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Chamber Transport for Heavy Ion Fusion

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Since the First Workshop on Heavy Ion Fusion (HIF) was held in Berkeley in 1976, the concept of HIF for energy production has continuously been an outstanding contender for Inertial Fusion Energy (IFE). One of the attractive features of HIF is that there exists a wide variety of heavy ion beam transport modes for beam propagation in the reactor chamber. Of course, the HIF target parameters dictate the required beam parameters, which in turn dictates which chamber transport modes are permissible. Here, we review the evolution of the required beam parameters, the evolution of the preferred chamber transport modes, and finally, how recent research on neutralized ballistic drift compression for Warm Dense Matter investigations contributes to the long-term goal of HIF.

Possible heavy ion beam transport modes include hard-vacuum ballistic propagation, charge-neutralized ballistic propagation, co-moving electron neutralized ballistic propagation, charge- and current- neutralized ballistic propagation, pre-formed channel propagation, and self-pinched propagation. Possible reactor beam transport environments include dry-wall, wetted-wall, and thick-liquid wall reactor scenarios. With insights from all of the major IFE reactor scenarios (HIF, LIF, HAPL, Z-IFE, LIFE), we trace the development of the preferred HIF transport modes through several HIF studies [HIBALL-I (1981), HIBALL-II (1984), HYLIFE-I (1985), HYLIFE-II (1991), PROMETHEUS-H (1992), OSIRIS (1992), Heavy Ion LMF (1993), etc.].

For each of the possible HIF beam transport modes, we comment on possible focusing limits caused by, e.g., instabilities (two-stream, filamentation, etc.); micro-charge non-neutralization; voltage accuracy requirements for axial bunching; and emittance requirements for focusing and bunching.

For the last many years, transport of heavy ion beams (with beam parameters reduced from those needed for IFE) has been investigated for applications to Warm Dense Matter. A brief summary of current research on neutralized drift compression (theory and simulations, NDCX-I, NDCX-II, possible final-focus discharge channel, etc.) is given. The importance of this research for scaling to the long-term goal of HIF for IFE is noted.

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