On the Origin of X-ray/VHE Correlation in LS I +61 303

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- Night-to-night variability in VHE, X-ray.
- Kilosecond/hour scale variability in X-ray
- Long-term four year superorbital radio peak modulation (Paredes 1987) on top of orbital varibility.
- SGR-like burst lasting $\sim$0.5 s in hard X rays (de Pasquale et al. 2008, GCN 8209).

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- Orbital periodicity (26.5 d) in radio, X-ray, HE and VHE γ-ray.
- Periodic outbursts in X-ray and VHE in $0.6 < \phi < 1.0$, while maximum in HE is around $0.0 < \phi < 0.4$.

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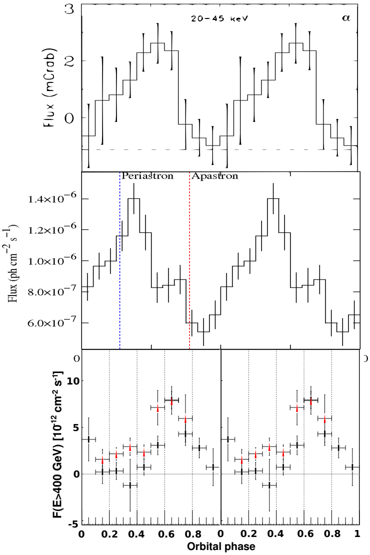

INTEGRAL Hard X-ray

(Hermsen et al. 2006)

Fermi HE γ-ray

(Abdo et al. 2009)

MAGIC VHE γ-ray

(Albert et al. 2009)

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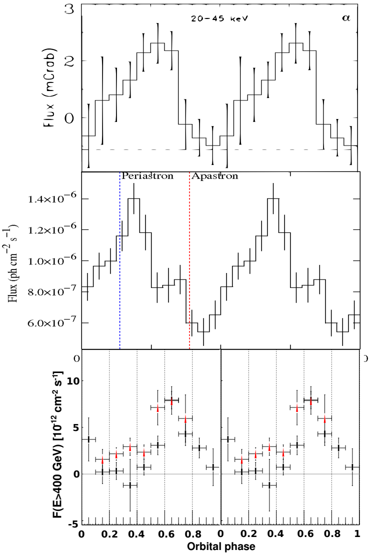

INTEGRAL Hard X-ray

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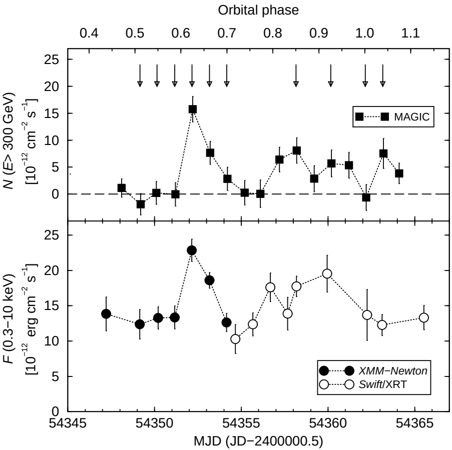
But NOT stable! See talks by Diego, Tobias, Gernot.

VHE/X-ray Multiwavelength observations



- MAGIC, *XMM-Newton* and *Swift* campaign covering $\sim$ 60% of an orbital period in 2007 (Anderhub et al. 2009, ApJ, 706, L27).
- X-ray (*XMM-Newton* and *Swift*) and VHE (MAGIC) $\sim$ 17 observations.
- Significant correlation: $r = 0.81^{+0.06}_{-0.21}$ ($r = 0.97$ for first outburst)

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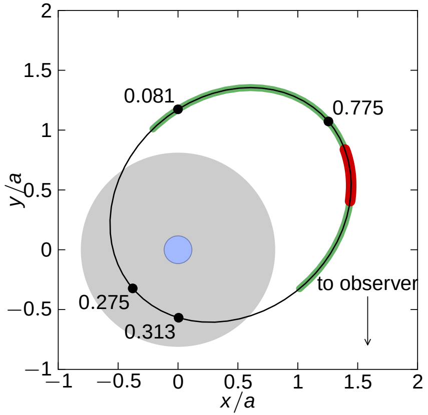

