PHOTON AND NEUTRINO EMISSION FROM AGN JETS WITH THE SAME BARYON LOADING

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Introduction

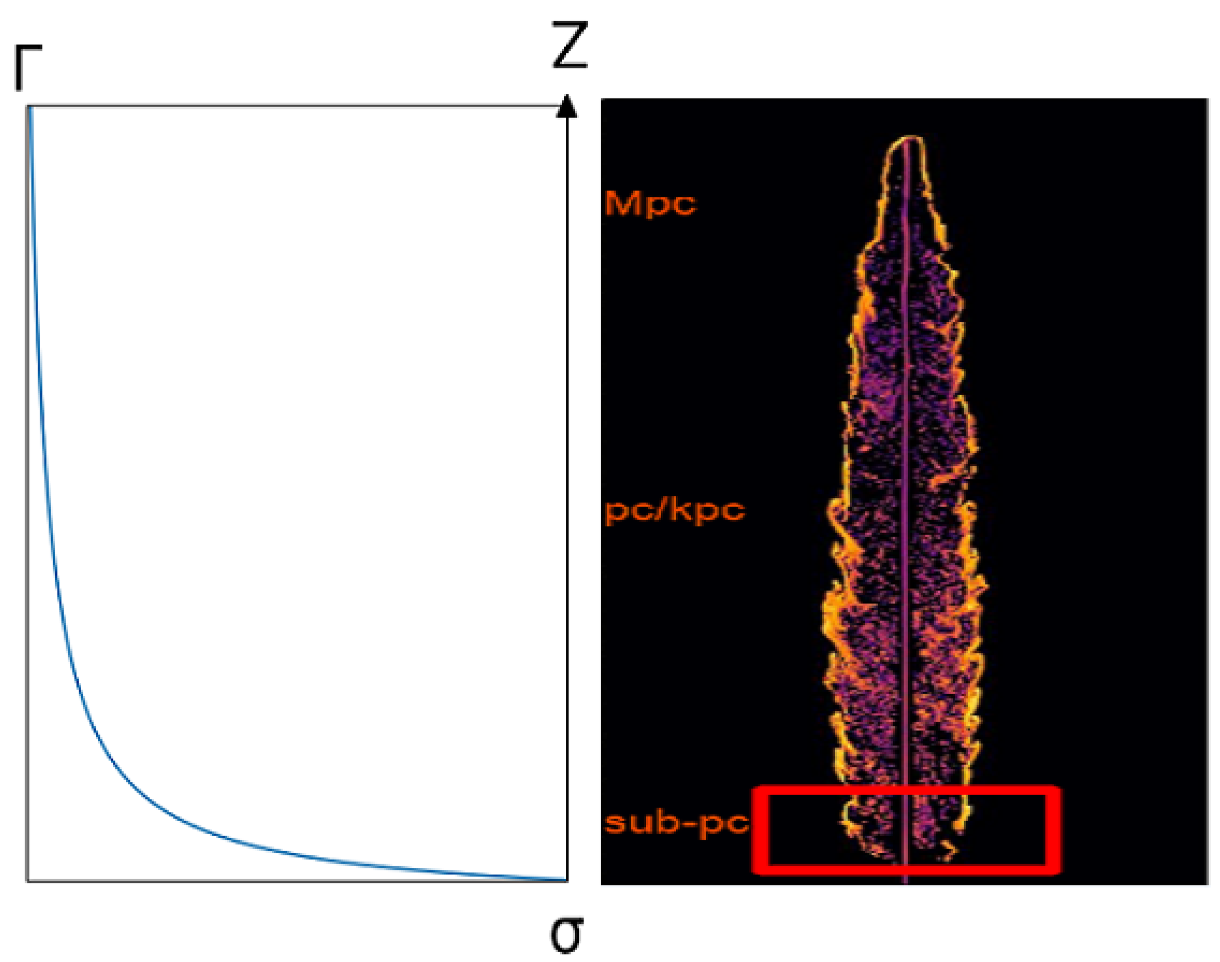

Fig. 1: The diagram, on the left, shows the relation between the bulk Lorentz factor and the magnetization of the jet ($\mu = \Gamma(1+\sigma)$), for a selected μ value (total energy flux per rest mass energy flux). It is also shown how these values change in respect to the jet distance, z, from its base. As z increases, the jet is getting more matter dominated. The red rectangle, in the right sketch, represents the location, that we are focusing in this work, where magnetic reconnection is the most probable mechanism of accelerating particles [3].

