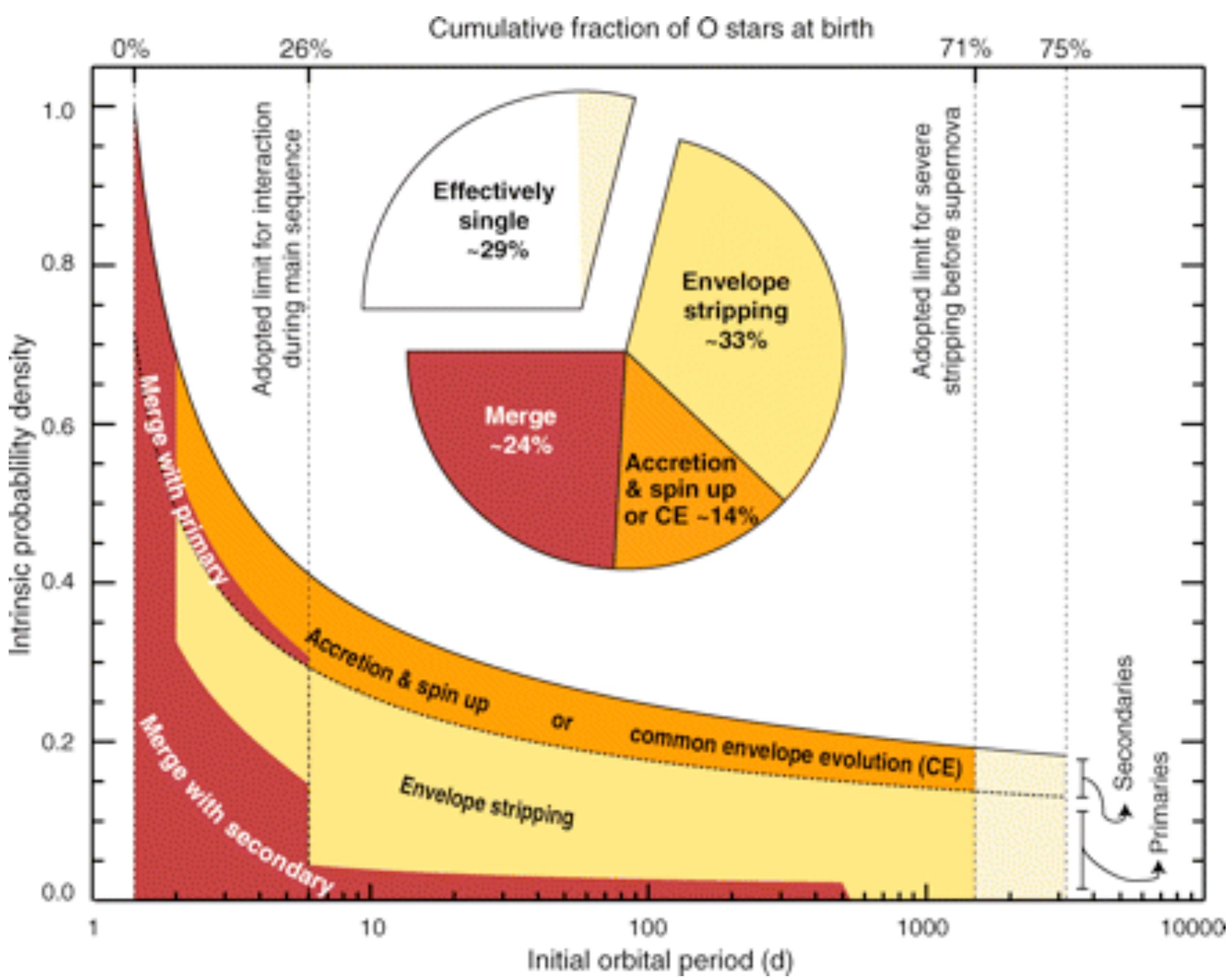
Binaries are important

Long GRBs may also form in compact binaries where companion spins up GRB progenitor.

e.g. Church, Kim, Levan & Davies (2012)

80-100% of massive stars are in binaries.

