大質量X線/ガンマ線連星系の統一的理解に向けて

岡崎敦男（北海学園大学）

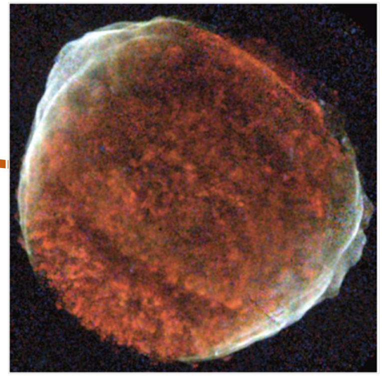
Talk Outline

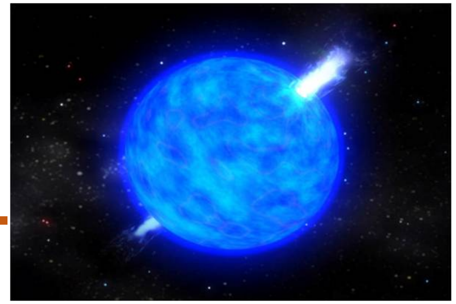
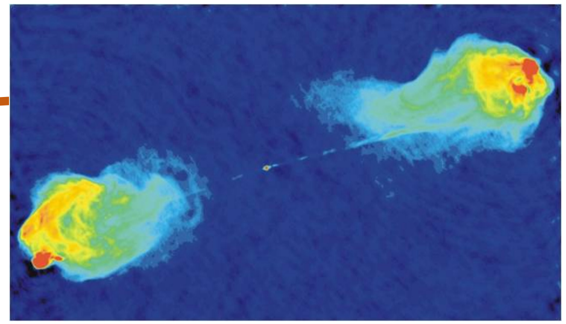
1. Gamma-ray binaries
   - Probing the nature of the compact object and physics of high-energy emission
2. High mass X-ray binaries vs. gamma-ray binaries
   - Is there any evolutionary link between these groups?
   - Where are other types of massive binaries?

1. Gamma-ray binaries

(TeV) gamma-ray sources

- Supernova remnants
- Pulsar wind nebulae
- Massive binaries
- Gamma-ray bursts
- Active galactic nuclei



