Researches on reactor core in Heavy ion inertial fusion.

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In Heavy ion inertial fusion (HIF), the issues include the generation and transport of heavy ion beam (HIB), the optimum pellet structure, the realistic nuclear fusion reactor design, etc. In this research, we have studied a conceptual design of a nuclear fusion reactor system in HIF (see Fig. 1).

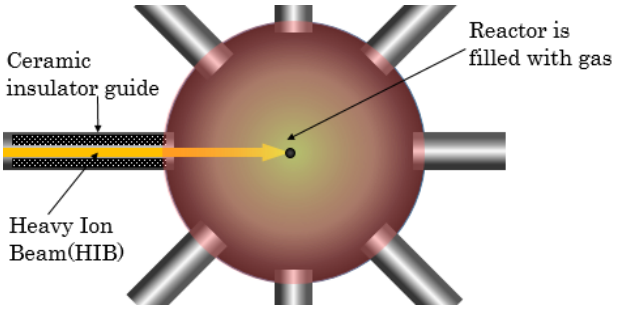

Fig.1 A conceptual diagram of a HIF

The HIB should be focused and transported in a fusion reactor against the beam space charge onto a fuel pellet at the reactor center. The target radius is the order of mm. One of the promising transport schemes is the neutralized ballistic transport, in which preformed-plasma electrons or wall-emitted electrons neutralize the HIB space charge. On the other hand, the HIB ion number density increases from n_{b0}~10^{11}–10^{12}cm^{-3} at a HIB port entrance to 100~$200 \times n_{b0}$ at the fuel pellet position. As a practical HIB neutralization method in an HIF reactor, an insulator annular tube guide was proposed at the final transport part, through which a HIB is transported (see Fig. 1) [1]. A local electric field created by the intense HIB induces local discharges, and a plasma is produced at the annular insulator inner surface. The electrons are extracted from the plasma by the HIB net charge. The electrons neutralize the HIB charge, and move together with the HIB in the reactor chamber [2].

In addition, the chamber background electron density should be always larger than or equal to the HIB number density: $n_{ce} > Z_b n_b$. Here, n_{ce} is background electrons density, Z_b is degree of ionization and n_b is HIB density. In our design, the fusion reactor is filled with helium gas, and its density is ~10^{16}~$10^{17}[1/cm^3]$. In this case, the HIB space charge is always neutralized in the reactor well. The instability analyses were also performed including the two-stream instability and the filamentation instability; it was found that the HIB is rather stable in the reactor chamber gas [3].

However, a part of the exhaust gas and debris coming up may have influences to the HIB accelerator. The vacuum of the accelerator part should be kept to the low pressure to avoid the HIB ions scattering and the halo formation. In the HIF reactor system we may have the ceramics HIB transport annular guide as shown above, whose inner surfaces would absorb the upcoming exhaust chamber gas to the accelerator final section. At the final part of each accelerator near the chamber wall, each accelerator final part may several mechanical shutters, and two pairs of the mechanical shutters would confine the exhaust gas and absorb it at the ceramics guide inner surface, as shown in Fig.2.

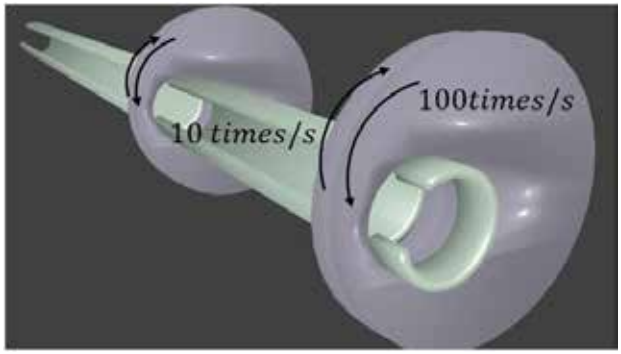

Fig.2 Mechanical shutter

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