Modeling of spectra from γ-ray binaries with pulsars

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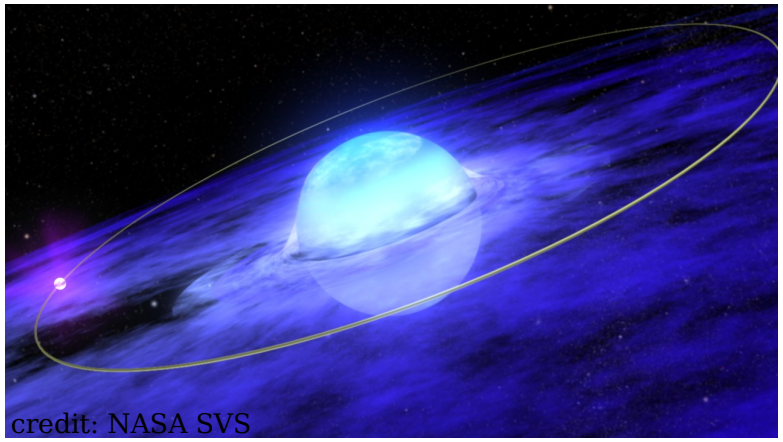
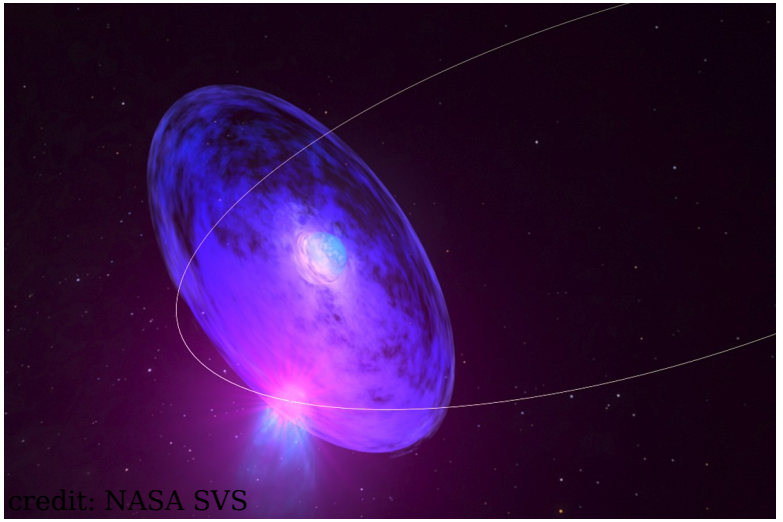
31.07.2014

credit: NASA SVS

γ-ray binaries

- compact object + massive star
- peak in νF_ν above 1 MeV
- winds play crucial role

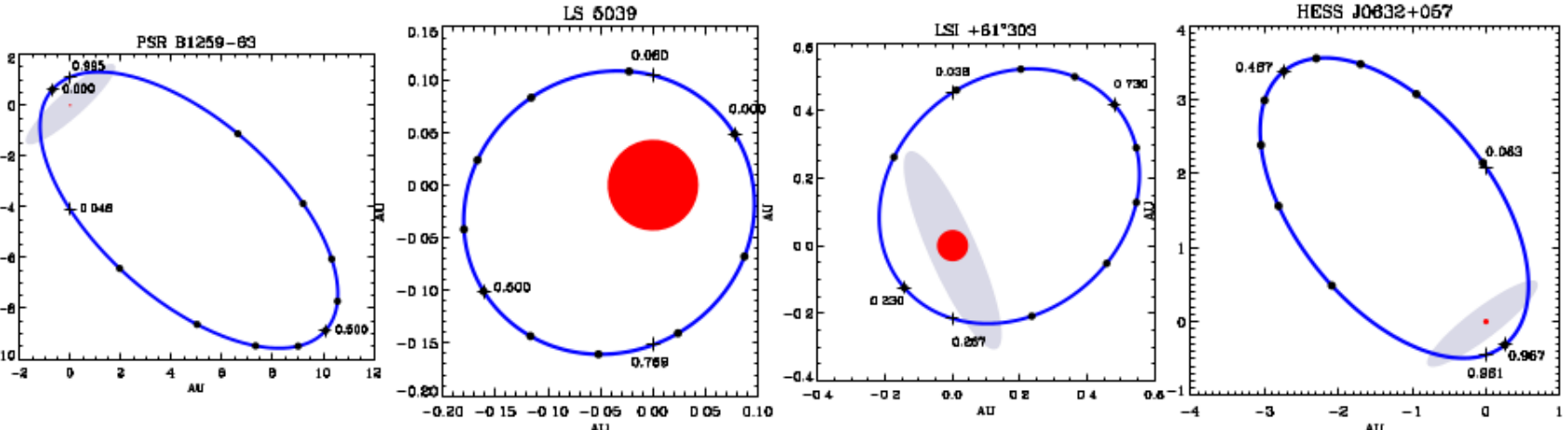

credit: NASA SVS

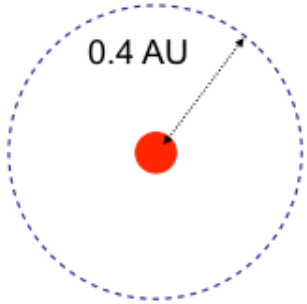

credit: NASA SVS

γ-ray binaries

$HE \in (0.1-100)\,GeV$
$VHE > 100\,GeV$

PSR B1259-63	LS 5039	LS 1+61 303	HESS J0632+057	1FGL J1018.6-5856
PSR + Be $M_{Be} = 31\ M_\odot$	? + O $M_O = 23\ M_\odot$	? + Be $M_{Be} = 12\ M_\odot$	? + Be $M_{Be} = 16\ M_\odot$	? + O $M_O = 31\ M_\odot$
P = 1237 day e = 0.87	P = 3.9 day e = 0.35	P = 26.5 day e = 0.54	P = 315 day e = 0.84	P = 16.6 day
HE + VHE	HE + VHE	HE + VHE	VHE	HE + VHE



