Gamma-ray binaries: from low frequencies to high resolution

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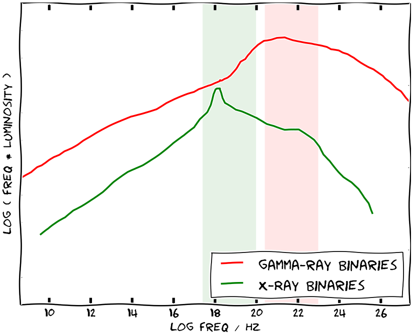
Gamma-Ray Binaries

Binary systems which host a compact object orbiting a high mass star that have the non-thermal maximum of the Spectral Energy Distribution in γ-rays (Paredes et al. 2013, Dubus 2013)

System	Main star	P/ days
Cygnus X-3	WR	0.2
Cygnus X-1 ??	O9.7Iab	5.6
MWC 656 ??	Be	60.4
PSR B1259–63	09.5Ve	1236.7
HESS J0632+057	B0 Vpe	315.0
LS I +61 303	B0 Ve	26.5
1FGL J1018.6–5856	O6V	16.6
LS 5039	O6.5V	3.9

Green: X-ray binaries with gamma-ray emission

Red: known gamma-ray binaries



SED of gamma-ray binaries versus HMXRBs

Gamma-Ray Binaries

Young non-accreting pulsar scenario

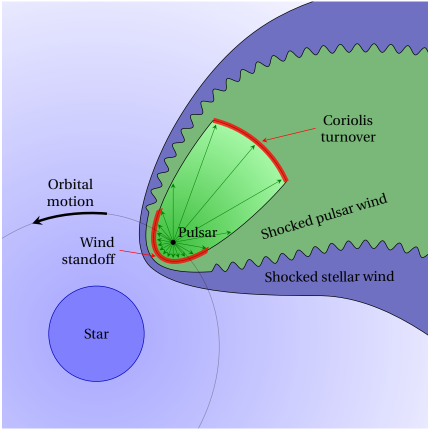
Strong shock between both winds:

- Relativistic pair plasma wind from the pulsar
- Stellar wind from the massive companion star

Originally proposed by Maraschi & Treves (1981),

re-proposed by Dubus (2006)

Radio flux dominated by the synchrotron emission at $\sim$GHz



Model for LS 5039 from Zabalza et al. (2012)