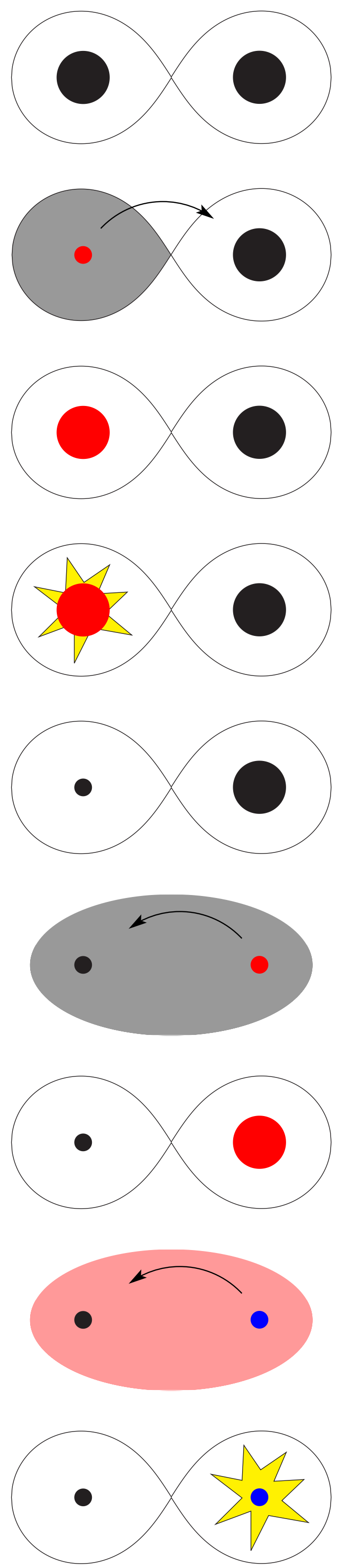
e.g. Kiminki & Kobulniki (2012)



About 70% of high-mass (O-type) stars interact significantly with their companion.

Sana et al. (2013)