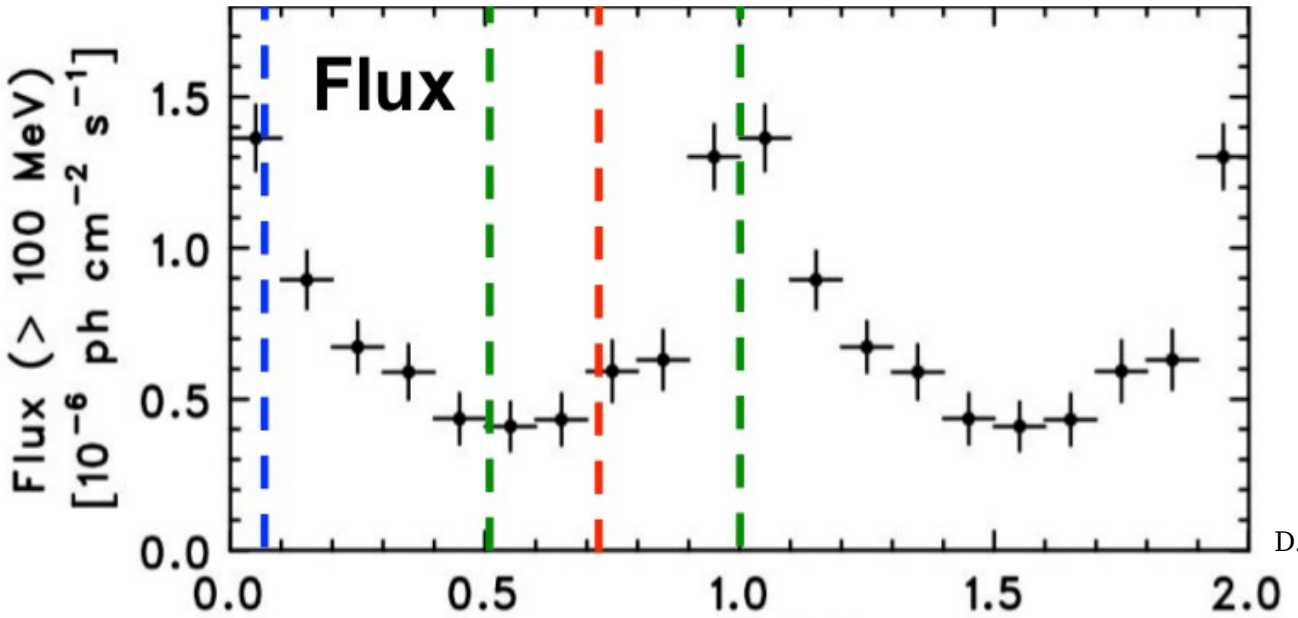


credit: G.Dubus

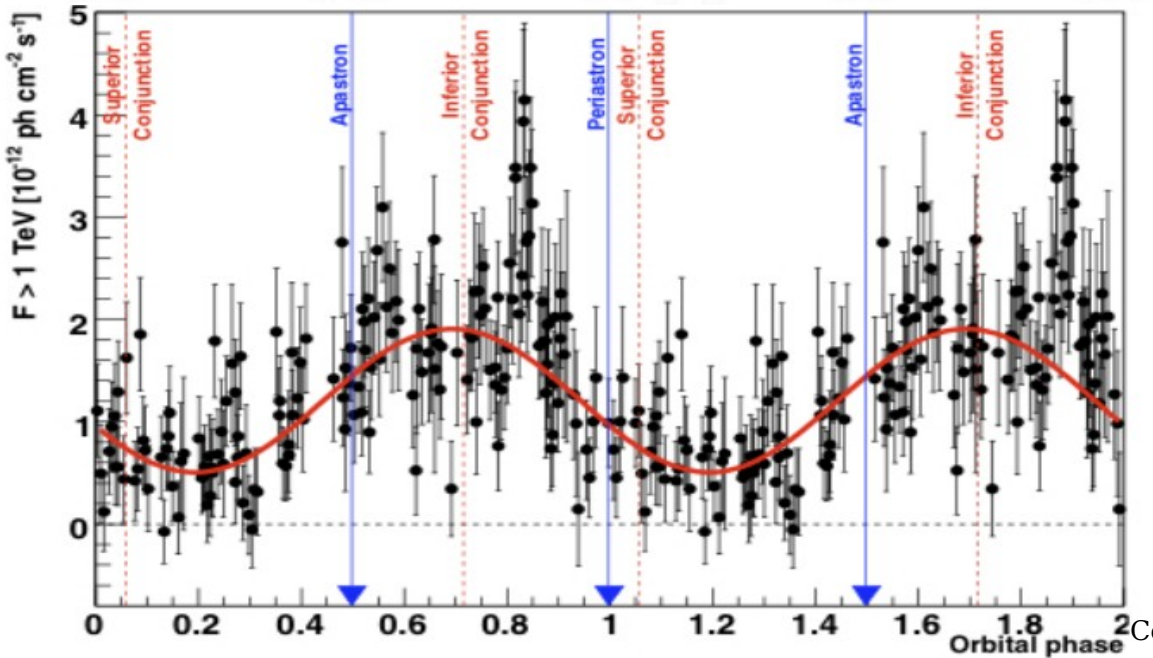
γ-ray binaries

anti-correlation in fluxes from TeV and GeV ranges for

LS 5039

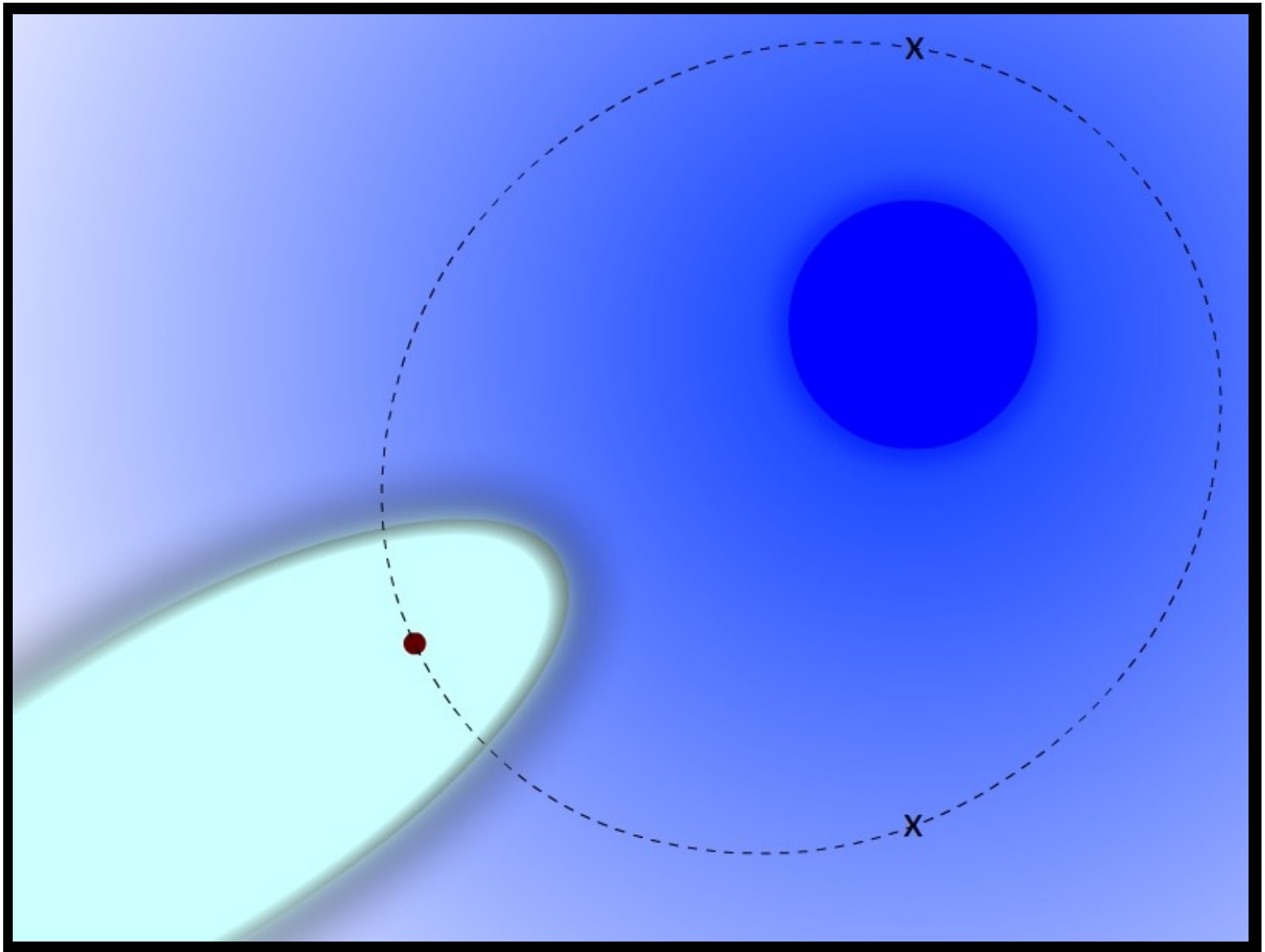


