Six Ion Gun Fusion Experiment Findings and Future Work

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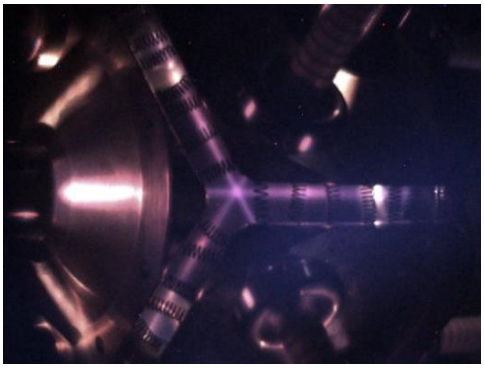
The Six Ion Gun Fusion Experiment (SIGFE) is an experiment that replicates and expands upon Hirsch's 1967 ion gun fusion device [1]. The SIGFE, like the original device, uses electrostatic lenses to focus 6 ion beams at the center of a central cathode. It was postulated, in the original experiment, that potential structures formed and caused increased reaction rates to occur where the six beams converged. This structure and high neutron production efficiency, compared to other IEC devices, made this an interesting experiment to revisit.



It has been found that alignment of the lenses and electron confinement within the cathode are significant factors in the performance of the SIGFE. Also, it was shown that the focus of the beams has a strong influence on neutron production rates. The focus can be changed during operation by adjusting the voltage applied to the focus lens. Neutron production rates are directly related to pressure when the beams are over-focused (the focal point is closer to opposite cathode lens) and vary inversely with pressure when the beams are under-focused. The SIGFE matched Hirsch's best neutron production rate when the beams were fully defocused. Simulations show that a large portion of the ions strike the inside of the cathode in the defocused mode. This suggests that the main mode of fusion is beam-embedded.

Several diagnostics were used, including a neutron detector and the Fusion Ion Doppler shift (FIDO) device. The FIDO device was connected to the SIGFE so that it could only see fusion protons near the center of the cathode, where the potential structures were reported to have formed in Hirsch's experiment. The proton counts from the FIDO device were compared to the overall neutron counts and were found to be a very small fraction of the DD reactions taking place in the SIGFE. This suggests that there were no significant potential structures in the SIGFE. Also, the energy shift observed with the FIDO device suggests that beam-background reactions are the dominant mode of fusion. Further work will use more extensive diagnostics and expand the operating space, including pulsed operation, to investigate possible potential structures.

[1] R.L. Hirsch, "Inertial-Electrostatic Confinement of Ionized Fusion Gases," *Journal of Applied Physics* **38**, 4522 (1967).