Evolutionary pathway to produce NS-NS binaries



Initial main sequence–main sequence binary

Stable mass transfer from primary

Helium star–main sequence star binary

First supernova

Neutron star–main sequence star binary

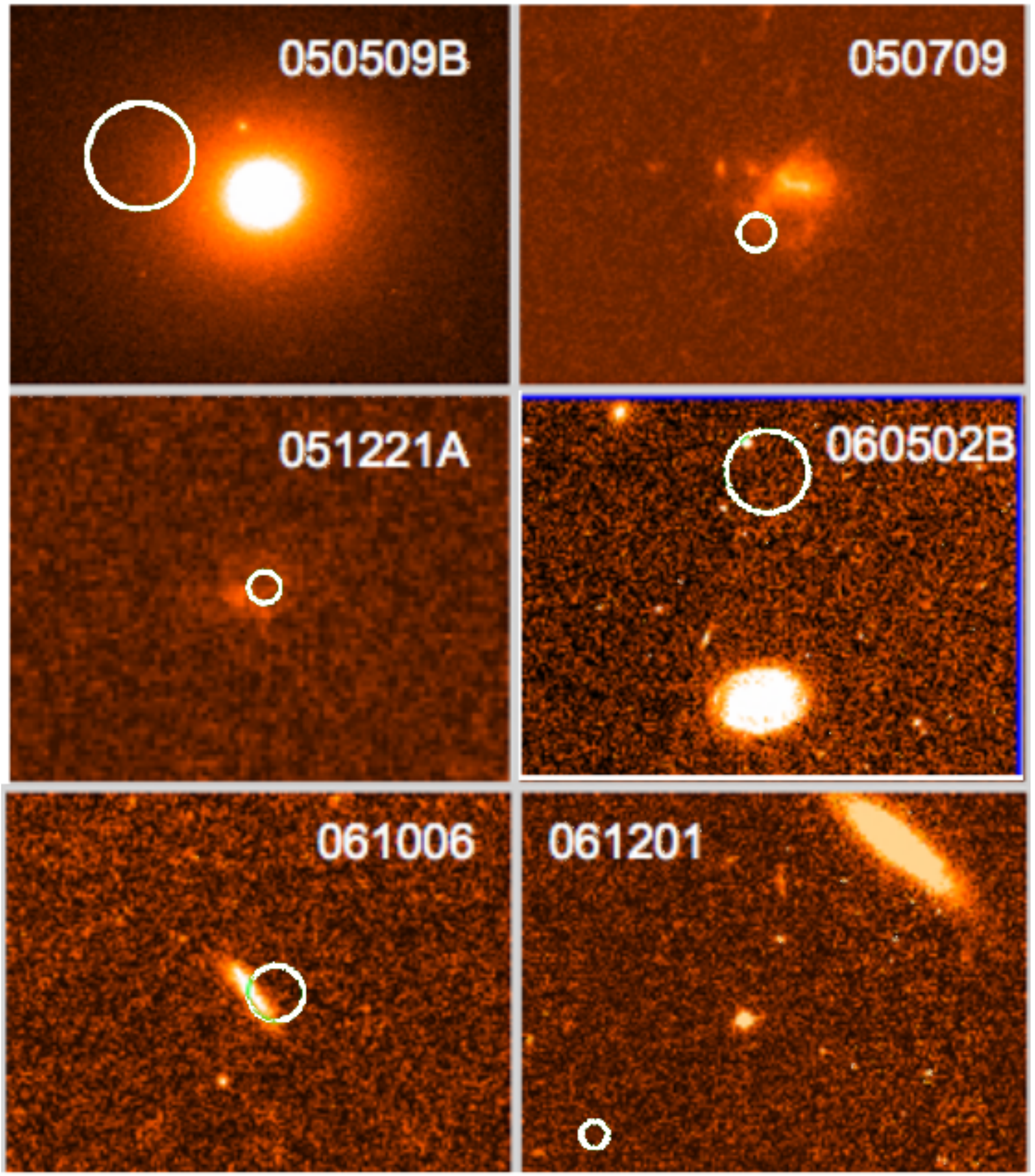
Common envelope evolution

Close neutron star–helium star binary

Common envelope evolution (round 2)