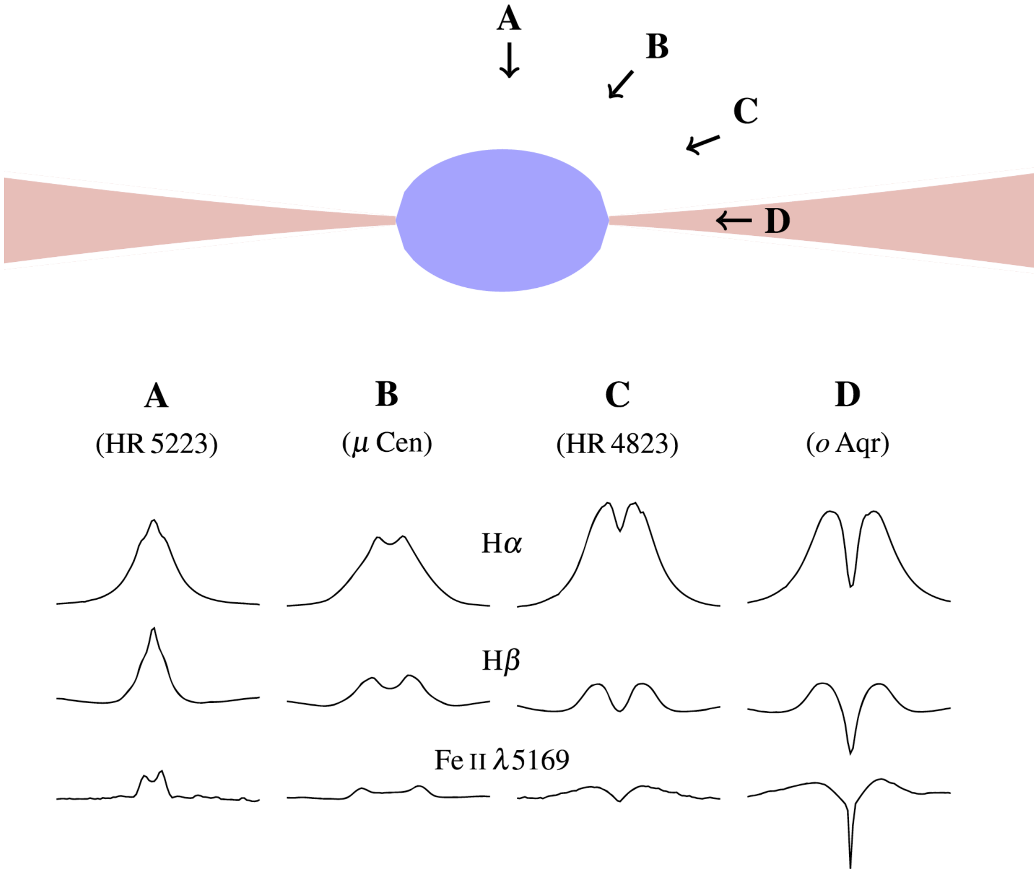



(TeV) gamma-ray binaries

- **Binaries with SED dominated by gamma-ray emission**
- Only 7 systems, all of which consist of an OB star and a compact object
  - **4 Be-star systems** (P_{orb}=30d-50yr, e=0.5-1)
  - **3 main-sequence O-star systems** (P_{orb}=4-20d, e=0.1-0.4)
- Nature of compact object established only for two systems to be non-accreting pulsars

Be stars

Non-supergiant early-type stars whose spectra have shown one or more Balmer lines in emission
(Collins 1987)



(Rivinius+ 2013)

Two competing scenarios for other systems

Pulsar wind scenario

Collision shocks between pulsar wind and stellar wind (and/or Be disk)

Microquasar scenario

Accretion of stellar wind and/or Be-disk gas

⇨ Relativistic jet

⇨ Acceleration of electrons ⇨ { synchrotron ⇨ radio, X-rays; IC ⇨ gamma-rays }

The biggest challenge

Clarifying the nature of the compact object and physics of interaction leading to high-energy emission