Model

We construct our model, taking into account the following assumptions:

- A positive correlation between Γ and $\dot{m}$ [2]:

$$\dot{m} = 1.56 \times 10^{-5}\Gamma^{3} \tag{1}$$

- An external radiation field produced by the Broad Line Region (BLR), which is monochromatic ($\epsilon_{BLR} \sim 2eV$) and isotropic, with energy density:

$$u_{\rm BLR} = 0.1\frac{L_{\rm d}}{4\pi c R_{\rm BLR}^2} \tag{2}$$

- Jet luminosity is linked with the disk luminosity ($L_{\rm d} = \eta_{\rm d}\dot{M}c^2$) and consequently with accretion rate:

$$L_{\rm j} = \frac{\eta_{\rm j}}{\eta_{\rm d}} L_{\rm Edd}\dot{m} \tag{3}$$

- The emission region is a spherical blob, located at the outer edge of the BLR:

$$R_{\rm em} = 0.9 R_{\rm BLR} \tag{4}$$

- The magnetic field can be found by combining the expressions that correspond to the magnetic power of the jet:

$$L_B = 2\pi u_{\rm B}' R_{\rm b}'^2 c\beta\Gamma^2 \tag{5}$$

with the definition of magnetization, which is the ratio of Poynting to matter fluxes:

$$\sigma = \frac{L_{\rm B}}{L_{\rm j} - L_{\rm B}} \tag{6}$$

- Magnetic reconnection will result to a transfer of magnetic field energy to particle energy. The power injected into non-thermal particles is:

$$L_{\rm i}' = f_{\rm rec}\frac{2L_{\rm B}}{3\beta\Gamma^2} \tag{7}$$

where $f_{\rm rec}$ is a fraction of the dissipated magnetic energy that is distributed to particles and estimated to be ~ 0.25.

- For the particles, we expect a power law energy distribution [4]:

$$Q'(\gamma') \propto \gamma'^{-p} \quad for\ \gamma'_{\rm min} < \gamma' < \gamma'_{\rm max} \tag{8}$$

We can find the extrema of this distribution, by taking into account that after the reconnection takes place, the average particle energy will be:

$$<\gamma_i> \sim f_{rec}\sigma\frac{m_p}{m_i} \tag{9}$$

Knowing that the distribution is getting steeper as σ decreases, we test the following sets of values: $(\sigma, p) = (1,3), (3,2.5), (10,2.2), (15,2), (30,1.5), (50,1.2)$

Results

To compute the blazar electromagnetic and neutrino emission in the model outlined above we use the numerical code ATHEνA. The code computes the multiwavelength photon and all-flavour neutrino spectra as a function of time by solving the kinetic equations for relativistic protons, secondary electrons and positrons, photons, neutrons, and neutrinos [1].