credit: D.Hadasch 2012



credit: HESS Collaboration 2005

Model



Pulsar

- electron energy distribution

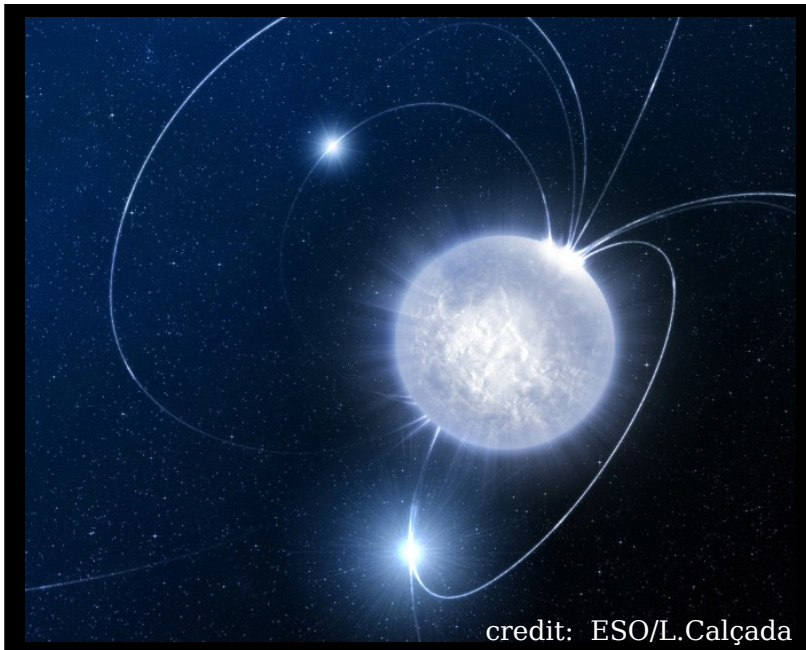
$$\frac{dN_e}{d\gamma\, d\Omega\, dx} = K_1 \gamma^{-\delta}$$

