What is the origin of the GeV γ-ray emission in Cygnus X-3?

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Introduction: The microquasar Cygnus X-3 emits high-energy radiation (>100 MeV) modulated with the 4.8h orbital period of the system. We model the γ-ray modulation and calculate the γ-ray optical depth in the system. These two analyses constrain the location of the γ-ray source in Cygnus X-3.

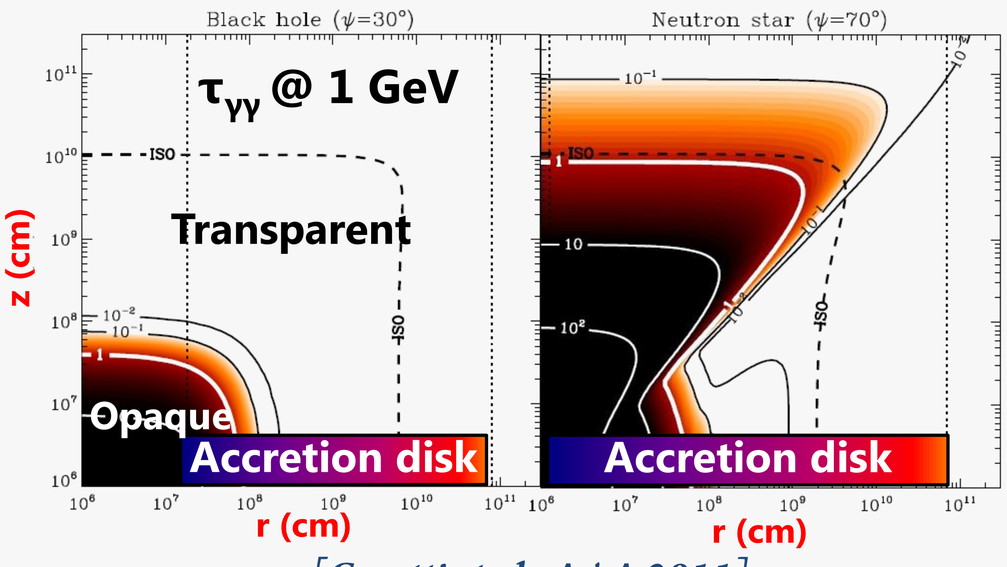
1. Gamma-ray Absorption

1.1 X-rays in Cygnus X-3

GeV γ-rays are absorbed by soft X-rays (~keV). In Cygnus X-3, γ-rays are observed when the X-ray spectrum is dominated by the thermal emission from the accretion disk (soft state) and a hard non-thermal tail extending beyond 10 keV possibly emitted by the accretion disk corona.

1.2 Absorption by the disk

We compute the γ-ray optical depth $\tau_{\gamma\gamma}$ above an optically thick, geometrically thin disk.

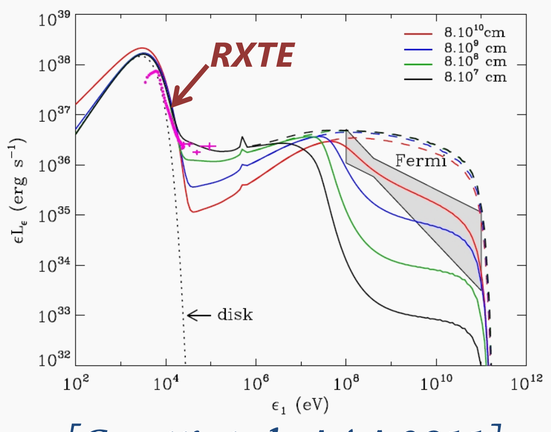


[Cerutti et al., A&A 2011]

The γ-ray source should be located >10^{10} cm from the compact object.

