Spatial Distribution of D-^{3}He Advanced Fuels Fusion Reactions in an Inertial Electrostatic Confinement Device

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Abstract:

In this study, in order to make spatial and embedded fusion distribution in IECF device clear, we assembled a proton counting system using a solid state detector (SSD) and circular collimator masks of three different diameters on a linearly movable rod set between the SSD and the IECF chamber.

Together with the 14.7 MeV protons (observed around 14.3 MeV just according to an energy loss through a shielding foil), an unaccounted peak at 7.9 MeV different from D-D (3.03 MeV) and D-^{3}He was also observed, whose origin has been finally revealed by the following spatial distribution determination. By use of the movable masks, the 7.9 and 14.3 MeV signals were measured simultaneously as functions of the collimation geometry. Then, the Maximum Likelihood - Expectation Maximization method, commonly utilized in CT scanning for reconstructing a 2-d image from a set of projected 1-d images, was applied and resulted successfully in the distribution.

In the reconstruction process, spherical symmetry was assumed except for the gridded cathode consisting of six ring-shaped Mo plates. The proton yield fractions on the six rings were treated as six independent variables. The results show volumetric production of the 14.7 MeV protons within and nearby the cathode grids (52 %), and embedded fusion on the six rings (48 %). In contrast the 7.9 MeV signal's birthplace is found localized strongly on one of the six rings which faces normal to the detector observation direction. Eventually, the energy discrepancy is found to agree well with the energy loss of the 14.7 MeV proton through the 0.3 mm-thick Mo plate. The reason for no 7.9 MeV protons from the other Mo rings is that the protons from the other Mo rings would go through them with some angles to lose their whole energy. The volumetric contribution of over 50% concentrated within the cathode is very encouraging , compared with the data by University of Wisconsin, which shows a much higher contribution of the embedded D-^{3}He fusion, and also the theoretical prediction of a diverse distribution of fusion reactions due to undesirable atomic processes.