Final supernova, NS-NS binary produced

Locations of short bursts

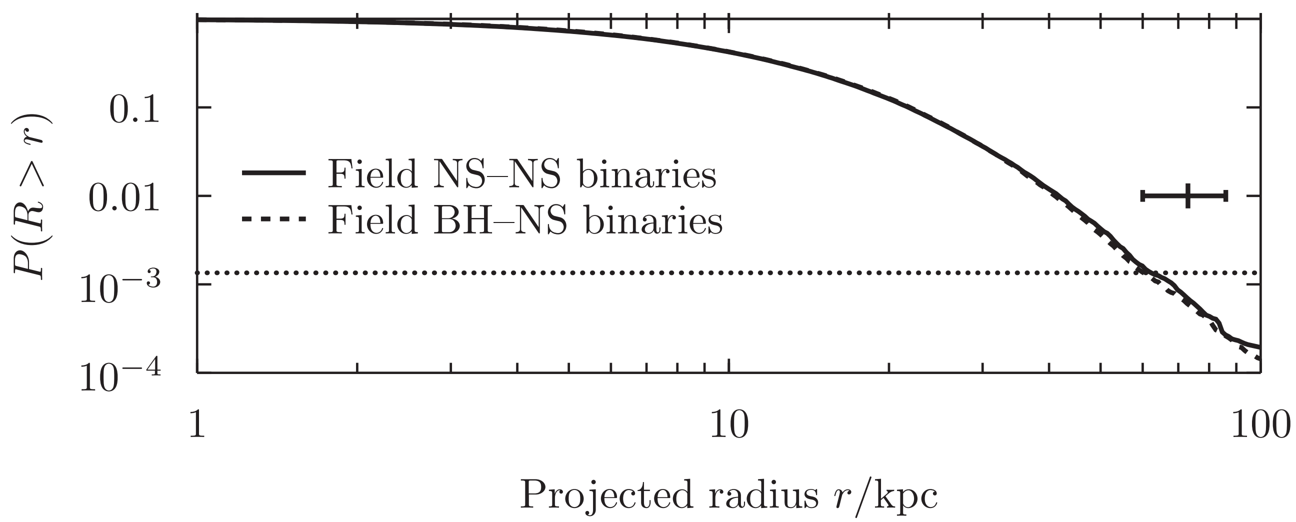


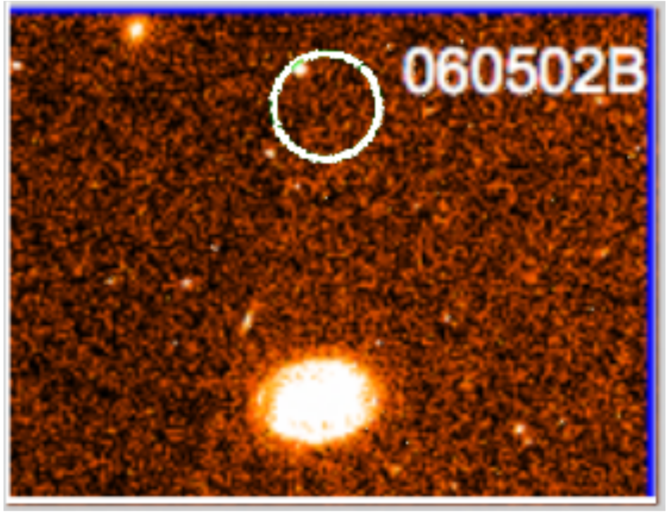
Localisations from the Swift satellite

Church, Levan, Davies & Tanvir (2011)

Offsets larger than expected

060502B - burst occurred outside host galaxy.

