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Opacity Build-up in Impulsive Relativistic Sources

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Abstract content

Opacity effects in relativistic sources of high-energy gamma-rays, such as gamma-ray bursts (GRBs) or Blazars, can probe the Lorentz factor of the outflow as well as the distance of the emission site from the source, and thus help constrain the composition of the outflow (protons, pairs, magnetic field) and the emission mechanism. The attenuation of high energy photons will be probed by the Large Area Telescope (LAT) onboard the Gamma ray Large Area Space Telescope (GLAST), the next generation gamma-ray observatory to be launched in late 2007. While most previous works consider the opacity in steady state, we study here the time dependence of the opacity to pair production (\gamma\gamma \to e^+e^-), which may be especially relevant for impulsive relativistic sources, such as flares in Blazars or the prompt emission and flares in GRBs. We present a simple, yet rich, semi-analytic model that describes the build-up of the (target) photon field, and derive the time and energy dependence of the optical depth $\tau_{\gamma\gamma}$. Our model features a thin spherical shell that expands ultra-relativistically and emits isotropically in its own rest frame over a finite range of radii ($R_0 \leq R \leq R_0 + \Delta R$). We find that in an impulsive source (ΔR
lesssimR_0), while the instantaneous spectrum has an exponential cutoff above the photon energy $\epsilon_1(t)$ where $\tau_{\gamma\gamma}(\epsilon_1) = 1$, the time integrated spectrum has a power-law high-energy tail above the photon energy $\epsilon_{1} \sim \epsilon_1(\Delta t)where\Delta tisthedurationoftheemissionepisode.Furthermore, photonswithe
> \epsilon_{1}areexpectedtoarrivemainlyneartheonsetofthespikeinthelightcurveorflare, whichcorrespondstotheshortem
upthe(target)photonfield, andthustheopticaldepthinitiallyincreaseswithtimeand\epsilon_1(t)correspondinglydecreasesw
> \epsilon_{1*}areabletoescapethesourcemainlyveryearlyonwhile\epsilon_1(t) > \epsilon.Asthesourceapproachesaquasi-
steadystate(\Delta R \gg R_0$), the time integrated spectrum develops an exponential cutoff, while the power-law tail becomes increasingly suppressed.

If this papers is presented for a collaboration, please specify the collaboration

Summary

Reference

Proceedings of the 30th International Cosmic Ray Conference; Rogelio Caballero, Juan Carlos D'Olivo, Gustavo Medina-Tanco, Lukas Nellen, Federico A. Sánchez, José F. Valdés-Galicia (eds.); Universidad Nacional Autónoma de México, Mexico City, Mexico, 2008; Vol. 3 (OG part 2), pages 1183-1186

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