The gamma-ray binary LS 5039

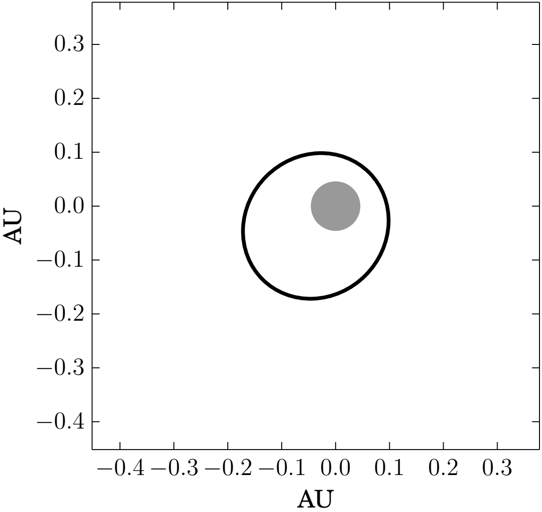
LS 5039

O6.5 V star ($23 \pm 3\ M_\odot$)
$d = 2.5 \pm 0.5$ kpc
$e = 0.35 \pm 0.04$

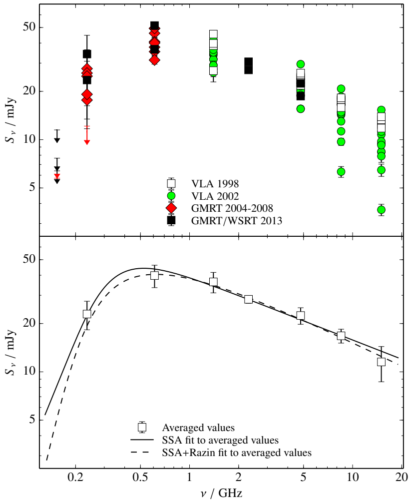
$P_{\rm orb} = 3.90603 \pm 0.00017$ d

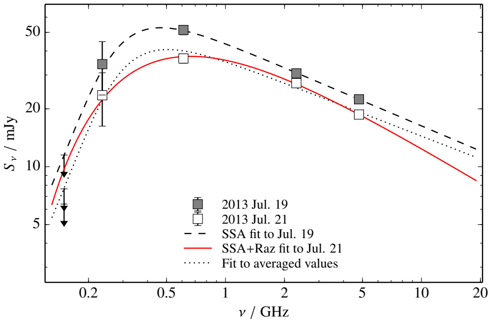
Light-curve:
TeV: periodic outbursts
GeV: periodic outbursts
X-rays: periodic outbursts
radio: not periodic
Small variability

Casares et al. (2005)



The gamma-ray binary LS 5039





Averaged spectrum explained by a synchrotron self-absorption emission.

Slightly differences in simultaneous spectra (WSRT+GMRT data)

The gamma-ray binary LS I +61 303

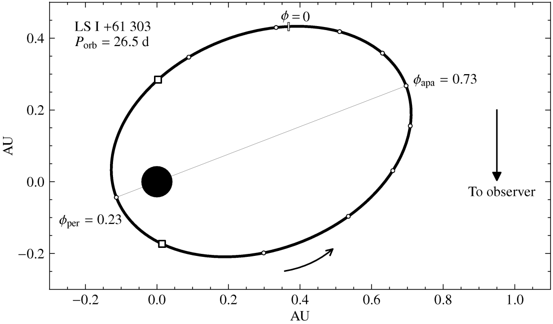
LS I +61 303

B0 Ve star ($12.5 \pm 2.5\ M_\odot$)
$d = 2.0 \pm 0.2$ kpc
$e = 0.72 \pm 0.15$

$P_{\rm orb} = 26.496 \pm 0.003$ d
$P_{\rm super} = 1667 \pm 8$ d

Outbursts at all frequencies
X-ray–TeV: correlated(?)
Radio–TeV: correlated
Optical–Radio: correlated
GeV–TeV: anticorrelated

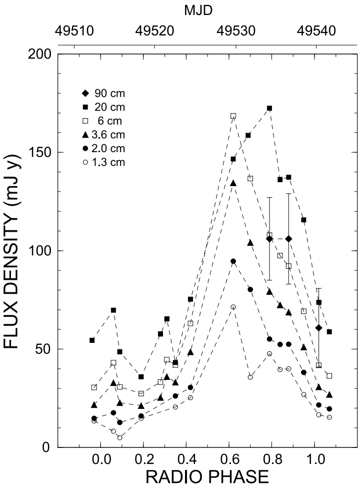
Frail & Hjellming (1991),
Casares et al. (2005),
Gregory (2002)

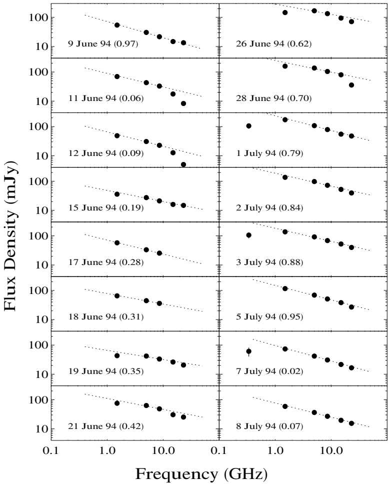


Radio emission of LS I +61 303

LS I +61 303 exhibits a large variability at radio frequencies.