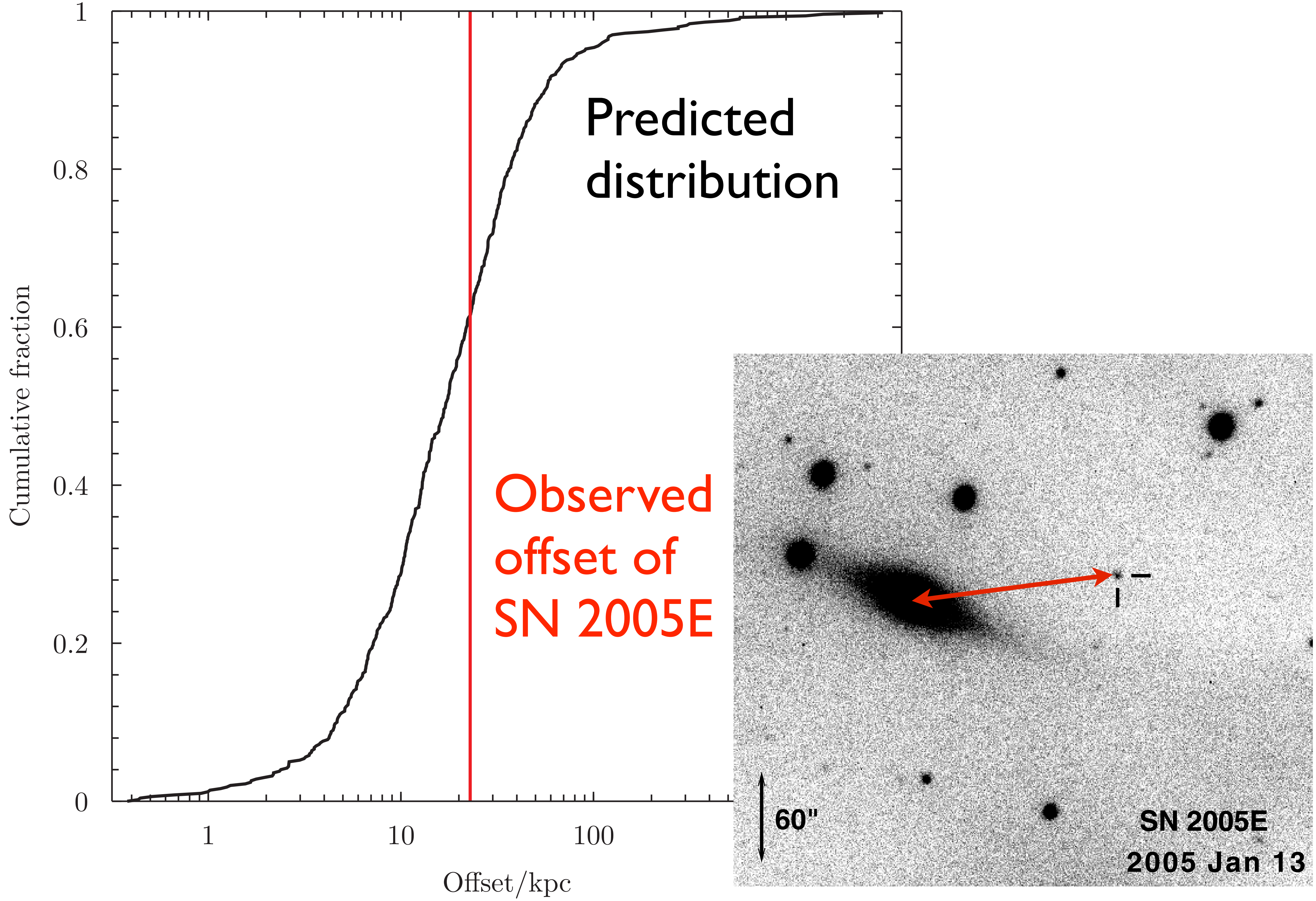




It could be that the progenitor formed dynamically in a globular cluster.

Church, Levan, Davies & Tanvir (2011)

Predicted offsets for gap transients



Church, Levan & Davies in preparation

Fast Radio Bursts

	FRB 010724	FRB 010621	FRB 110220	FRB 110627	FRB 110703	FRB 120127
Observed width (ms)	4.6	8.3	5.6	<1.4	<4.3	<1.1
$(\tau_0^2 + \tau_s^2)^{1/2}$ (ms)	3.1	4.8	5.5	<1.1	<4.1	<0.9
Predicted τ_s (ms)[a]	2.89	177	802	145	2251	28
DM (pc cm^{-3})	375 ± 1	746 ± 1	944.38 ± 0.05	723.0 ± 0.3	1103.6 ± 0.7	553.3 ± 0.3
Extragalactic DM (pc cm^{-3})	330	213	910	677	1072	521
Peak flux density (Jy)	30 ± 10	0.4 ± 0.1	1.3	0.4	0.5	0.5
Spectral index[b2]	-4 ± 1	0 ± 1	0 ± 1	0 ± 1	0 ± 1	0 ± 1
Observed rate (h^{-1} deg^{-2})[c]	$0.0019^{+0.0045}_{-0.0006}$	$0.00051^{+0.0013}_{-0.0001}$	$0.0017^{+0.0013}_{-0.0005}$	$0.0017^{+0.0013}_{-0.0005}$	$0.0017^{+0.0013}_{-0.0005}$	$0.0017^{+0.0013}_{-0.0005}$

Hassall, Keane & Fender (2013)

(see also Lorimer et al 2007; Keane et al 2012; Thornton et al 2013)

Short timescales (few ms implying ~1000km source)

High DM implies cosmological distances (though note Loeb et al 2013)

Energetic events (~10^{33}J)

What are FRBs?

Soft gamma-ray repeaters (SGRs)

(Ofek 2007; Hurley et al 2005)

Merging NS-NS binaries

(Hansen & Lyutikov 2001; Totani 2013)

ccSN explosion + NS magnetic field

Egorov & Postnov (2009)

Rotating supramassive neutron stars

Falcke & Rezzolla (2013)

Linked to GRBs

Zhang (2014)

What are FRB rates?

Object	Rate[a] (Gpc^{-3} d^{-1})	Reference
FRBs (high scattering)	51^{+31}_{-14}	This work
FRBs (no scattering)	$5.3^{+3.1}_{-1.4}$	This work
Short GRBs	~0.3–3	Fong et al. (2012)
NS mergers	~0.3–30	Abadie et al. (2010)
CC supernovae	~200–2000	Li et al. (2011)

[a]The rates given here are 'local' ($z < 1$), but the true rates depend on redshift. They should be treated as order of magnitude estimates.

Hassall, Keane & Fender (2013)

Detection rate with SKA Phase 1 could be one per hour.

(Trott, Tingay & Wayth 2013; Hassall, Keane & Fender 2013)