GAMMA-RAY BINARIES

Second Astrogam Workshop: towards a White Book on MeV Gamma-ray Astrophysics

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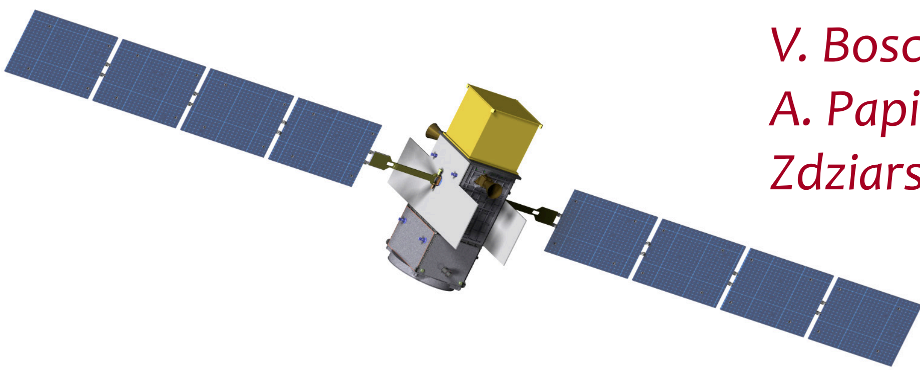

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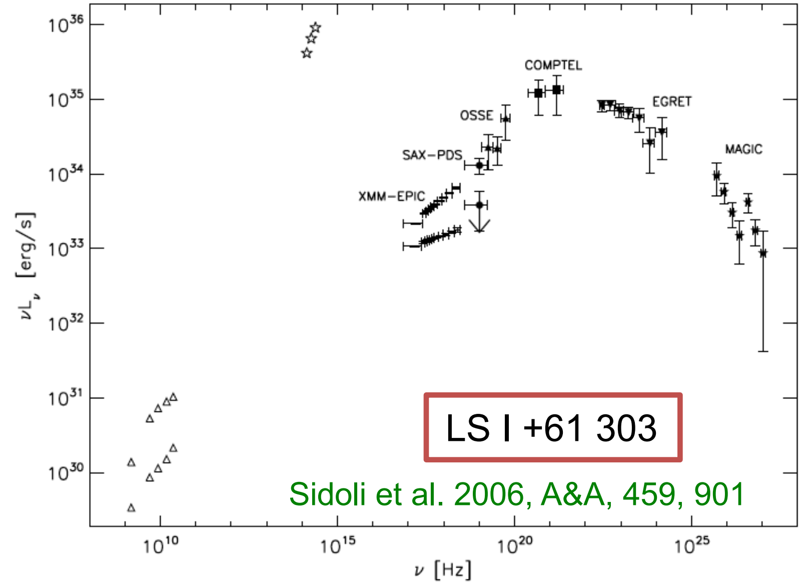
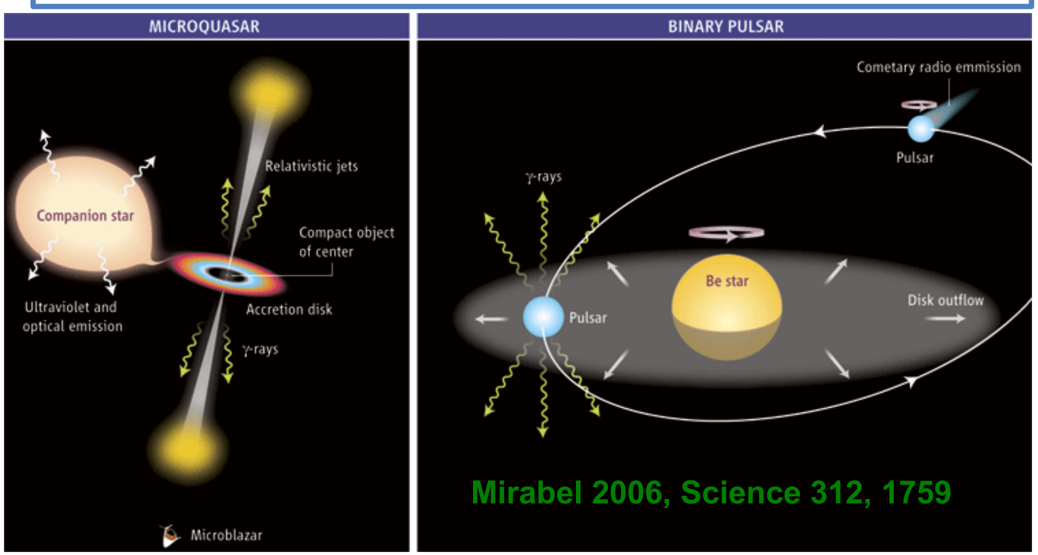
Gamma-ray binaries