$$\kappa_1 L_{sd} = 4\pi c \int \gamma mc^2 \frac{dN_e}{d\gamma\, d\Omega\, dx} d\gamma$$

- HE pulsar component

$$\frac{dN_\gamma}{dE} = K_2 E^{-\Gamma} e^{E/E_{cutoff}}$$

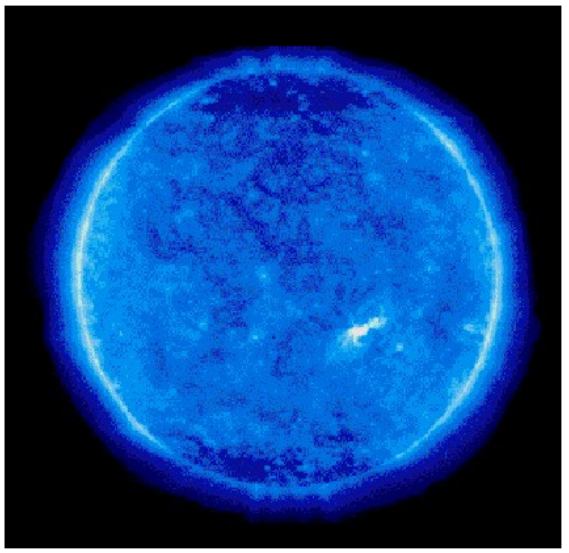
$$\kappa_2 L_{sd} = 4\pi \int E \frac{dN_\gamma}{dE} dE$$



Star

- stellar photon emissivity

$$\frac{dn_{ph}}{dE\,d\Omega} = \frac{2E^2}{h^3 c^3}\left(e^{E/kT} - 1\right)^{-1}$$

