Famiano Model API and Code Specification

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Definitions and Variables

This section contains a summary of all the variables, along with their definitions and units (if applicable). The variables used in the Famiano et al., 2002 paper were:

1. Y_i: Abundance per baryon belonging to species i. It is a unitless quantity.
2. $\mathbf{Y}$: A vector containing the current abundances of all species used in the reaction network. It is unitless.
3. $f(\mathbf{Y})$: Time rate of change (in s^{-1}) of the abundance of each species. This is given by the sum of the reactions that create and destroy each species.
4. h: A discrete time step (in seconds) taken in the network evolution.
5. ϵ: Factor to ensure that the time step is small (therefore, the change in abundance is small per time step).
6. E_0: Initial energy of the jet. For consistency let's keep this in MeV.
7. $S(E, E_0)$: The fraction of particles in the jet that survive to energy, E. This is also called the survival fraction.
8. N_m: Abundance of the particles in the cloud participating in reaction m.
9. ϵ_i: Stopping power of the incident particles in the medium. Stopping power tells us essentially how far the jet particles can travel in the cloud before coming to a complete stop.
10. y_k: Yield for a particle, k, produced by the reactions between cloud and jet particles.
11. ζ_{ik}: Destruction fraction (ζ) is the fraction of reacting jet particles with energy E_k that are destroyed via reaction i.
12. σ_{ik}: The cross section for reaction i and projectile energy E_k, is the average cross section for $E_{k-1} < E < E_k$.
13. ϕ_{pq}^{ik}: Energy distribution tensor is defined to be the fraction of products p with energy E_q from a reaction i with a projectile that has energy E_k. For constant reaction type (i), projectile energy (E_k), and products (p), this tensor gives the energy distribution of product p and is normalized to unity, i.e., $\sum_q \phi_{pq}^{ik} = 1$.
14. y_{pq}^{in}: Yield of particles p with discrete energy E_q per incident projectile with energy E_n in reaction i between jet and cloud.

Cloud Geometry, Evolution, and Composition

There are three cloud models used:

1. Constant volume: $d\rho/dt = \dot{M}/V_0$
2. Constant density: $dV/dt = \dot{M}/\rho_0$
3. Variable volume and density:

$\frac{d(\rho V)}{dt} = \dot{M} \implies \rho V = \rho_0 V_0 (1 + \frac{\dot{M}}{\dot{M_0}})$

where, $\rho = \rho_0(1 + \dot{M}/M)^{0.5}$ and $V = V_0(1 + \dot{M}/M)^{0.5}$

Modeling notes: User should have ability to choose a model. Need to update

geometry after each timestep!

Assumptions: Most simulations assumed the cloud contained primordial initial number density fraction of elements. However, a few simulations seeded the cloud with an initial number of heavier isotopes.

Jet Energy, Evolution, and Composition