Emission orbitally modulated ($P_{\mathrm{orb}} \approx 26.5$ d)

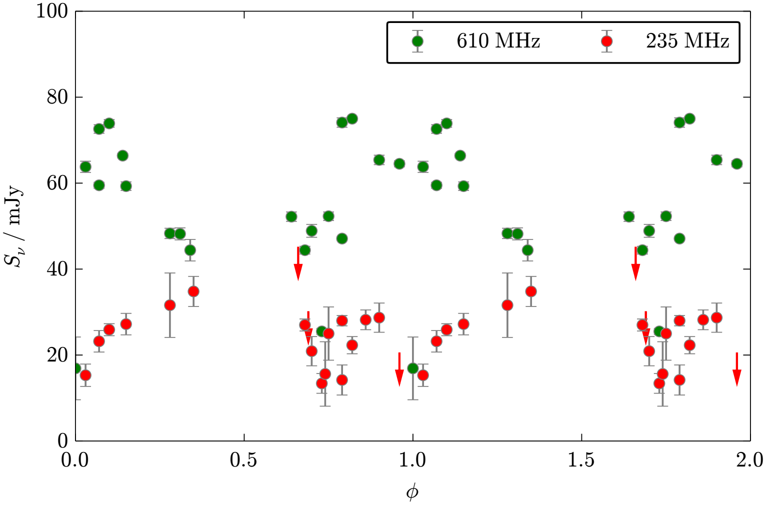




Strickman et al. (1998)

Results from the GMRT observations

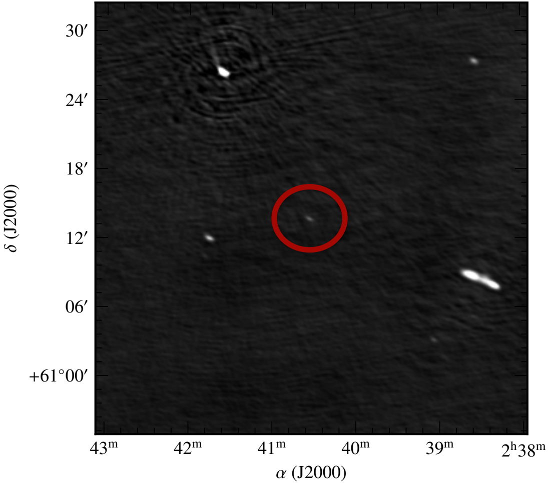
GMRT data from Nov. 2005 to Feb. 2006



Results at very low frequencies

With the GMRT observation at 154 MHz we detected for first time a gamma-ray binary at these very low frequencies.

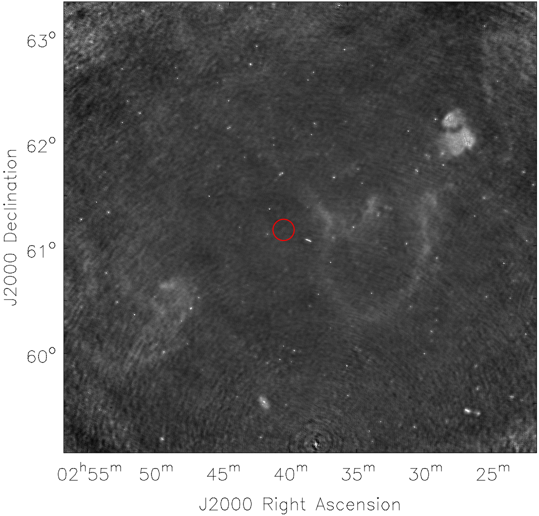
- $\nu = 154$ MHz
- Bandwidth 32 MHz
- Beam:
  30 $\times$ 14 arcsec
- Point-like source
- $S_\nu = 37 \pm 2$ mJy



