



INSTITUTO DE FÍSICA
DE PARTÍCULAS Y DEL COSMOS

IPARCOS



Preprint Series in Particles and Cosmos Physics

n° IPARCOS-UCM-24-029

Influence of Cosmic Voids on the propagation of TeV Gamma Rays and the Puzzle of GRB 221009A

by H. Abdalla, S. Razzaque, M. Böttcher, J. Finke
and A. Domínguez

June 2024

Plaza de las Ciencias, 1 28040 Madrid, Spain

www.ucm.es/iparcos/



UNIVERSIDAD
COMPLUTENSE
MADRID



Abstract

The recent detection of gamma-ray burst GRB~221009A has attracted attention due to its record brightness and first-ever detection of $\gtrsim 10$ TeV γ rays from a GRB. Despite being the second-nearest GRB ever detected, at a redshift of $z=0.151$, the distance is large enough for severe attenuation of γ -ray flux at these energies due to $\gamma\gamma \rightarrow e^+e^-$ pair production with the extragalactic background light (EBL). Here, we investigate whether the presence of cosmic voids along the line of sight can significantly impact the detectability of very-high energy (VHE, >100 GeV) gamma rays from distant sources. Notably, we find that the gamma-gamma opacity for VHE gamma rays can be reduced by approximately 10% and up to 30% at around 13 TeV, the highest-energy photon detected from GRB~221009A, for intervening cosmic voids along the line-of-sight with a combined radius of 110 Mpc, typically found from voids catalogs, and 250 Mpc, respectively. This reduction is substantially higher for TeV photons compared to GeV photons, attributable to the broader target photon spectrum that TeV photons interact with. This finding implies that VHE photons are more susceptible to variations in the EBL spectrum, especially in regions dominated by cosmic voids. Our study sheds light on the detection of $\gtrsim 10$ TeV gamma rays from GRB 221009A in particular, and on the detection of extragalactic VHE sources in general.