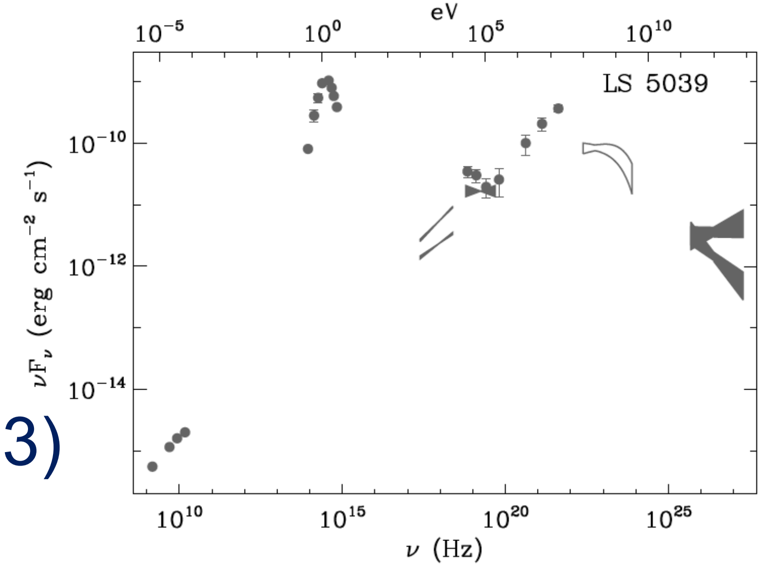
Standard approach

Observed SED and multi-wavelength LCs

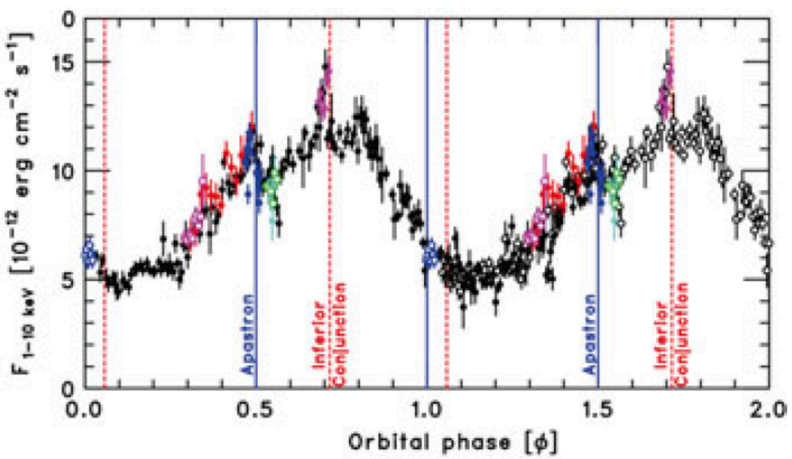
⇕ comparison

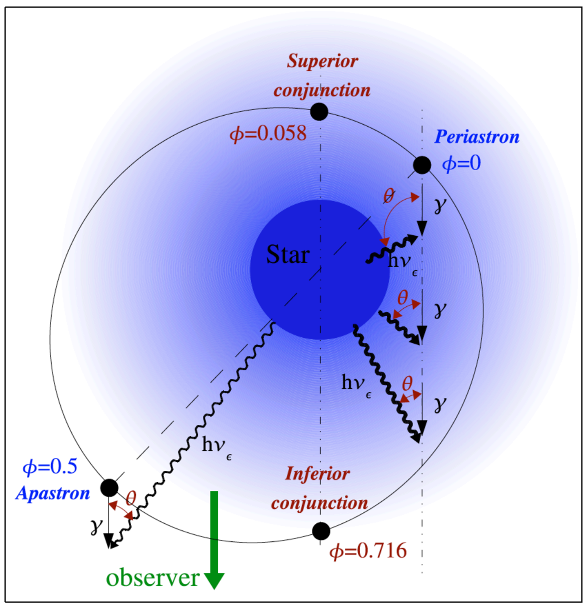
Analytical model or sims of interaction
+ Emission model

LS 5039
(O6V + compact object; P_{orb}=3.9 d, e=0.35)

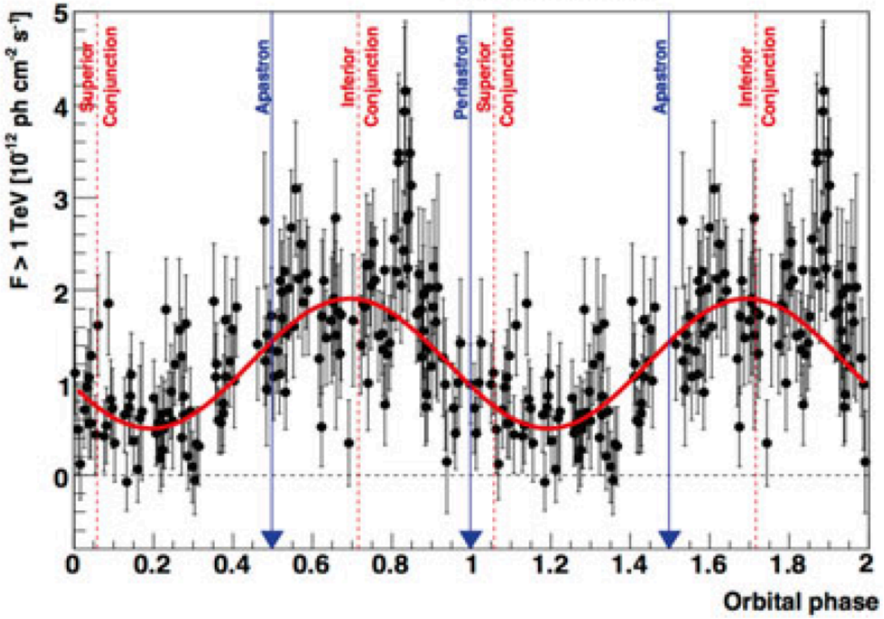


(Dubus 2013)





(Aharonian+ 2006)



Another approach

If there is a clear feature that is characteristic to the PW or MQ scenario, it will enable us to distinguish between these scenarios.

Be-star systems have such a feature!

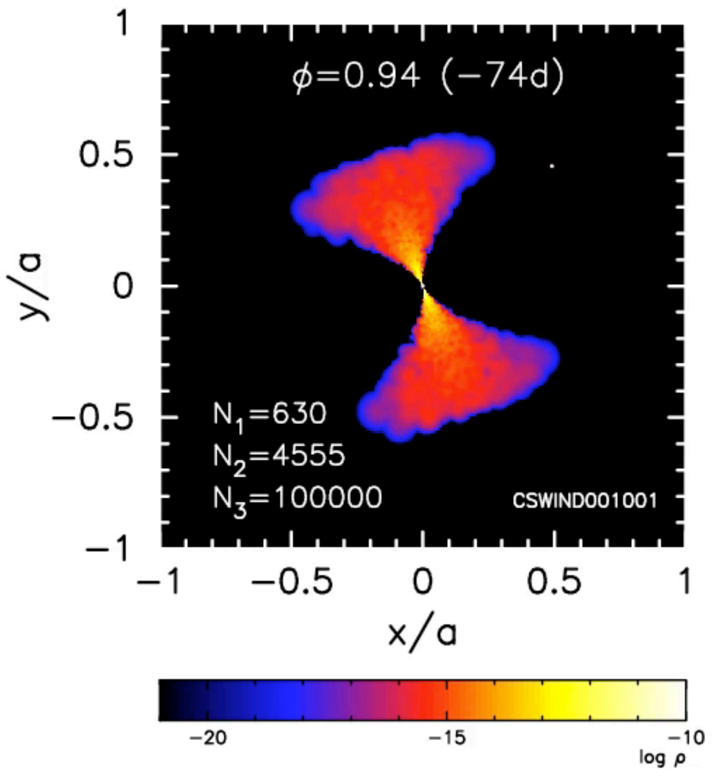
Both of two systems, where the nature of compact object is known, have a Be star:

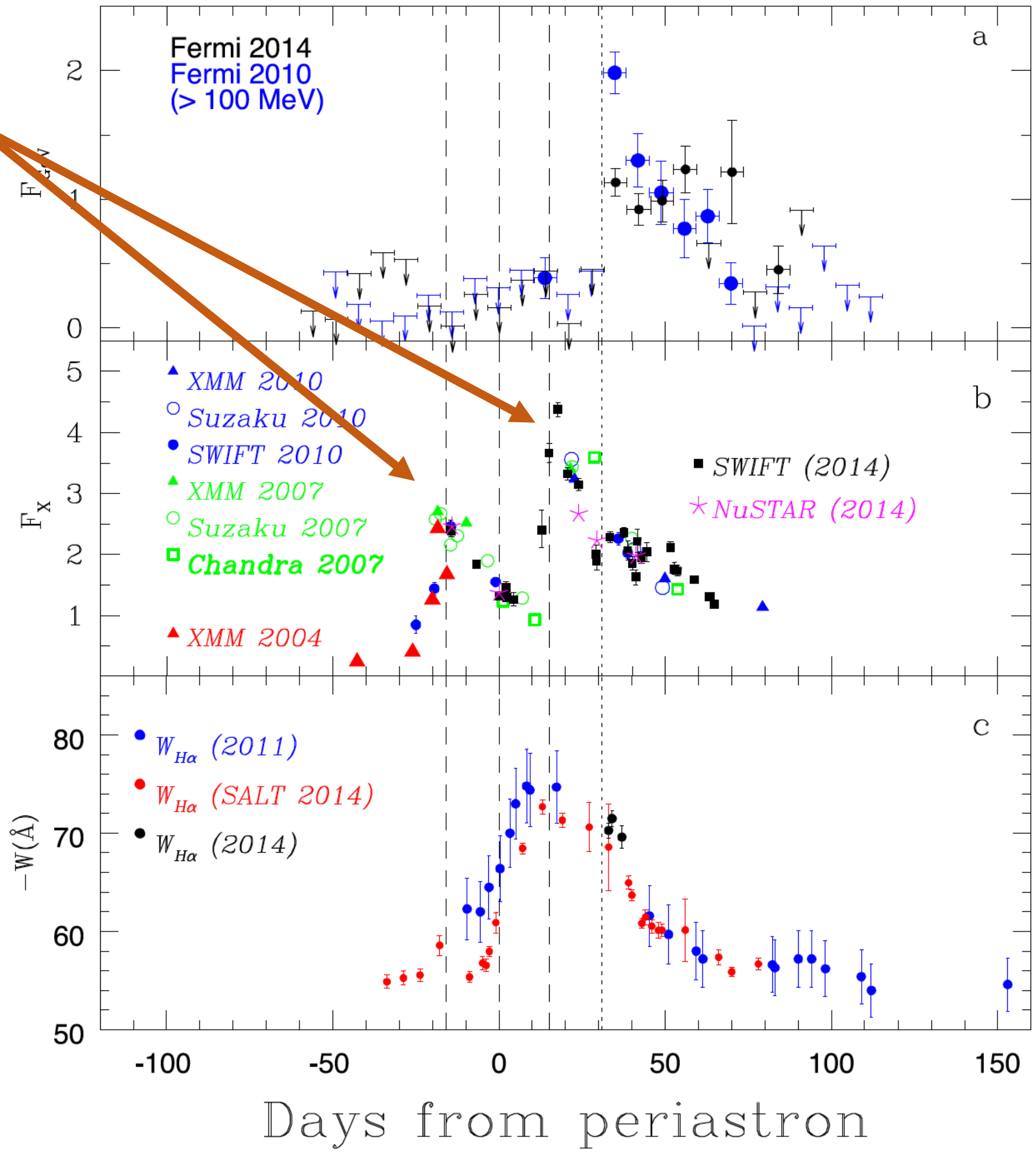
- PSR B1259-63
  - O9.5Ve + 49 ms pulsar
  - Porb=3.4 yr, e=0.87
- PSR J2032+4127
  - B1Ve + 143 ms pulsar
  - P_{orb}=48 yr, e=0.978

PSR B1259-63

(O9.5Ve + 49 ms pulsar; P_{orb}=3.4 yr, e=0.87)