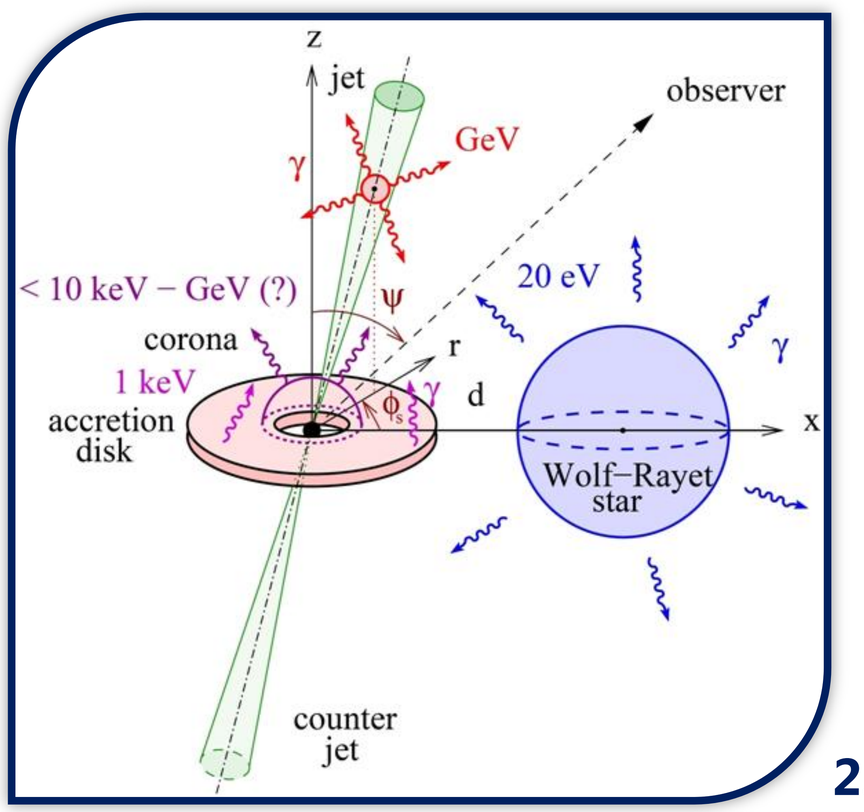
1.3 Gamma-ray emission from the corona?

High-energy γ-rays cannot originate from the corona unless it is unrealistically extended (radius>10^{10} cm) because of high absorption by the disk.



[Cerutti et al., A&A 2011]

Diagram of Cygnus X-3



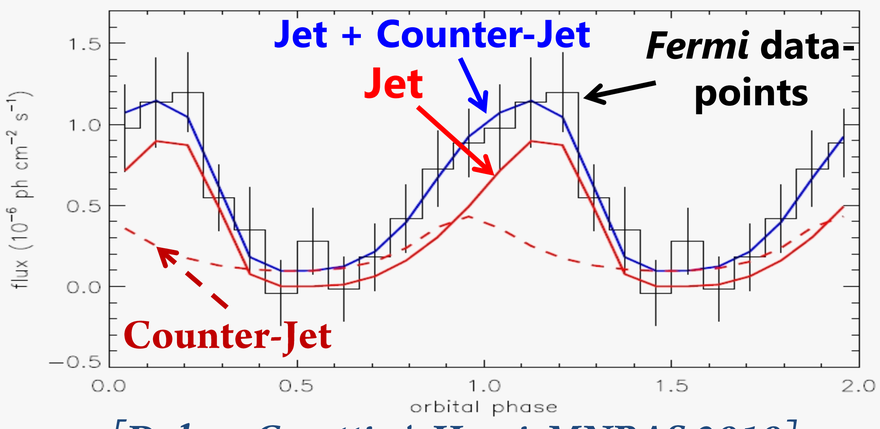
2. Gamma-ray Modulation

2.1 Origin of the modulation

The γ-ray orbital modulation is naturally explained by the anisotropic inverse Compton scattering of the Wolf-Rayet star photons (~20 eV) onto ultra-relativistic electron-positron pairs corotating with the compact object.

2.2 Modeling of the modulation

We compute the γ-ray lightcurve assuming that pairs are accelerated in a relativistic jet.

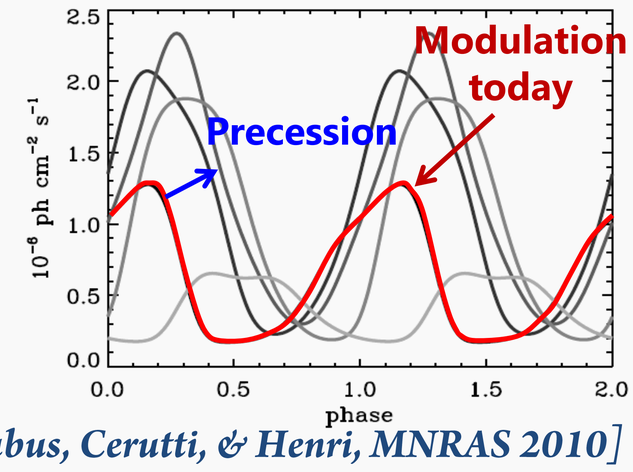


[Dubus, Cerutti, & Henri, MNRAS 2010]

Resulting constraints:
- Jet inclined, close to the line of sight
- Jet mildly relativistic
- Pairs injected ~10^{11}-10^{12} cm from compact object

2.3 Effect of the precession of the jet

If the jet precesses, the shape and the amplitude of the modulation should change significantly.



[Dubus, Cerutti, & Henri, MNRAS 2010]

3. Conclusion: The gamma-ray emission should be emitted **far (>10^{10} cm)** from the compact object, possibly in an **inclined** and **mildly relativistic jet.**

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