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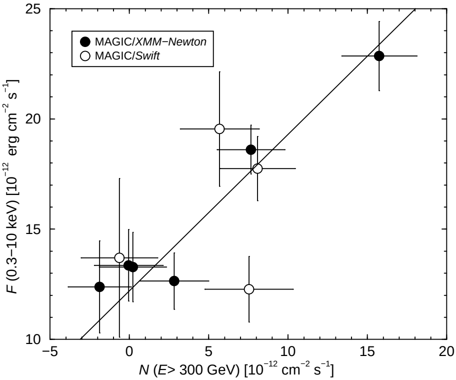

$$F_X/[10^{-12}\,\mathrm{erg/cm^2/s}] = 12.2^{+0.9}_{-1.0} + (0.71^{+0.17}_{-0.14}) \times F_{TeV}/[10^{-12}\,\mathrm{ph/cm^2/s}]$$

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Model description

- Emitter located at the position of the compact object.
- OZM: Homogeneous physical properties throughout the emitter.
- Constant magnetic field along the orbit.

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Khangulyan et al. (2007) and Takahashi et al. (2009) take the same approach for PSR B1259-63 and LS 5039.

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- X-ray photon index ($\Gamma_X \simeq 1.5$) matches a $\alpha_e = 2$ injection spectrum

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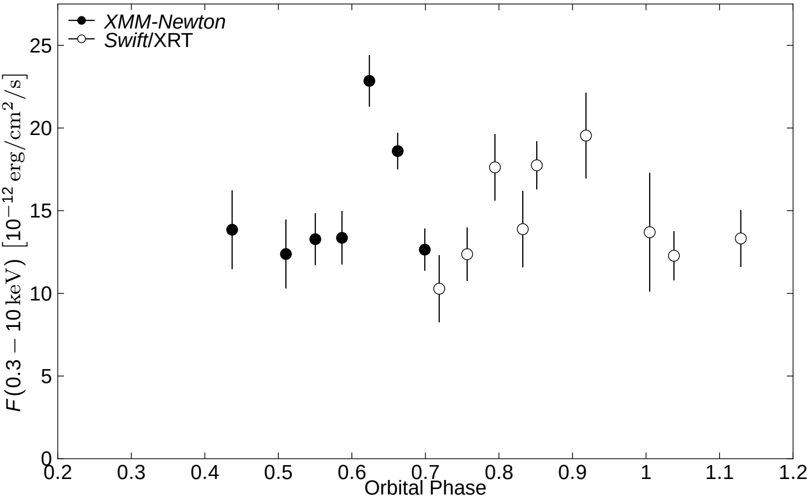
Model description: Derivation of t_{ad}



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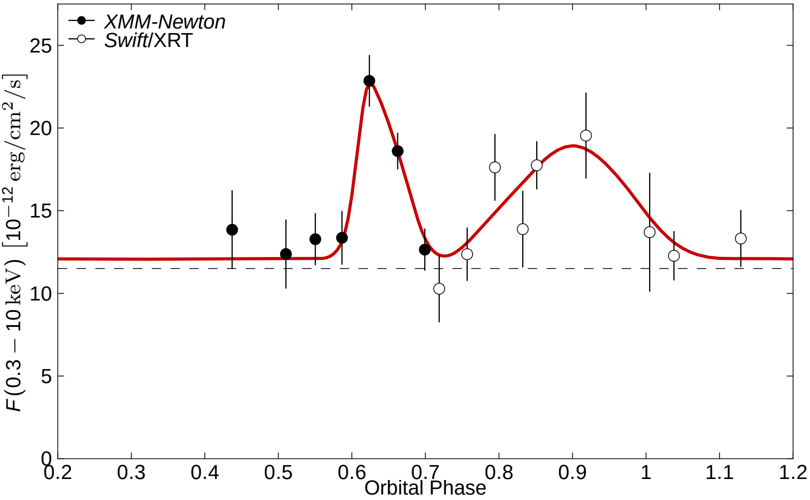

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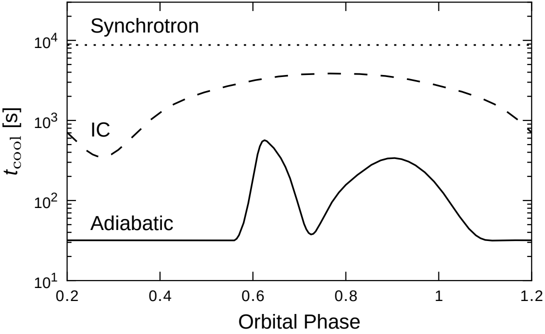

- Requirements for t_{ad}:
  - $t_{ad} \propto F_X$
  - $t_{ad} < \min(t_{IC}, t_{syn})$