X-ray flux peaks at disk transit

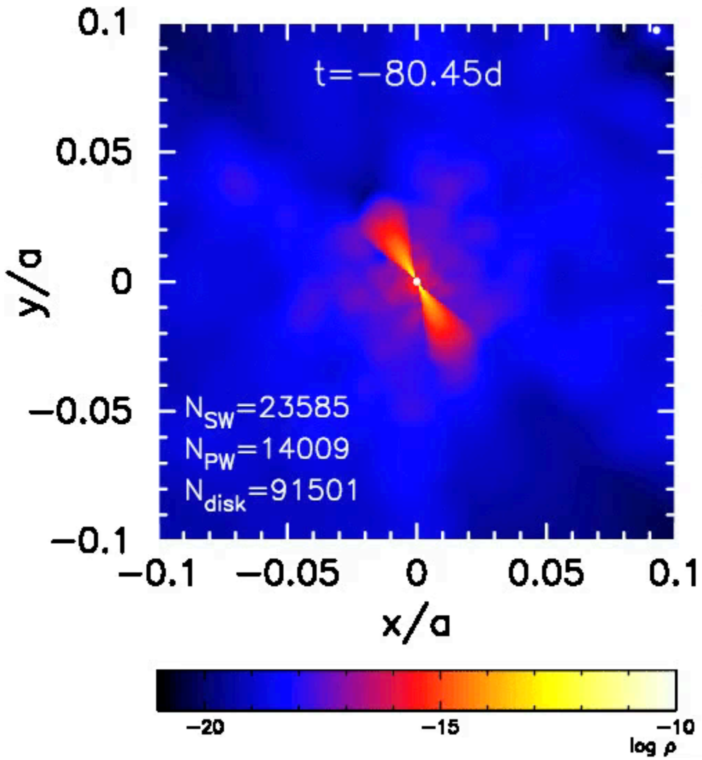


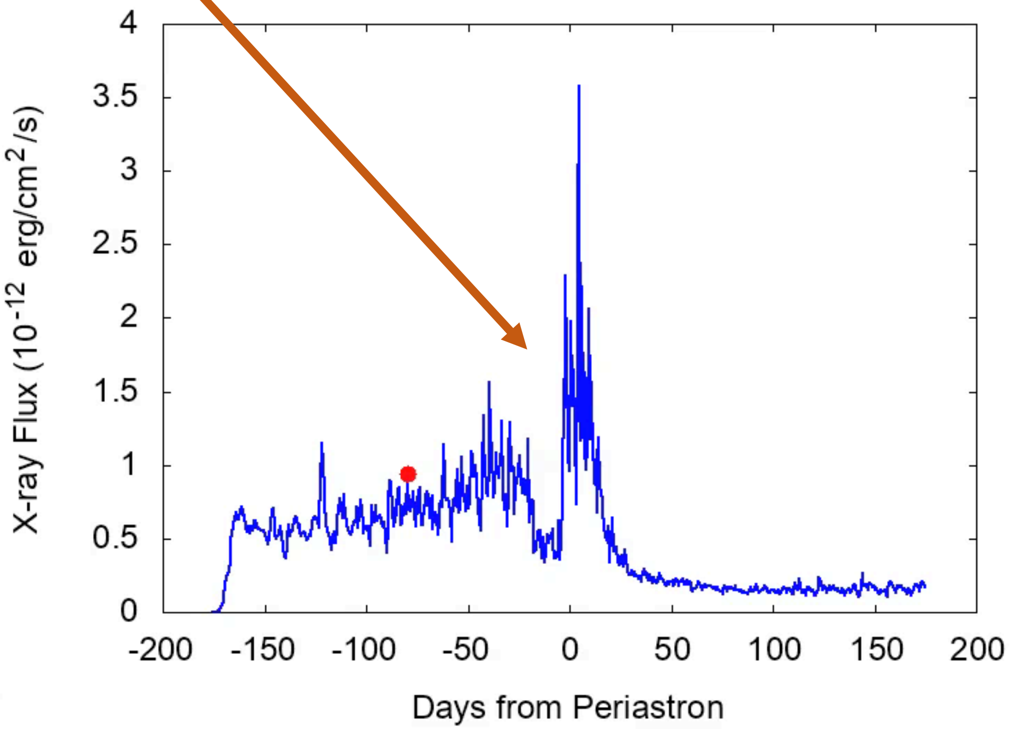


(Chernyakova+ 2015)

PSR J2032+4127
(B1Ve + 143 ms pulsar; P_{orb}=48 yr, e=0.978)