Gamma-ray binaries are systems composed of a massive star and a compact object where the non-thermal emission peaks above 1 MeV in a νF_ν spectral luminosity diagram (Dubus 2013).

The definition is simple and based on observational features



Two scenarios to describe the particle acceleration



1. Jets of a microquasar powered by accretion

2. Shocks between the relativistic wind of a young non-accreting pulsar and the wind of the stellar companion

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Known Gamma-ray binaries

Source	System Type	Orbital Period (d)	Radio Structure (AU)	Radio	X-ray	GeV	TeV
PSR B1259-63	O9.5Ve + NS	1237	Cometary tail ~ 120	P	P	P?	P
LS I +61 303	B0Ve + ?	26.5	Cometary tail? 10 – 700	P	P	P	P
LS 5039	O6.5V((f)) +?	3.9	Cometary tail? 10 – 1000	persistent	P	P	P
HESS J0632+057	B0Vpe + ?	320	Elongated (few data) ~ 60	V	P	?	P ?
1FGL J1018.6-5856	O6.5V((f)) +?	16.6	?	P	P	P	P
CXOU J053600.0-673507 (LMC P3)	O5III + NS?	10.3		P	P	P	

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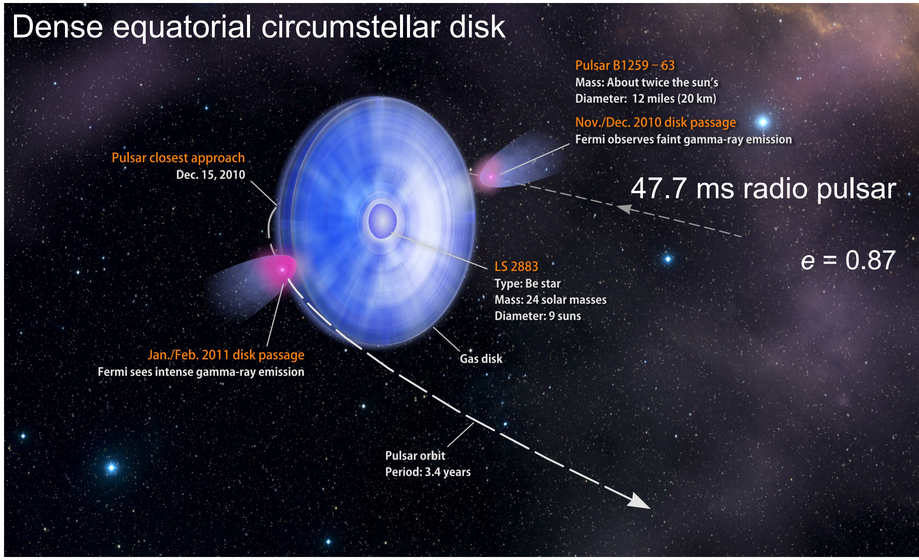
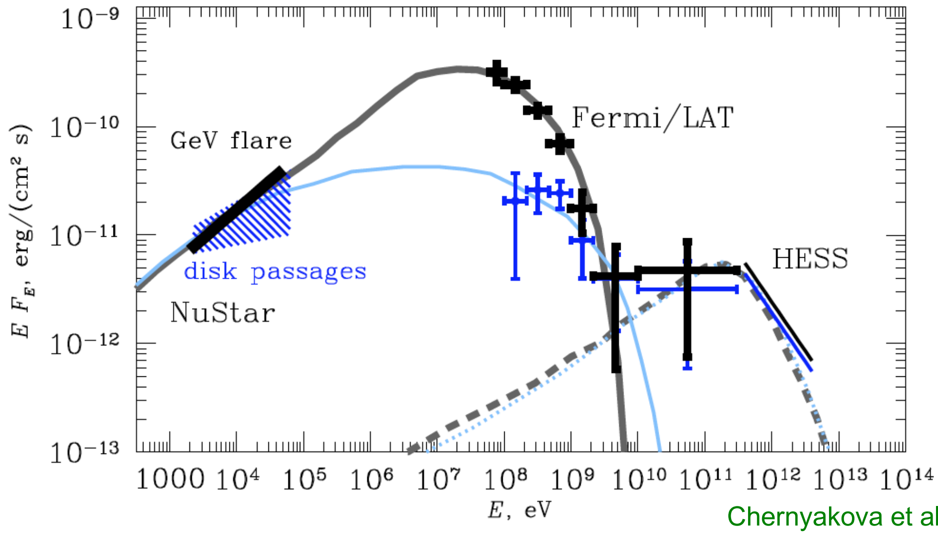
PSR B1259-63: Pulsar + massive star

