RevMexAA (Serie de Conferencias), **33**, 121–121 (2008)

ELECTROMAGNETIC CASCADES IN THE RADIATION FIELD OF MASSIVE STARS

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The new generation of Cherenkov telescopes have recently confirmed that some binary systems containing a massive early-type star are the source of TeV gamma-ray photons. The discussion is open about the mechanisms leading to such energetic emission. From theoretical grounds, to model the expected detectable spectra requires a careful treatment.

The radiation field of early-type stars provides a suitable target for the absorption of γ-ray photons. Energetic electron-positron pairs are then created. These leptons, in turn, boost the stellar photons to high-energies via Inverse Compton scattering. Under favourable conditions, the γ-ray absorption and production mechanisms can proceed very fast, resulting in the development of an electromagnetic cascade. As a result, the energy of the original photons is distributed between a certain number of secondary particles and photons of lower energy, modifying the original spectrum even at energies where the optical depth results $\tau \ll 1$.

We have followed the line proposed by Protheroe (1986) and Protheroe et al. (1992) to develop a computational code to perform Monte Carlo simulations of one-dimensional cascades induced by very high-energy photons traversing the anisotropic radiation field of an early-type star. We introduce the effects of the finite size of the star and the spatial variation of the field density by considering the geometric configuration as in Dubus (2006). In this work we investigate the changes induced in injected spectral energy distributions of γ-rays by electromagnetic cascade development. For simplicity, effects of the presence of a magnetic field were disregarded in these simulations, though it may influence the pure IC cascade by changing the direction of propagation of the leptons (see Bednarek 1997, and subsequent works). For a more extensive explanation of our code see Orellana et al. (2006). Here, typical parameters of a Wolf-Rayet colliding wind system (e.g. WR 140) are assumed: $T_\star = 4.7 \times 10^4$ K, and $R_\star = 12\ R_\odot$.

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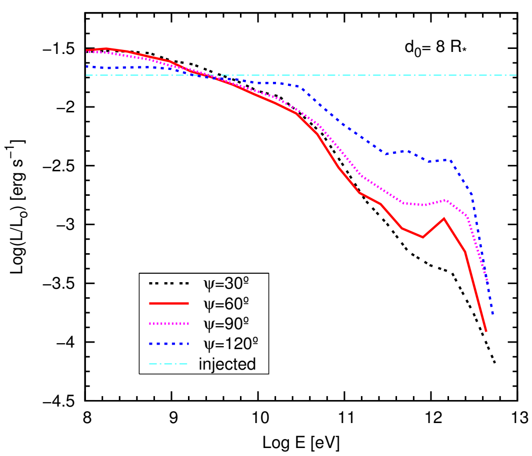

Fig. 1. Simulated emerging spectra of electromagnetic cascades, changing the injection angle ψ.

As an exampe, we consider γ-ray photons injected at a distance $d_0 = 8R_\star$ from the center of the star. The injected photons follow a power-law spectrum $I(E) \propto E^{-\alpha}$ with $\alpha = 2$, for energies between 0.1 GeV and 10 TeV. Figure 1 shows results of the simulated 1-D cascade outgoing spectra for different values of the injection angle ψ. This is the angle subtended by the line of sight and the line joining the injection point and the center of the star. The inclination of the binary orbit can sometimes be enough to induce changes in ψ with the orbital movement. Information about the distribution of the secondary leptons that have participated in the cascade could also be reconstructed from our code.

In conclusion, we are starting to perform cascade simulations that can be a step ahead in the correct modelisation of high-energy spectra. As a future task, we hope to improve our simulations by including the effects of a magnetic field.

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