Researches in Japan on heavy ion inertial fusion

S. Kawata[1], T. Karino[1], A. I. Ogoyski[2], T. Kikuchi[3], J. Hasegawa[4], K. Horioka[4], Y. Iwata[5], W. Jiang[3], K. Kondo[6], Y. Oguri[7], K. Okamura[8], M. Okamura[9], T. Sasaki[3], K. Takahashi[3], K. Takayama[8], M. Murakami[10], T. Iinuma[1], S. Kondoh[1], H. Katoh[1], T. Kubo[1], and HIF Japan Group

[1] Utsunomiya University, Utsunomiya 321-8585, Japan
[2] Varna Technical University, Varna 9010, Bulgaria
[3] Nagaoka University of Technology, Nagaoka, 940-2188, Japan
[4] Tokyo Institute of Technology, Yokohama 226-8502, Japan
[5] National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba 305-8561, Japan
[6] National Institutes for Quantum and Radiological Science and Technology (QST), Kyoto, 619-0215, Japan
[7] Tokyo Institute of Technology, Meguro, Tokyo, 152-8550, Japan
[8] High Energy Accelerator Research Organization (KEK), Tsukuba, Japan
[9] Brookhaven National Laboratory, Upton, NY 11973, USA
[10] Osaka University, Osaka 565-0871, Japan
*Corresponding author: kwt@cc.utsunomiya-u.ac.jp

Recent research activities in Japan are presented in this paper in heavy ion inertial fusion (HIF) [1]: shown are particle accelerator developments, beam dynamics researches, interaction between heavy ions and target materials, ion source developments, and illumination schemes of heavy ion beams (HIBs) in HIF.

The HIB has remarkable preferable features to release the fusion energy in inertial fusion and also for studies on the warm dense matter(WDM) physics [2]: in particle accelerators HIBs are generated with a high driver efficiency of ~ 30-40%, and the HIB ions deposit their energy inside of materials. Therefore, a requirement for the fusion target energy gain is relatively low, that would be ~50-70 to operate a HIF fusion reactor with the standard energy output of ~1GW of the electricity. The HIF reactor operation frequency would be ~10~15 Hz. Several-MJ HIBs illuminate a fusion fuel target, and the fuel target is imploded to about a thousand times of the solid density. Then the DT fuel is ignited and burned. The HIB ion deposition range is defined by the HIB ions stopping length, which would be 500 μm~1 mm or so depending on the material and on the ion particle energy. Therefore, a relatively large density-scale length appears in the fuel target material. One of the critical issues in inertial fusion would be a spherically uniform target compression, which would be degraded by a non-uniform implosion. The implosion non-uniformity would be introduced by the Rayleigh-Taylor (R-T) instability, and the large density-gradient-scale length helps to reduce the R-T growth rate.

The HIB accelerator has a high controllability to define the ion energy, the HIB pulse shape, the HIB pulse length and the HIB number density or current as well as the beam axis. The HIB wobbling axis motion may give another tool to smooth the HIB illumination non-uniformity [2].

In the paper the KEK digital accelerator is first presented based on an induction acceleration technique for the all-ion accelerator [1]. Then the activities in Japan are shown for the beam dynamics researches in Nagaoka, the HIB interaction with target materials in Nagaoka and Utsunomiya, the ion source developments in KEK, Tokyo Tech., BNL, and AIST, the illumination scheme of heavy ion beams in Utsunomiya and Osaka, and other issues in HIF

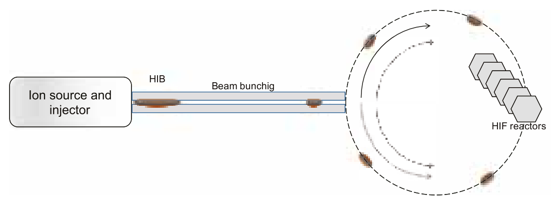

Fig. 1 A concept of a HIF reactor system.

Acknowledgements: The work was partly supported by JSPS, MEXT, CORE (Center for Optical Research and Education, Utsunomiya University), ASHULA, ILE / Osaka University, and CDI (Creative Department for Innovation, Utsunomiya University).

References

[1] K. Horioka, et al, Nuclear Instrument and Methods in Phys. Res. A, 606 (2009) pp.1-5.
[2] S. Kawata, et al., to appear in MRE (Matter and Radiation at Extremes), (2016). preprint: arXiv:1511.06508, pp.1-21(2015).