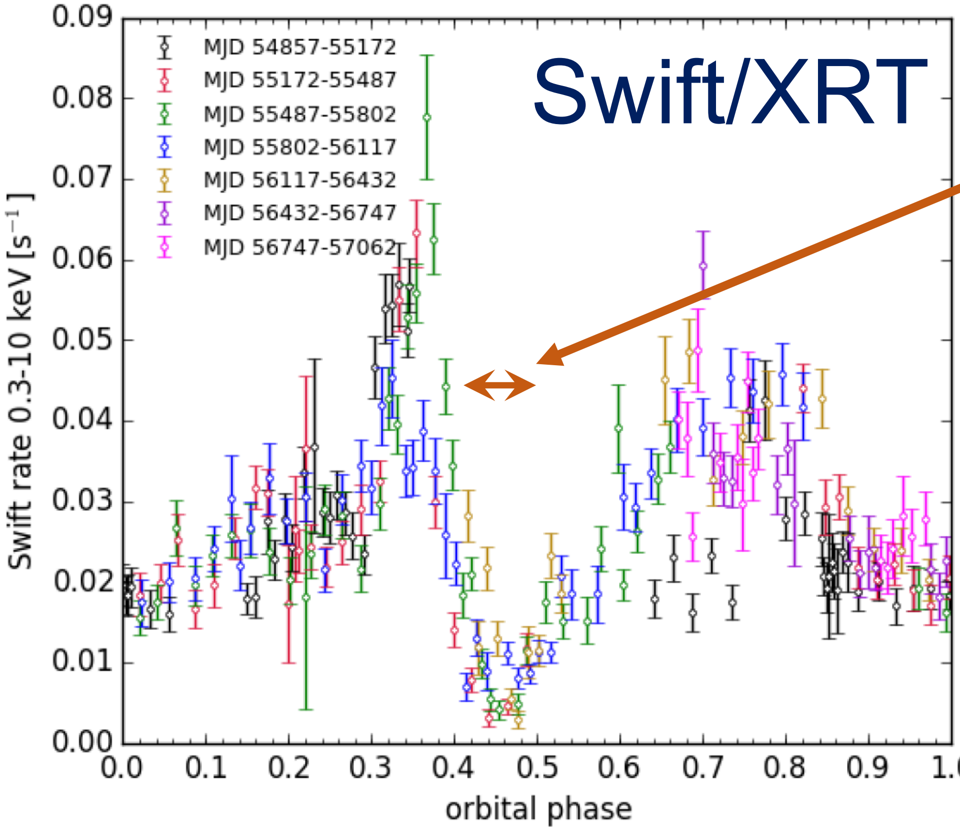
X-ray dip when pulsar is in Be-disk shadow





Take a look at the other Be systems with compact object with unknown nature

HESS J0632+057 (P_{orb}=315 d, e=0.83)

