ON THE RELEVANCE OF THE PROTON TO ELECTRON LUMINOSITY RATIO FOR HIGH ENERGY NEUTRINOS

L. Merten\(^1\) and J. Becker Tjus\(^1\)
Lukas.merten@rub.de, julia.tjus@rub.de

\(^1\) Plasma-Astroteilchen | Theoretische Physik IV | Ruhr-Universität Bochum

Our results are presented in Figures 4 and 5. The energy dependency of \(f\) is clearly visible in Figure 5. Figure 4 shows that for fixed \(\nu\), the dominant effect is given by the index difference.

- For equal spectral indices \((2.0 < a_\nu = a_p < 2.3)\) we derived: \(0.008 < f < 0.02\)
- For different spectral indices with \(a_\nu = a_p = 0.1\) and \(0.2 < f < 0.3\)

Standard prediction overestimates the neutrino flux larger allowed region (Figure 6).

How is \(f\) related to neutrino fluxes?
A direct and unique allocation of a cosmic ray spectrum with a specific GRB is impossible due to deflection in magnetic fields. The observation of the neutrino flux \(L\), which is proportional to the proton flux, is interesting because it clearly pinpoints to the source. A common technique to predict \(L\) is to use the chargeless synchrotron radiation produced in leptonic processes.

The electron spectrum can be derived from the synchrotron measurement. Thus, if the electron-proton luminosity ratio \(f\) is known, it is possible to estimate the neutrino spectrum from leptonic data. This assumption leads to the fact that \(L\) is proportional to \(f\) (Fig 2, 3).

What is the conventional ratio?
The conventional luminosity ratio \(f_{\text{conv}}\) (e.g. \([2]\)) is derived for equal spectral indices \(a_\nu > a_p\). This leads to the common assumption \(a_\nu = 2.2\) to \(f_{\text{conv}} = 1/100\). But from GRB observations it is known that it should be around \(f_{\text{conv}} > 1/100\) [3]. Furthermore, \(f_{\text{conv}}\) is not energy dependent and therefore giving rise to problems.

The new calculation
In our more detailed study the assumption of equal spectral indices was dropped (Equation 1). Different loss processes could affect the indices in such a way that the proton distribution is slightly steeper than the electron one \([4,5]\). This leads to an energy dependent luminosity ratio. All results were solved analytically and no approximations or numerical methods were needed. The definition of \(f\) is shown in Equation 2.

Equation 2: Definition for the differential particle number ratio and the luminosity ratio \(f\)

Take-home message
- The conventional ratio is insufficient for flux prediction of sources with different spectral indices.
- Our new results provide the opportunity to handle these sources correctly and will soon be available [4].

Figure 1: GRB produce cosmic rays, neutrinos and photons. To predict the neutrino flux the proton to electron luminosity ratio is essential [1].

Figure 2: The predicted neutrino flux is proportional to the proton flux. Since the proton spectrum is calculated from leptonic synchrotron radiation \(L_p\) scales with \(f\) [6].

Figure 3: The neutrino normalization scales with \(L_e\). The red line indicates the lower limit for equal indices. A spectrum for different spectral indices has to be fixed between the green lines [7].

Figure 4: Luminosity ratio for fixed kinetic energy and varying spectral indices. Deviations from conventional ratio grow exponentially with increasing index difference [4].

Figure 5: Luminosity ratio for different spectral index combinations. Deviations from the conventional ratio are visible. For different indices the energy dependency is noticeable [4].

Figure 6: GRBs are excluded with 90% possibility for conventional \(f\) and an average Lorentz factor of 300. For different spectral indices the parameters could be shifted into the allowed region [6].

Conclusion
What are the consequences of \(f\) for neutrino fluxes?
Our results are presented in Figures 4 and 5. The energy dependency of \(f\) is clearly visible in Figure 5. Figure 4 shows that for fixed Lorentz factor the dominant effect is given by the index difference.

- For equal spectral indices \((2.0 < a_\nu = a_p < 2.3)\) we derived: \(0.008 < f < 0.02\)
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