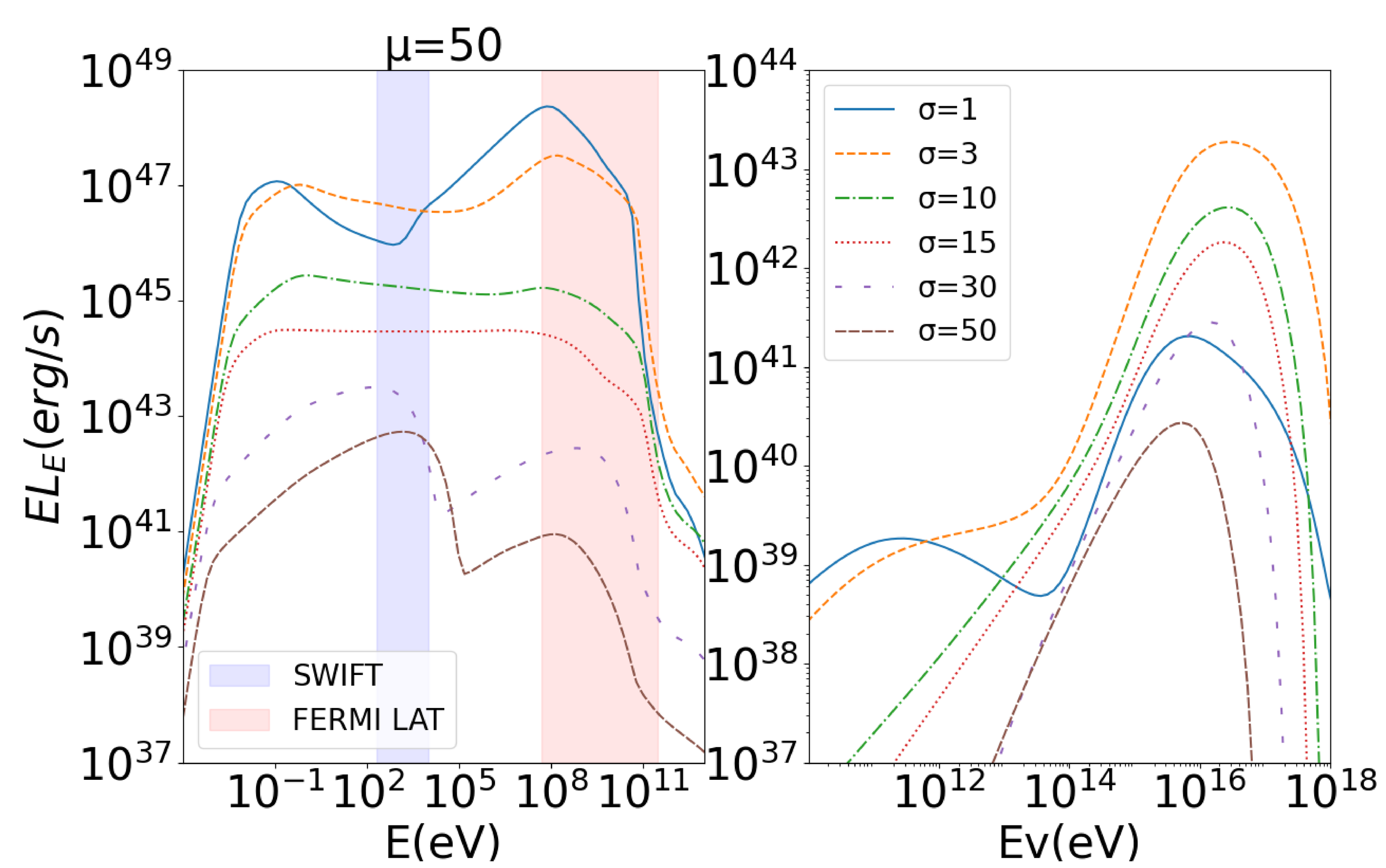

Fig. 2: Photon (left) and neutrino (right) energy distribution for different σ values and $\mu = 50$. We obtain similar results in other cases of μ that we tested, such as $\mu = 70, 90$.

Regarding fig.2 we can see that:

- FSRQs ($\sigma \leq 10$) are the most luminous blazars in all frequencies and they are Compton dominated.
- Moving from FSRQs to BL Lacs, L_{ICS} to L_{syn} peak ratio is getting closer to ~ 1, while synchrotron peak is shifting to higher frequencies.
- For $\sigma \geq 10$ neutrinos are mainly produced from proton interactions with internal synchrotron photons, while for $\sigma \leq 10$, they interact with the BLR.