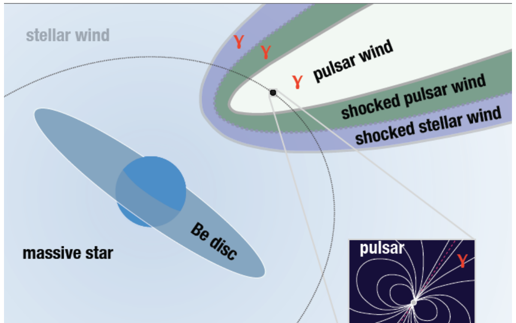


- ✧ The first variable galactic source of VHE
- ✧ A shock forms between the pulsar wind and the circumstellar material. The non-thermal emission is due to high energy particles that are scattered and accelerated at the shock

(Tavani & Arons 1997, ApJ 477, 439)



Chernyakova et al. 2015



Dubus 2013, A&Arv 21, 64

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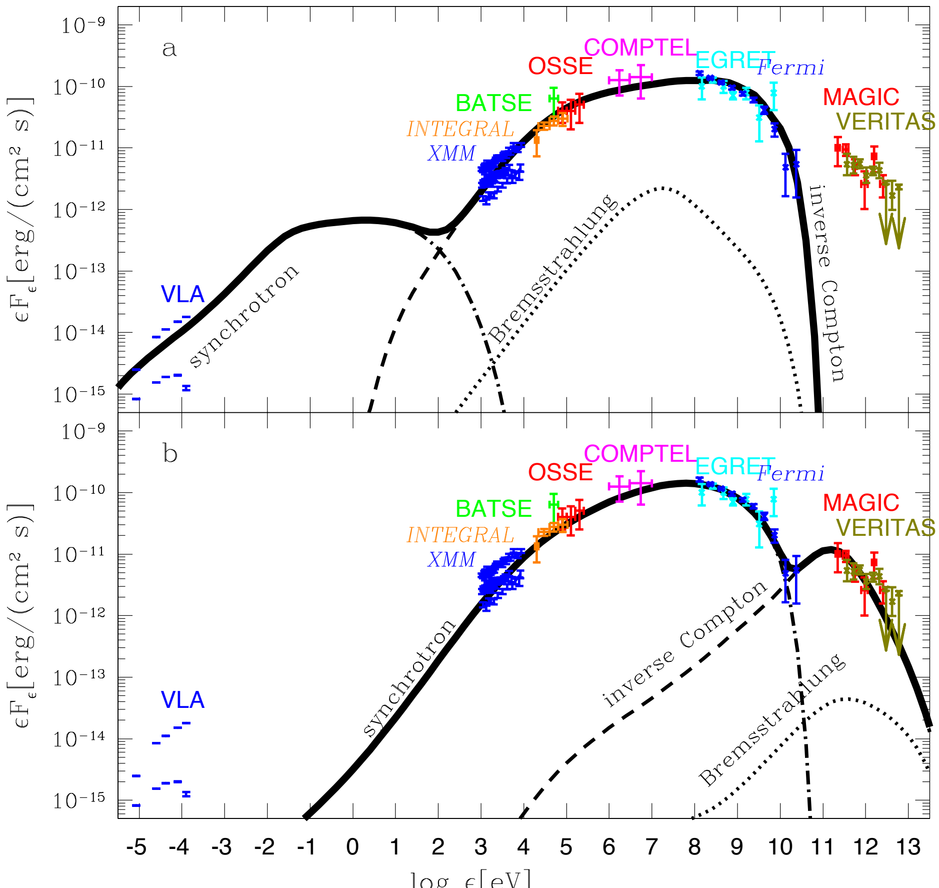
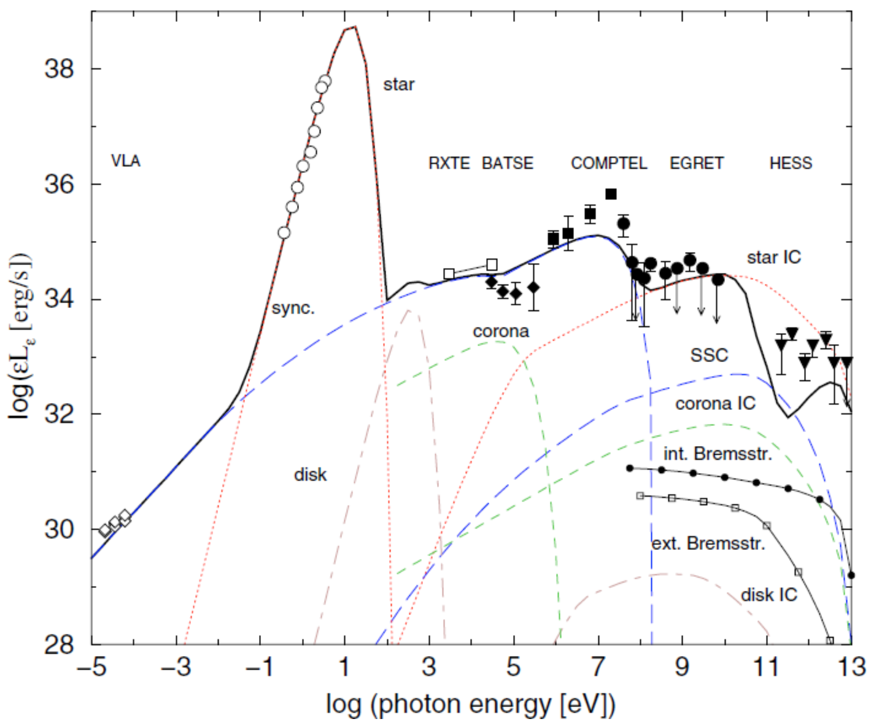
LSI+61303 and LS5039