Results at very low frequencies

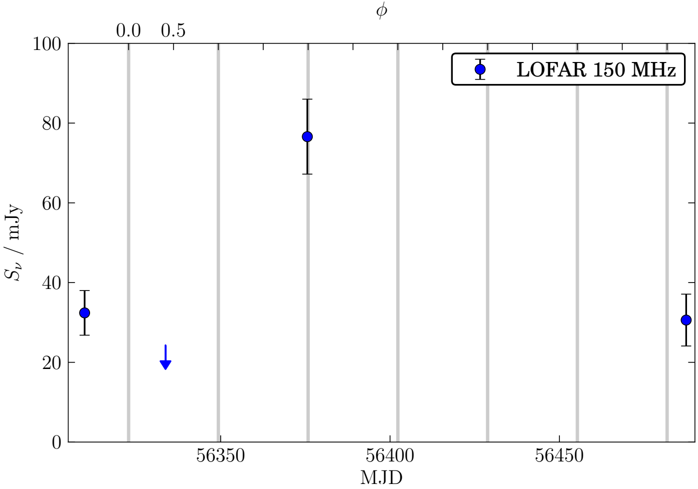
6 RSM pointings to LS I +61 303 with LOFAR up to now.

- $\nu = 149$ MHz
- Bandwidth 78 MHz
- Beam: 27×15 arcsec
- 4 analyzed obs.
- 3 detections $> 3\sigma$
- Point-like source



Results at very low frequencies

Preliminary results from the RSM LOFAR observations
Detection of LS I +61 303 in three of four analyzed observations
The behavior of the source is variable along the time



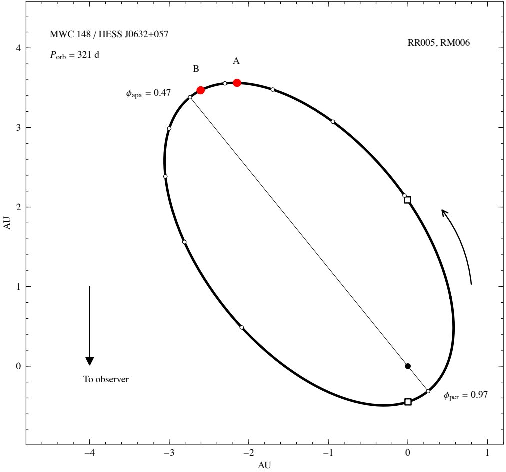
The gamma-ray binary HESS J0632+057

HESS J0632+057

B0 Vpe star (16 ± 3 $M_\odot$)
$d = 1.4 \pm 0.5$ kpc
$e = 0.83 \pm 0.08$

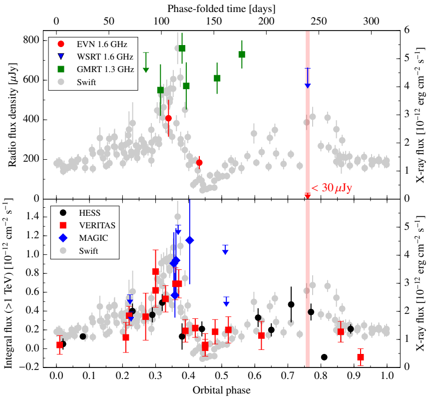
$P_{\rm orb} = 321 \pm 5$ d

Variability at all frequencies
TeV: periodic outbursts
GeV: periodic outbursts
X-rays: periodic outbursts
radio: ?

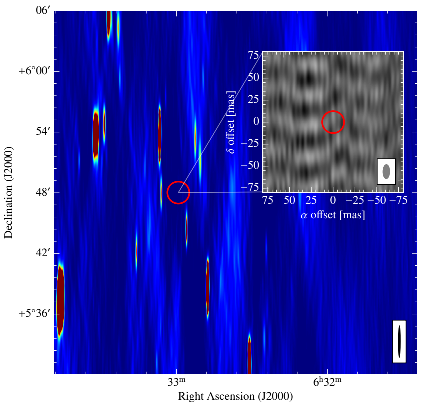


Moldón (2012)

Radio emission of HESS J0632+057



Light-curve of HESS J0632+057 in radio (color data, top), X-rays (gray circles) and TeV (color data, bottom).



EVN and WSRT observation in 2014. No detections in any case, with an EVN 3-σ upper-limit of 30 μJy.


Thank You!