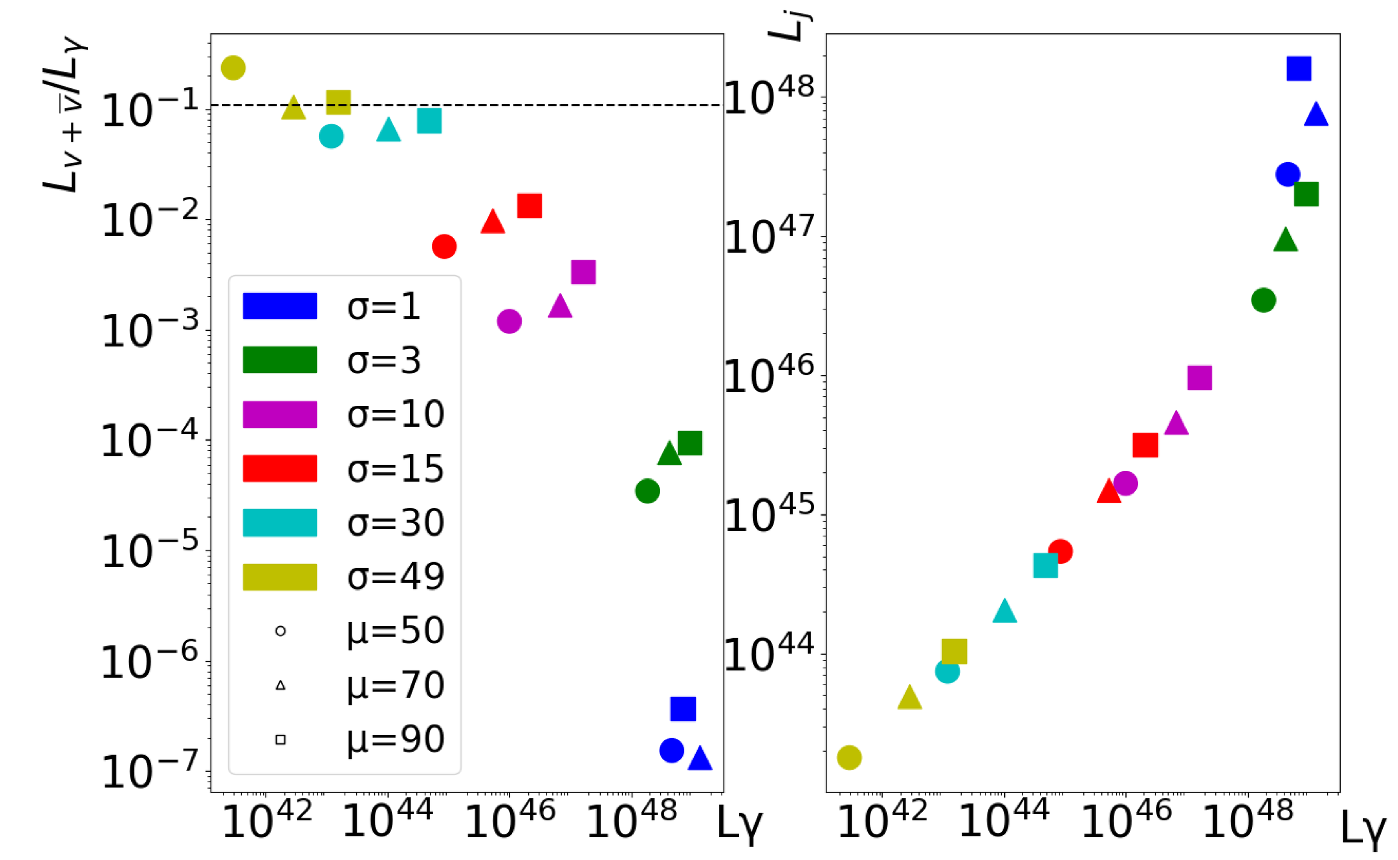

Fig. 3: The ratio of all-flavour neutrino luminosity to the γ-ray luminosity, $Y_{\nu\gamma} = L_{\nu+\bar{\nu}}/L_\gamma$, and the γ-ray luminosity (left), and the correlation between jet luminosity and L_γ in units of erg/s (right). The dotted line stands for the upper limits inferred by IceCube.

Fig. 3 reveals the following features:

- Blazars (for fixed μ) with high σ, have $Y \sim 1$ and low L_γ. The opposite trend is noticed, in the case of low σ.
- This is mainly attributed to how much more brighter FSRQs are, and less to the variation of L_ν, as σ changes.
- Jet luminosity is increasing with L_γ, since L_γ is getting higher when Γ overcomes σ. L_j follows this trend because of eq.(4).

References

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