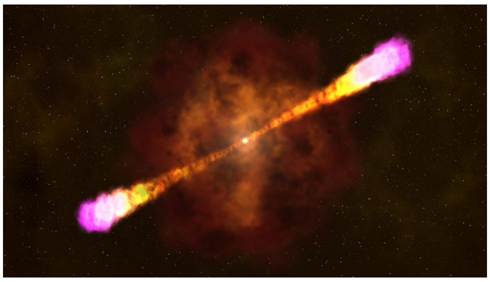
High energy astrophysics

Particle acceleration in turbulent astrophysical jets

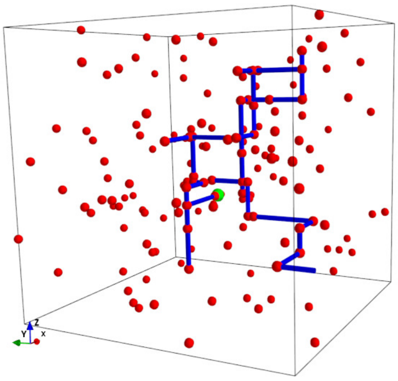


Summary
It is well established that Magmetohydrodynamical flows in astrophysical jets are in a strongly turbulent stage. The strongly turbulent flows will excite a mixture of coherent structures moving inside the flow with a Alfvénic or super Alfvénic speed. The interaction of charges particles with these coherent structures, their radiation properties and their comparison of the spectra with the observed high energy emission from the Jets will be the core of the project.

Model

by Loukas Vlahos

We follow the initial proposal by Fermi in 1949 for the acceleration of cosmic rays, but with one important difference, we replace the "magnetic Clouds" with the "coherent structures inside the turbulent flow". We construct a 3D grid $(N \times N \times N)$ with linear size L, with grid width $\ell = L/(N-1)$. Each grid point is set as either *active* or *inactive*, i.e. a scatterer or not. Only a small fraction $R = N_{\rm sc}/N^3$ of the grid points are active (5-15%). We can define the density of the scatterers as $n_{\rm sc} = R \times N^3/L^3$, and the mean free path of the particles between scatterers can be determined as $\lambda_{\rm sc} = \ell/R$. The relativistic particles suffer radiation losses along their path. The competition between acceleration from the coherent structures, the escape from the simulation box and the radiation losses will define their final energy distribution.



When a particle (an electron or an ion) encounters an active grid point, it renews its energy state depending on the physical characteristic of the scatterer. It then moves in a random direction with its renewed velocity v, until it meets another active point or exits the grid. The minimum distance between two scatterers is the grid width (ℓ). The time between two consecutive scatterings is $\Delta t = s/v$, where s is the distance the particle travels, and it is an integer multiple of the minimum distance ℓ.

Applications

At time $t = 0$ all particles are located at random positions on the grid. The injected distribution $n(W, t = 0)$ is a Maxwellian with temperature T. The initial direction of motion of every particle is selected randomly. We have applied this model to the turbulent solar atmosphere during solar flares and compare our result with the current observations. Our aim in this project will be:

(1) A detailed review of the observational constrains and the theoretical modeling on the excitation of strong turbulence in astrophysical flows.

(2) We choose the parameters for the model (density, magnetic field strength, temperature, etc) and follow a large number of particles inside the simulation box detailed above.

(3) Comparing our results with the observations and the existing models for particle acceleration in astrophysical jets will be the final step.

(4) Writing an article for a journal will be our ultimate goal.

See also

Details 1
Details 2

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