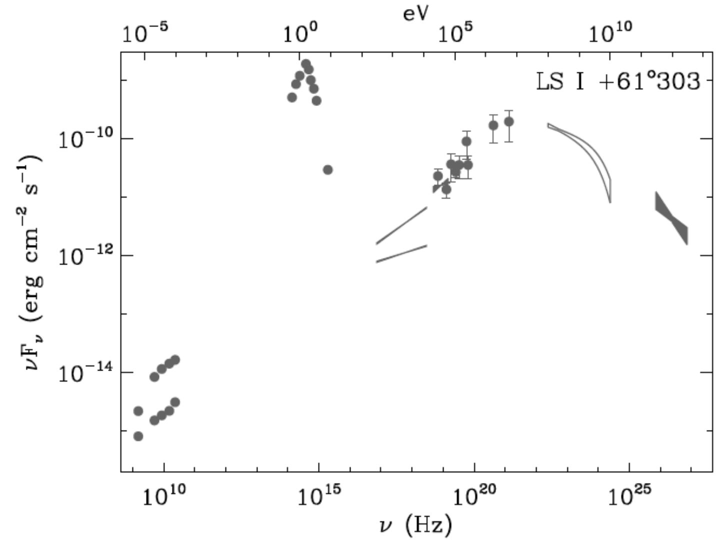


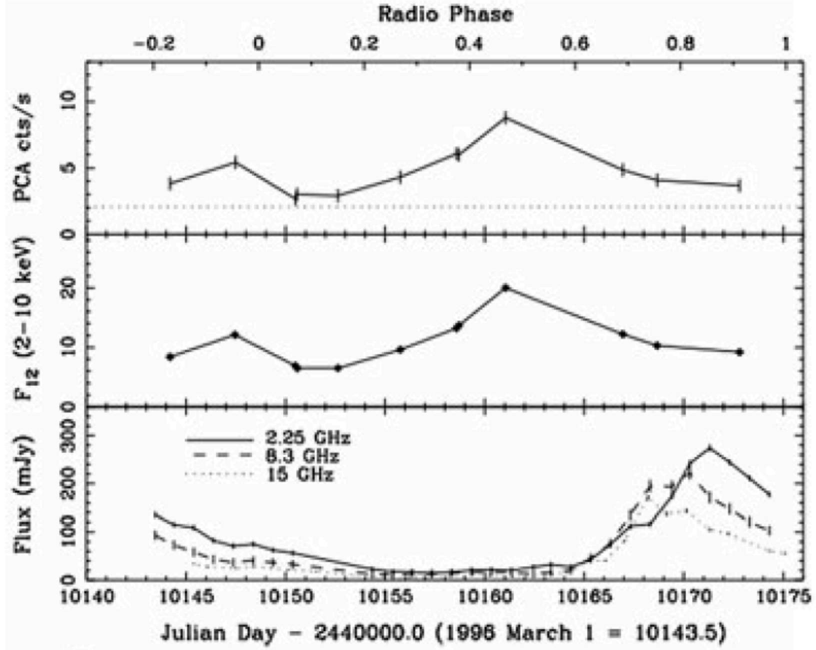
(Maier+ 2015)

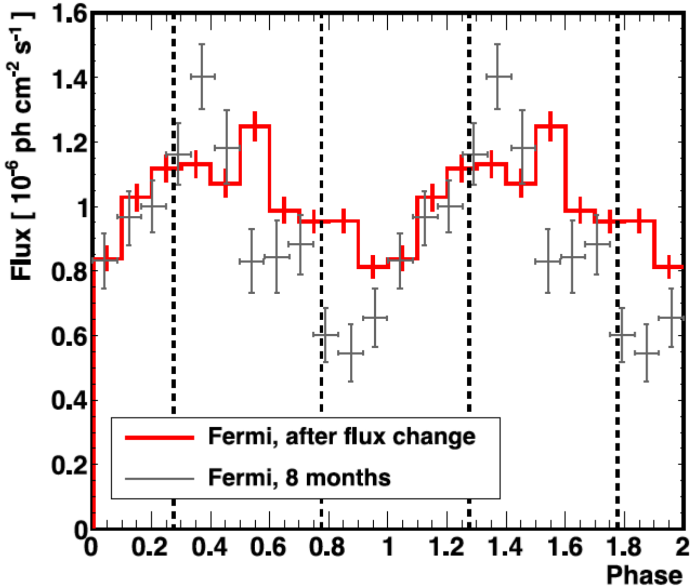
X-ray dip due to Be-disk shadow?

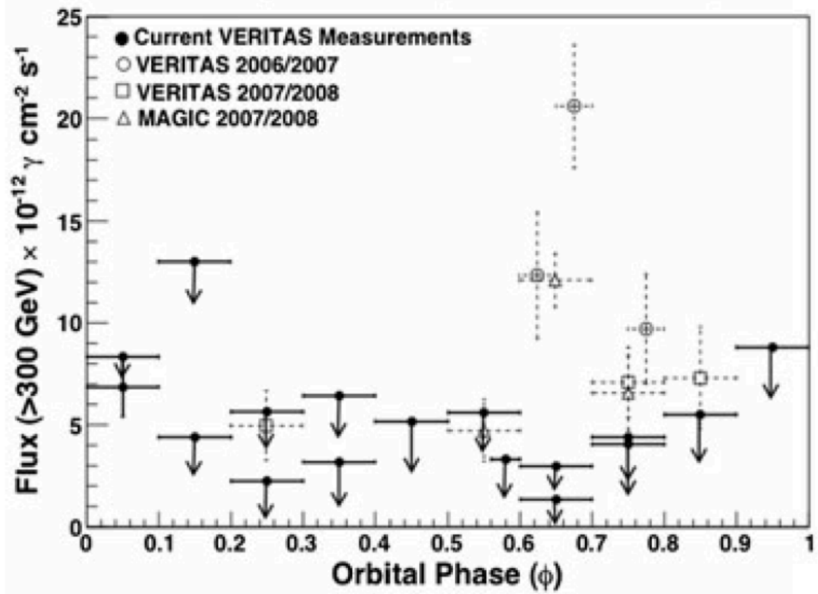
If so, this is a system with a pulsar wind.