Zdziarski et al. 2010, MNRAS, 403, 1873



Paredes et al. 2006, A&A, 451, 259



g-ray binaries have most likely two dominant radiation mechanisms: synchrotron emission, from radio to X-rays/soft g-rays, and IC scattering of stellar photons, dominant in the HE and the VHE range

Importance of g-ray observations

- SED of g-ray binaries often **peak below ~100 MeV**. The lack of enough coverage and sensitivity at these energies has so far hampered to assess the true nature of the g-ray emission from these sources.

- Sensitive observations below ~100 MeV
  - are likely to **detect many more** g-ray binaries, as the number of g-ray binaries in the Galaxy is expected to be between 50 and 200.
  - will probe the synchrotron and IC **intersection region**, allowing us to distinguish between the two components.

- If synchrotron emission is dominant, exploring the MeV-GeV range can allow probing extreme **particle acceleration**.

- If IC is dominant, the MeV-GeV range can provide important information related to how non-thermal particles **propagate away** from the stellar companion, as IC losses are slow for electrons producing MeV photons via IC with stellar photons.

Expected results with e-ASTROGAM

- COMPTEL data already indicated that g-ray binaries are powerful MeV emitters.

- e-ASTROGAM, with its sensitivity in soft g-rays two orders of magnitude better than that of COMPTEL, will discover many new cases of g-ray emission of binaries.

- e-ASTROGAM sensitivity will allow:
  - the characterization of the orbital light curve and spectral evolution of g-ray binaries
  - differentiating the synchrotron and the IC components
  - probing particle acceleration and g-ray reprocessing
  - potentially revealing pulsar wind physics that can only be probed in this kind of objects

- After the expected launch of e-ASTROGAM, major new facilities from radio to VHE g-rays, SKA, Athena and CTA, will also be operational. This will provide an unprecedented opportunity to study particle acceleration, outflows, and wind launching mechanisms in different types of binaries.