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Quasimonoenergetic Ion Production Through the Optimization of the Multiple Ion Species Spherical Coulomb Explosion

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Background

Under normal circumstances, Coulomb Explosion cannot yield quasimonoenergetic protons [1]. However, previous studies have shown that at a certain composition of light and heavy ions, it is possible to produce quasimonoenergetic ions [2]. This study aims to investigate the optimal structure and composition for quasimonoenergetic ion production via Coulomb Explosion.

Simple Analytic Models

In this study, we have simulated four different targets for spherical coulomb explosion. Target 1 is a solid spherical target of radius R and is a mixture of two ion species, one light species and one heavy species. Target 2 is made of two concentric hollow spheres. The inner sphere is composed of light ions while the outer sphere is composed of heavy ions. Target 3 is a single hollow sphere which is composed of both heavy and light ions. Target 4 is composed of two concentric hollow spheres. The outer sphere is composed of a heavy and light ion species, similar to target 2, while the inner sphere is composed of a heavy ion species. The models for the energy profile for each of the targets were calculated and are given by:

$$\tilde{\mathcal{E}}_1 = \frac{3(1-\beta)+(3\beta-1)\xi_0^2}{2} \quad (1)$$

$$\tilde{\mathcal{E}}_2 = \frac{\gamma\beta\xi_0^3-\beta\gamma+1}{\xi_0} \quad (2)$$

$$\tilde{\mathcal{E}}_3 = \frac{\gamma(3\beta-1)\xi_0^3+3\gamma(1-\beta)\xi_0-2\gamma-2}{2\xi_0} \quad (3)$$

$$\tilde{\mathcal{E}}_4 = \tilde{\mathcal{E}}_2 + \frac{\beta^*}{2\xi_0} \quad (4)$$

The optimum parameters for γ and β were obtained through least-squares optimization by solving the equation:

$$\frac{d}{d\beta}\left(\int_{\tilde{R}}^{1}\xi_0^2\left(\tilde{\mathcal{E}}-1\right)^2 d\xi_0\right)=0 \quad (5)$$

Simulation Results

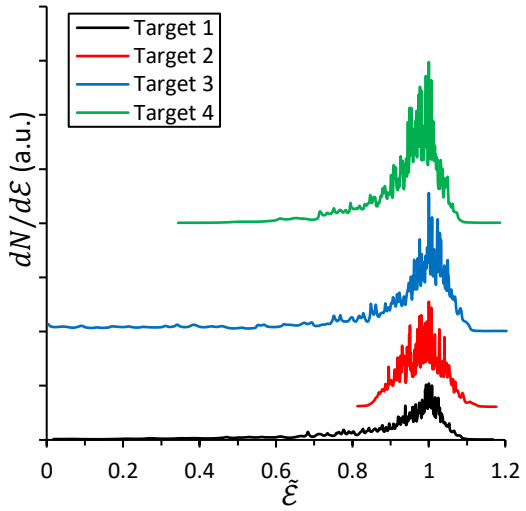

Figure 1: Shows the Energy Spectrum of the light ions for each of the targets

Three-dimensional molecular dynamics (3D-MD) simulations have confirmed that all four targets are capable of quasimonoenergetic ion production. Furthermore, targets 2 and 4 have shown a slight increase in the energy coupling efficiency of the system.

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