Obtained t_{ad}: tens to hundreds of seconds

Model description (II)

- Constant injection spectrum: Power-law with high energy cutoff at balance of $t_{\rm acc} = \eta R_L/c$ and $t_{\rm cool}$:

$$E_{e,max} \approx 9 B_G t_{ad} \eta^{-1} \text{ TeV} \qquad \text{for adiabatic}$$

$$E_{e,max} \approx 60 (B_G \eta)^{-1/2} \text{ TeV} \qquad \text{for synchrotron}$$

- To obtain 10 TeV electrons: $\eta \lesssim \min(B_G t_{ad}, 40 B_G^{-1})$

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- Steady state electron energy distribution at each phase:

$$n(\phi, \gamma_e) = \frac{1}{|\dot{\gamma}|} \int_{\gamma_e}^{\gamma_e^{\mathrm{max}}} Q(\gamma')\, \mathrm{d}\gamma'$$

- Orbital parameters from Aragona et al. (2009, ApJ, 698, 514) and $i = 45^\circ$

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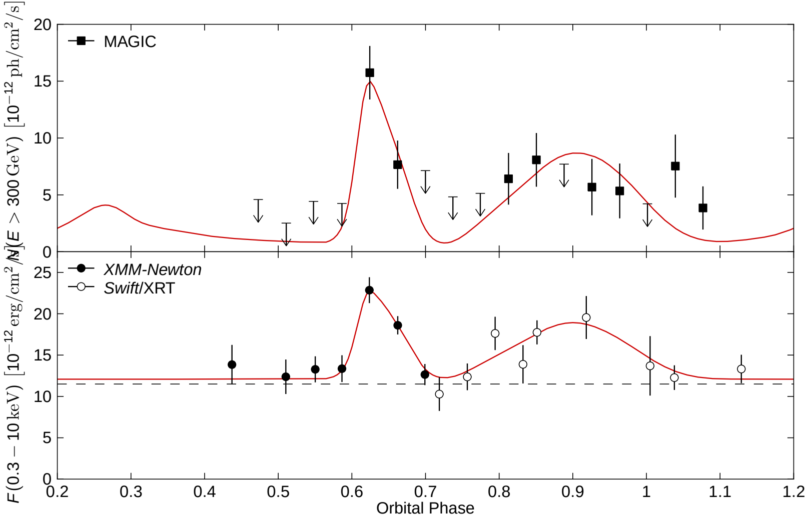
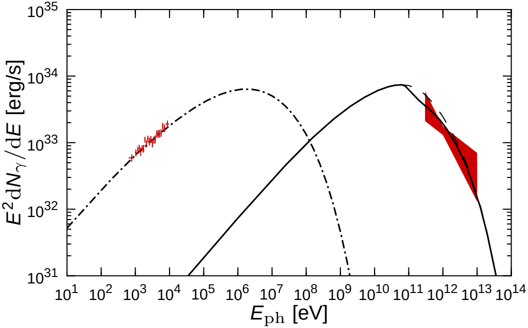
Results: MW lightcurve



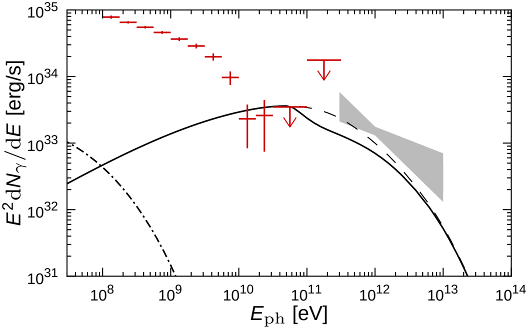
$B = 0.22$ G $\qquad \eta = 10 \qquad L_{inj} \sim 10^{35}$ erg/s

Results: SED during outburst (0.6 $<\phi<$ 0.7)



- SED averaged over the phases of three observations during the first outburst.
- Best agreement:
  - $\alpha_e = 2.1$
  - $\eta =$ 7–120

Phase averaged ($0 < \phi < 1$) SED: Fermi



MAGIC spectrum NOT simultaneous

Fermi data in 10–100 GeV require a harder particle distribution below $E_e = 4 \times 10^{11}$ eV.

$$\alpha_e \begin{cases} \lesssim 1.8 & \text{if } E_e < E_{break} \\ = 2.1 & \text{if } E_e > E_{break} \end{cases}$$

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- Adiabatically dominated OZM effective to isolate the emitter's properties:
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For more information: **arXiv:1011.4489**

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