LS I+61 303 (P_{orb}=26.5 d, e=0.54 or 0.72)





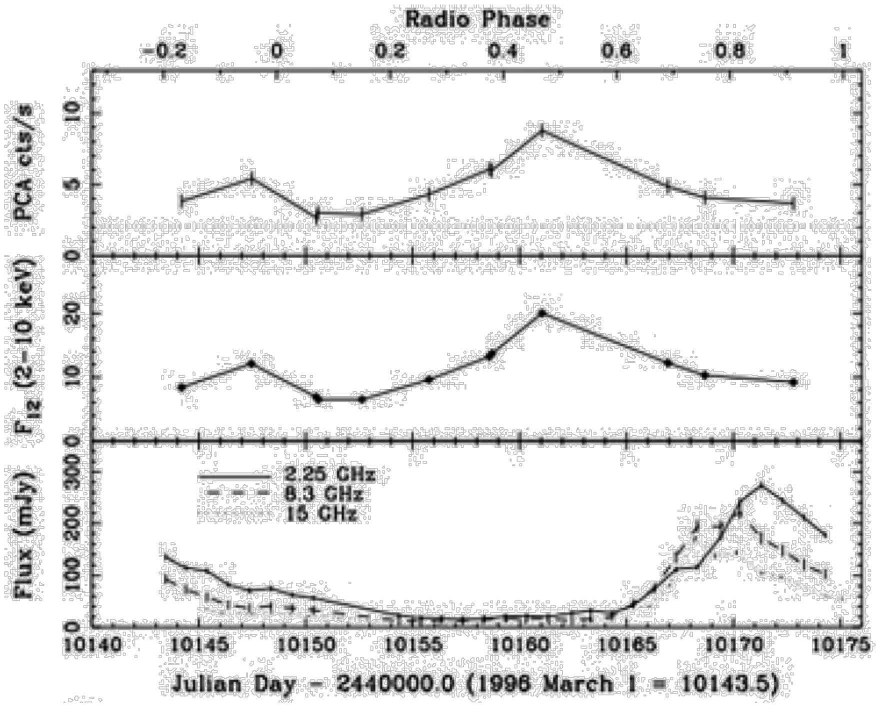




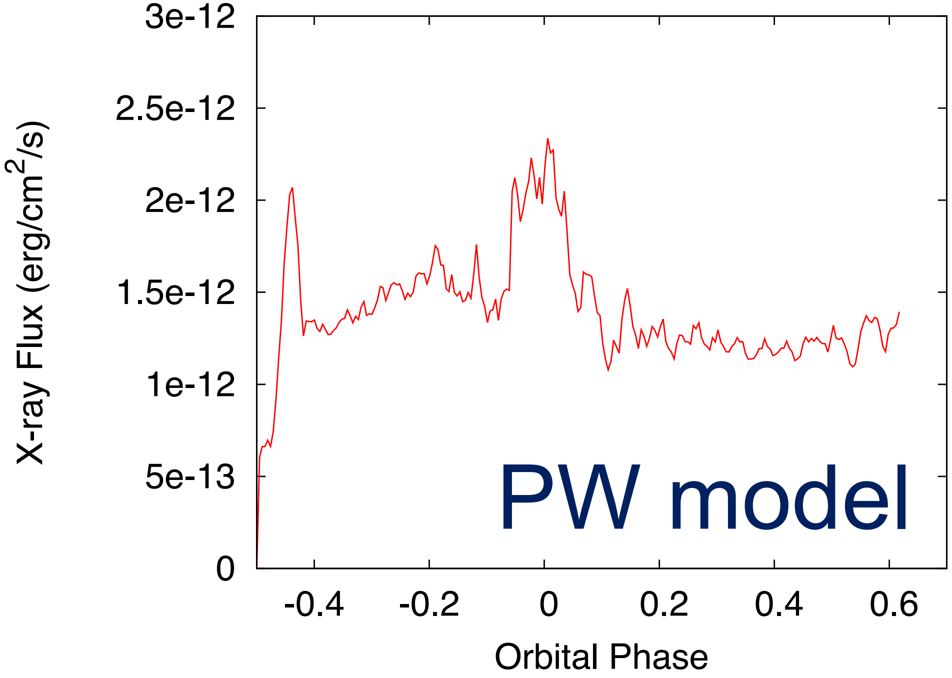
(Dubus 2013)

LS I+61 303 (P_{orb}=26.5 d, e=0.54 or 0.72)

Observed light curves



Simulated X-ray light curve



Observed X-ray flux varies much more smoothly than for PW model

⇨ MQ?

2. High mass X-ray binaries vs. gamma-ray binaries

Comparison between HMXBs and gamma-ray binaries

	HMXB	GB
Number of systems	>100	7
X-ray	Strong (thermal)	Weak (non-thermal)
Gamma-ray	No detection	Strong
Optical companion	Be stars, OB supergiants	Be stars, ms O stars

Evolutionary link between HMXBs and gamma-ray binaries?

Conventional idea based on PW scenario

Spin down of pulsar

Gamma-ray binaries	very young systems with rapidly rotating pulsars
⇩	Magnetar GB?
Transitional populations?	(No) supergiant GBs?
	Systems with flip-flopping pulsars?
⇩	
HMXBs	Slowly rotating, accreting pulsars