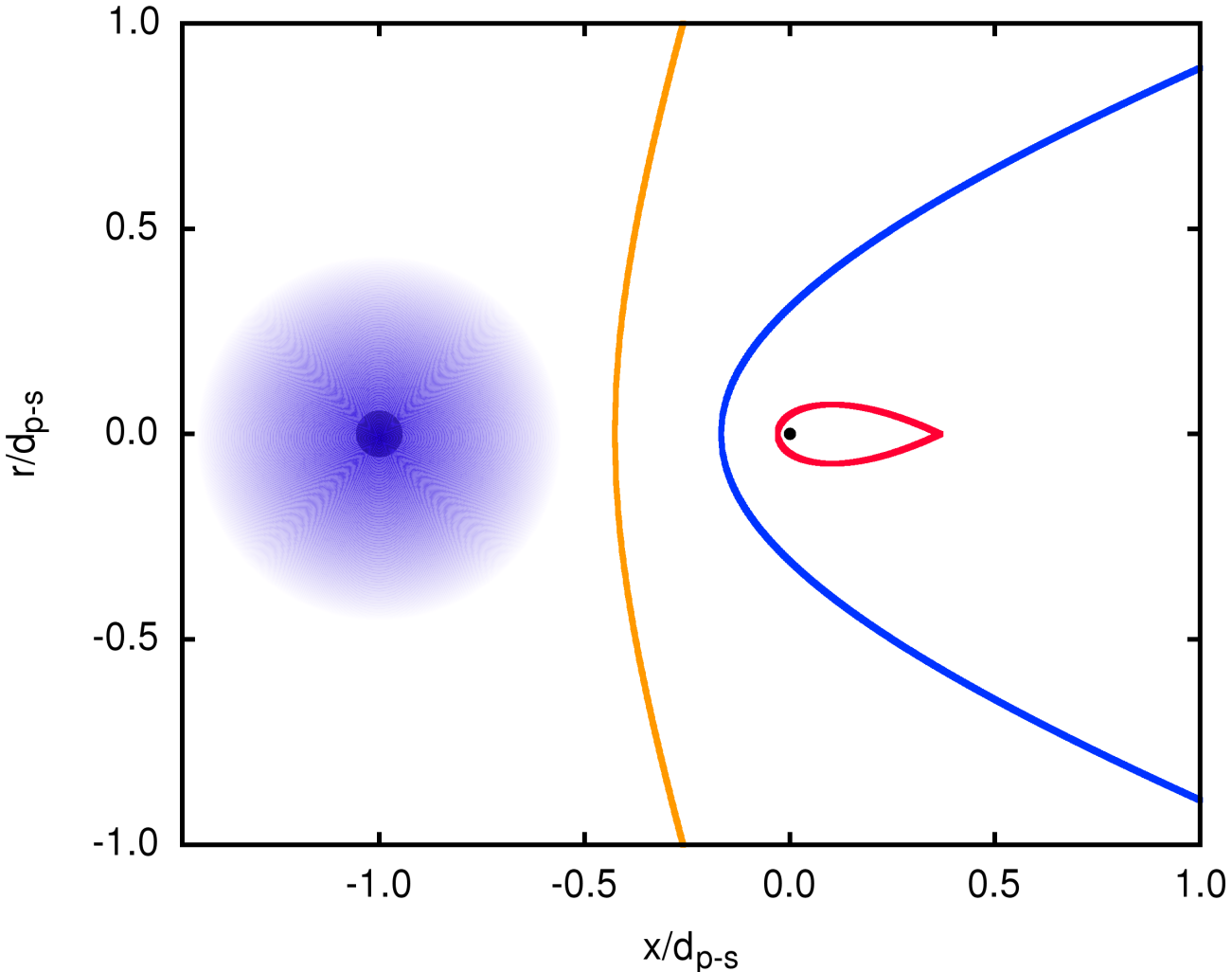


Termination shock

Ram pressures ratio: $\eta = \frac{P_{pw}}{P_{sw}}$

$$P_{pw} = \frac{L_{sd}}{4\pi r^2 c}$$

$$P_{sw} = \frac{\dot{M} V}{4\pi r^2}$$



η = 1

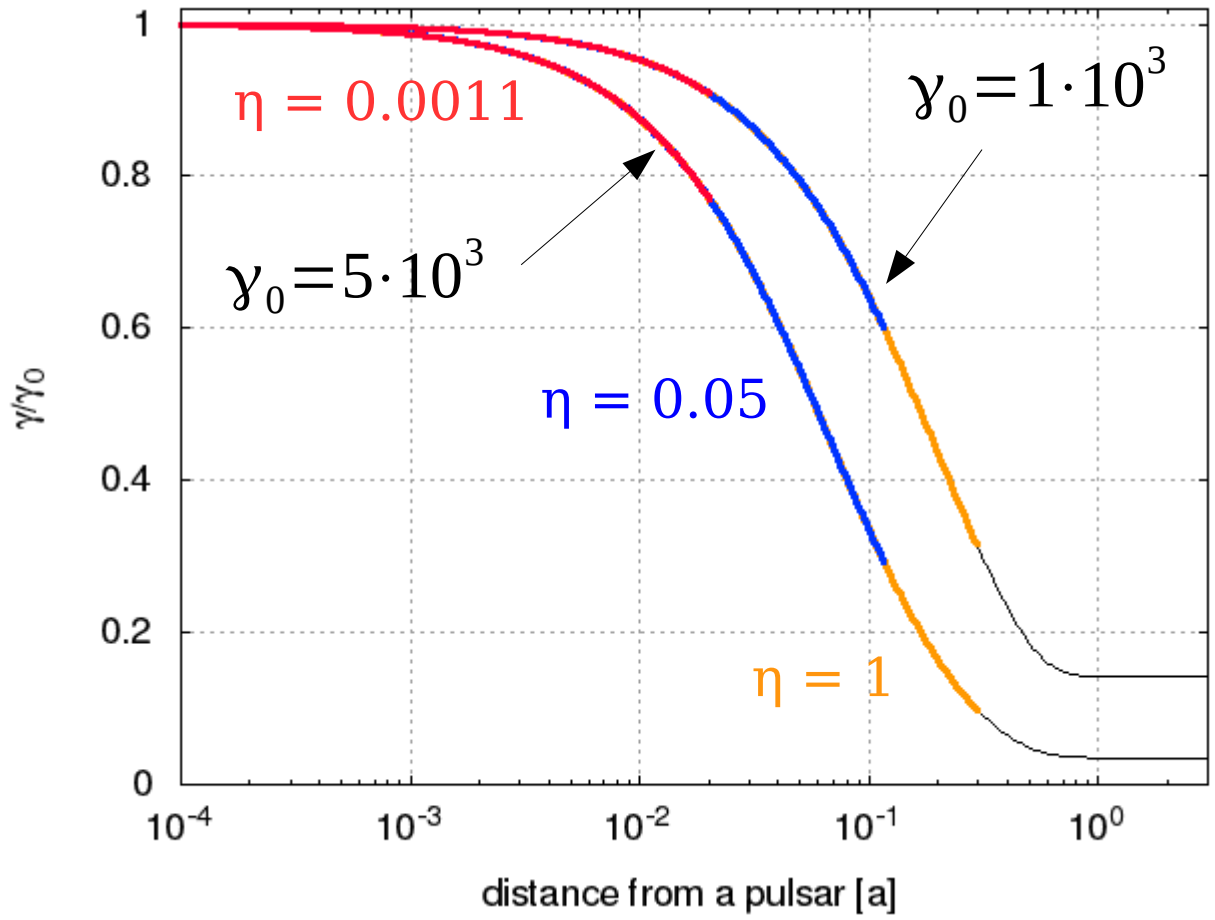
η = 0.05

η = 0.0011

Cooling of electrons by ICS

$$\frac{d\gamma}{dx} = -\frac{1}{mc^3}\int d\Omega \int dE \int dE_1 (E_1 - E)\frac{dn_{ph}}{dE\, d\Omega}\frac{dN}{dt\, dE_1}$$

example for superior conjunction



Results for LS 5039

- pulsar spin down luminosity:

$$L_{sd} = 6 \cdot 10^{36} \, erg/s$$

  - in electrons with a Lorenz factor $\gamma \in (10^3, 6 \cdot 10^3)$ with a $\delta = 2$:

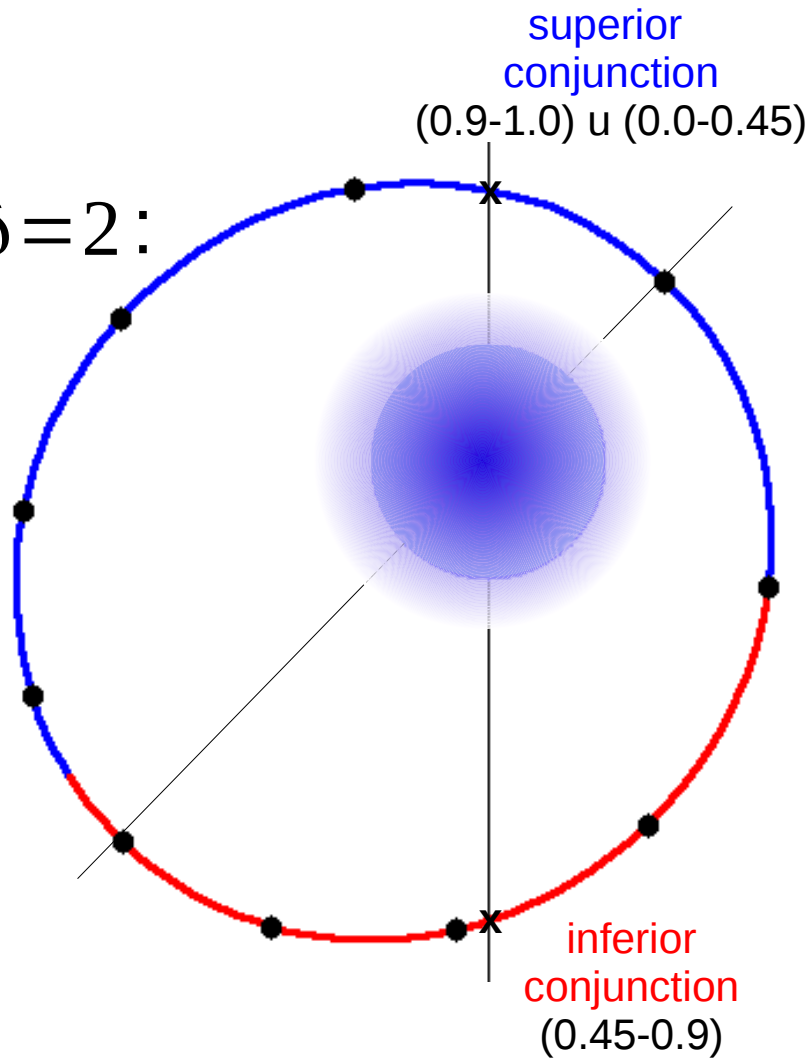
$$\kappa_1 = 0.2$$

  - in HE component of a spectrum with $\Gamma = 2.22$ and $E_{cutoff} = 4.5 \, GeV$:

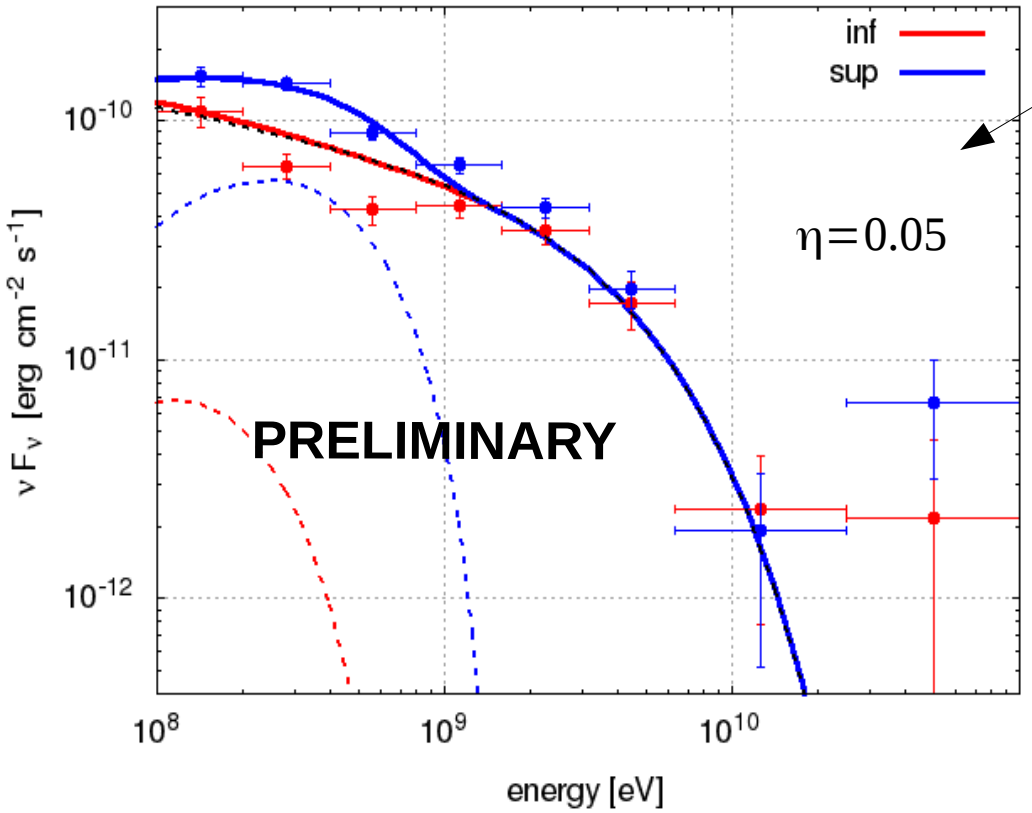
$$\kappa_2 = 0.14$$

- star with a temperature

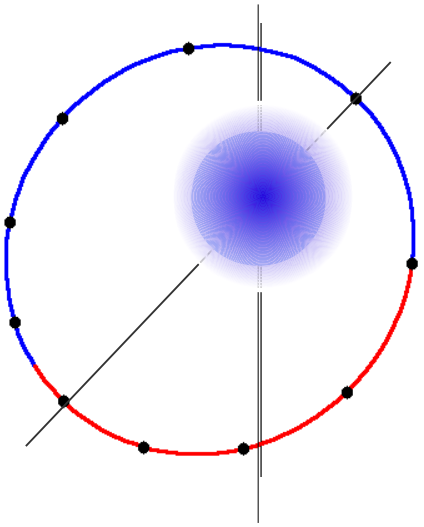
$$T = 39\,000 \, K$$

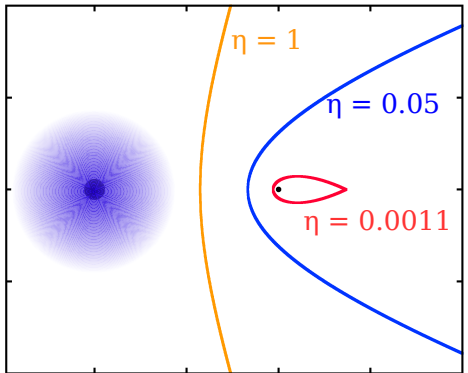


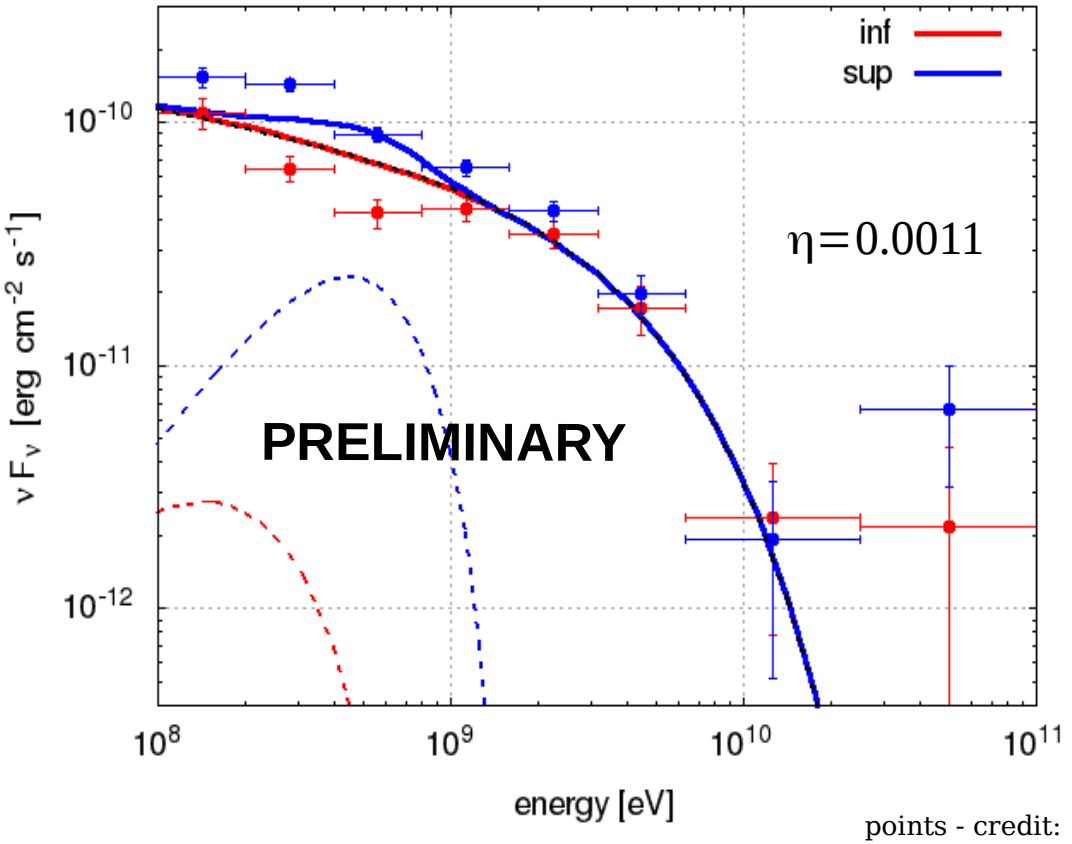
Results for LS 5039



almost the same for $\eta=1$

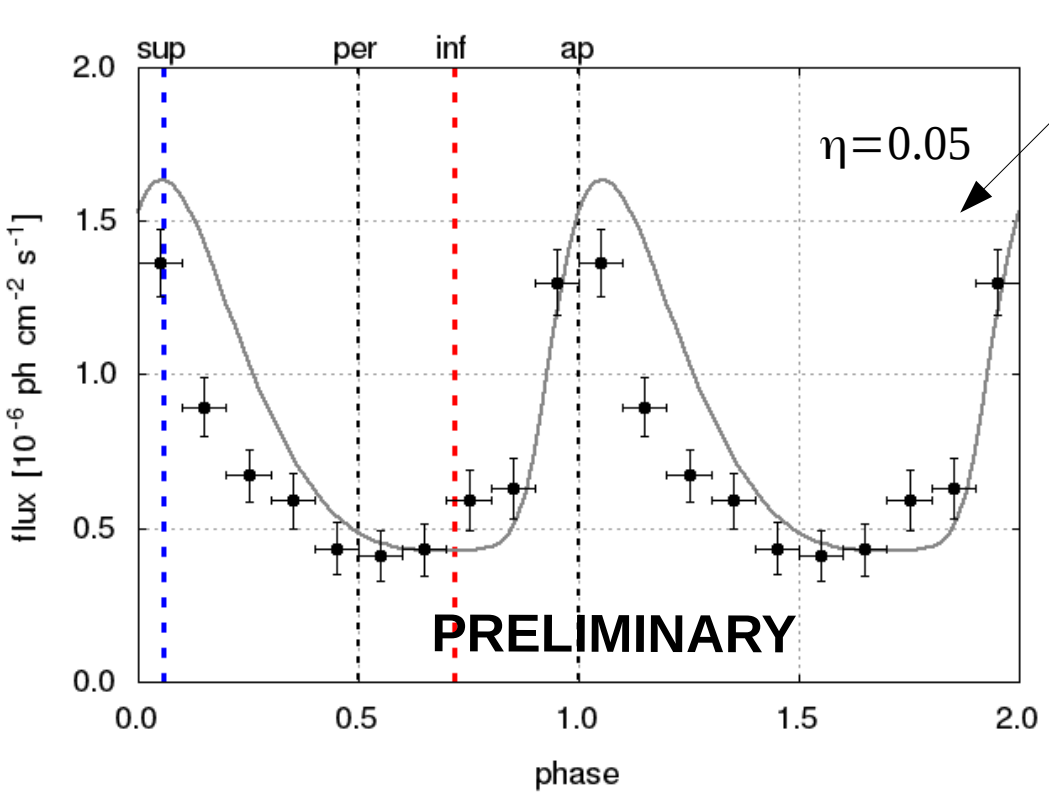






points - credit: D.Hadasch 2012

