SPECTRA AND TIME SCALES FOR PARTICLE ACCELERATION IN ULTRA-RELATIVISTIC FLOWS APPLICABLE TO GAMMA-RAY BURSTERS

A.Meli and J. J. Quenby
Astrophysics Group, Blackett Laboratory, Imperial College,
London SW7, 2BW, UK

Monte-Carlo computations of ultra-relativistic parallel and oblique shock acceleration is presented for upstream flow gamma factors, $\Gamma = (1 - V_{up}^2/c^2)^{-0.5}$ up to $\Gamma \sim 1000$, relevant to Gamma-ray burst (GRB) fireballs. For oblique sub-luminal shocks, the spectra depend on whether or not the upstream scattering is small angle with $\delta\theta < \Gamma^{-1}$ or isotropic, which is possible if $\lambda > r_g\Gamma$ where λ is the scattering mean free path along the field line and r_g the gyroradius. The large angle case exhibits distinctive structure in the basic power-law spectrum not nearly so obvious for small angle scattering but both cases yield a significant speed-up of acceleration rate when compared with the conventional, non-relativistic expression, $t_{acc} = [c/V_{up} - V_{down}][\lambda_{up}/V_{up} + \lambda_{down}/V_{down}]$. The Γ^2 energisation factor per shock crossing, important in the Vietri work on GRB ultra-high energy neutrino, and possibly cosmic ray and gamma-ray output, is supported for the first crossing cycle but the factor is less subsequently. Super-luminal shock results are discussed in a companion paper (Meli and Quenby, 2001).