The Multipole Ion-beam Experiment (MIX)

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IEC 'fusors' have been in operation at dozens of universities and in countless amateur hobby shops for over fifty years, ever since Farnsworth invented the concept at the ITT laboratories. In this elegant approach, peaks in the fusion cross-sections between various ions are easily exploited, and these devices have consistently astounded and inspired audiences when they produce measurable fusion reactions in a table-top configuration. Unfortunately, ill conceived ion optics, space charge limitations, and grid-engineering limitations have long established that with this technology it is impossible to achieve fusion rates beyond unimpressive levels. For neutron source applications, several Watts of fusion power are needed ($n_{rate} > 10^{12}$), and for net power generation a very high efficiency ($Q > 10$) and at least a kilo-Watt power level are required ($n_{rate} > 10^{15}$). However, with a few relatively simple changes and additions to the traditional fusor, a dramatic improvement in the performance of these machines might be achievable, in theory.

In 2009/10, an experiment was designed and built in which fusion reactive ions are accelerated in a quasi-spherically convergent manner through a powerful polyhedral electro-magnet, which substitutes for the traditional cathode-grid. All electrodes were carefully designed, aligned, and configured to provide stable ion orbits that do not intersect any material structures, and the background vacuum pressure kept low enough to prevent significant charge exchange collisions, This was achieved by using dedicated ion sources of various designs. In addition, miniature e-guns injected electrons into the cathode interior in order to establish modest negative potential wells. These electrons were aimed at neutralizing the build up converging ion space charge, and were also envisioned to aid the ion-focus via Gabor lensing effects. Finally, the type of magnetic field produced in the device interior is not only an effective means to trap primary injected electrons, but is also well known to confine a neutral plasma up to fairly high densities ($\beta \sim 1$). In principle, a warm core-trapped plasma could serve as an additional and important fusion target for the recirculating ion beams.

With the aim to determine if such an arrangement can be developed to produce useful fusion power, a company was incorporated. In 2009 we secured substantial venture capital funding with the mission to construct a prototype and demonstrate a multi-ampere IEC fusion neutron source. A modest success would result in commercially attractive high-energy particle sources, but the real goal was the production of net fusion power. In this talk, I will discuss the results of the important simulations and scaling calculations, describe the design of the experiment and associated diagnostics, and present experimental data. The MIX device was found to suffer from significant limitations and problems, and was abandoned in favor of alternate technology in 2011.