Results for LS 5039



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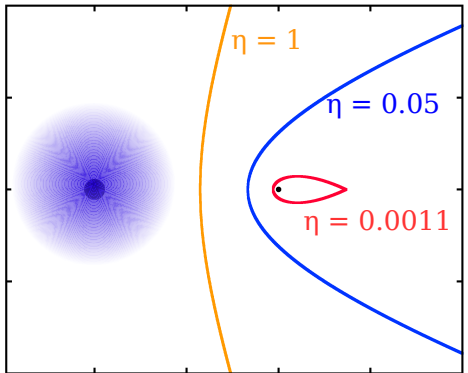

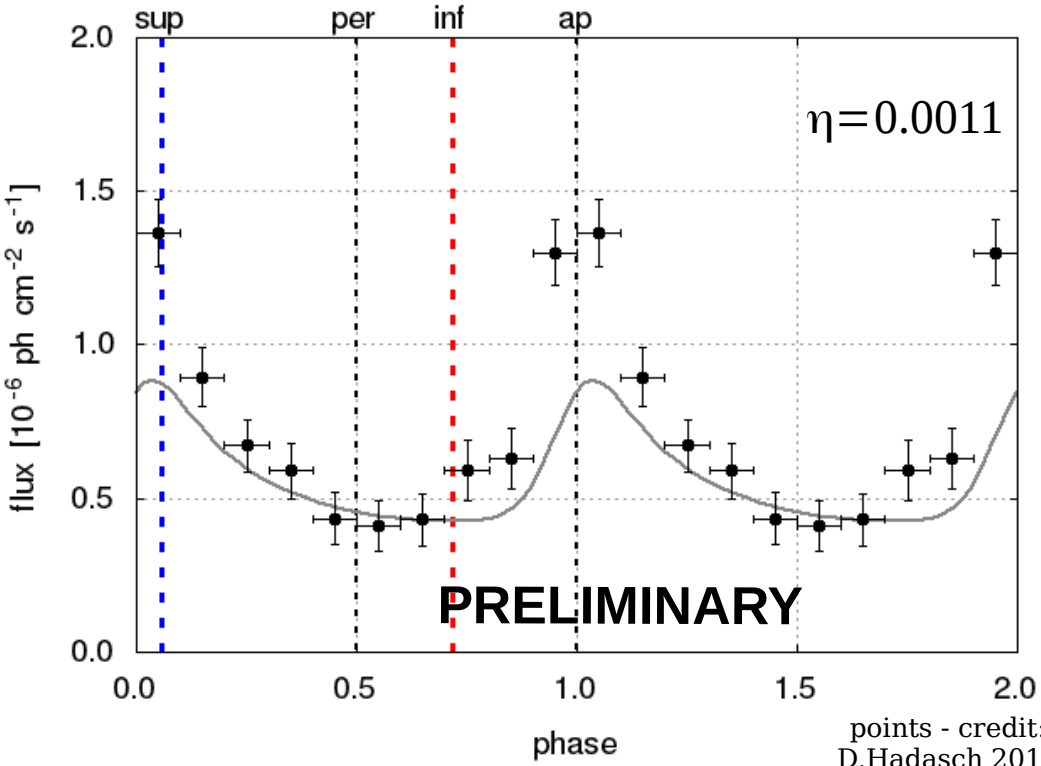

points - credit: D.Hadasch 2012

Conclusions

- We match the results from Fermi
- Our results point to η value in range $(0.0011 - 0.05)$
- The electrons' Lorenz factor no bigger than a few thousand