A cosmic collider: Was the IceCube neutrino generated in a precessing jet-jet interaction in TXS 0506+056? (Corrigendum)

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Maria Petropoulou and Bing Theodore Zhang brought to our attention that in the original paper (Britzen et al. 2019), the right-hand side of Eq. (14) had not been divided numerically by $c = 3 \times 10^{10} \text{ cm s}^{-1}$. This arithmetical error was carried through to the subsequent equations as well. Furthermore, the scaling factor, $\delta_{\text{I},1}^{-4}$, from Eq. (13) was not carried through. Equation (14),

$$u'_{t,a} \sim \frac{16 \Gamma_{\text{rel}}^4 L'_{\text{X},\text{I}}}{4 \pi d_{\text{ab}}^2 c},$$

thus numerically evaluates to:

$$\sim 7.3 \times 10^{-5} \Gamma_{\text{rel},1}^4 \delta_{\text{I},1}^{-4} d_{\text{mas}}^{-2} \text{ erg cm}^{-3}. \quad (14)$$

Interestingly, this further increases the number of relativistic protons needed to produce the IceCube neutrinos from TXS 0506+056 during the 2014–2015 neutrino flare to

$$N_0 \sim 3.6 \times 10^{61} \Gamma_{\text{rel},1}^{-4} \delta_{\text{I},1}^4 d_{\text{mas}}^2 \delta_{\text{II},1}^{-4}. \quad (15)$$

The corresponding total kinetic power in relativistic protons, under the assumptions spelled out in the original manuscript, consequently increases to

$$L_{\text{kin,p}} \sim 6.6 \times 10^{55} \Gamma_{\text{rel},1}^{-4} \delta_{\text{I},1}^4 d_{\text{mas}}^2 R_{16}^{-1} \delta_{\text{II},1}^{-4} \text{ erg s}^{-1}, \quad (16)$$

which, for the standard parameter values adopted above, is far above the Eddington luminosity of the central supermassive

black hole in TXS 0506+056. However, as the measured apparent speed of jet I appears to be significantly smaller than for jet II, an assumption of $\delta_{\text{I},1} \ll 1$ and $\Gamma_{\text{rel},1} \gg 1$, and also possibly $\delta_{\text{II},1} \gg 1$, may be realistic. In this case, more moderate jet power requirements result.

Based on this correction, we wish to reformulate our conclusion concerning the relation between the observed cosmic collision and the neutrino emission from TXS 0506+056 for the observed neutrino flare in 2014–2015 as follows. The quantitative analysis of the potential neutrino production in the jet of TXS 0506+056 suggests that the observed cosmic collision and interaction of jet components in the jet of this blazar may be related to the observed neutrino flare in 2014–2015. This would require a large velocity difference between the interacting jet components, assuming that the jet power is bounded by the Eddington limit of the central supermassive black hole in TXS 0506+056. Table 1 from our original paper, which remains unchanged, demonstrates that we find evidence for significantly different apparent jet speeds.

All of the results of the VLBA data analysis (kinematics, beaming, and the precession model), as presented in the original paper, are unaffected by this Corrigendum.

References

Britzen, S., Fendt, C., Böttcher, M., et al. 2019, *A&A*, 630, A103