Laboratory Astrophysics and Fusion Physics with Intense Lasers

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Since the invention of the laser in 1960, lasers have been applied as a tool for research in our surroundings and in advanced technology and basic science. Today, I will give talks on the following two physics topics in our research field. Finally, I would like to describe a project for which an open call has been launched.

1. Study of astrophysical plasmas by intense laser
2. Research on laser fusion using the world's largest NIF facility
3. Formation of an interdisciplinary research group for the fusion energy project.

Large lasers are necessary to study the physical phenomena of plasma in the universe. The largest laser in the world is the NIF (National Ignition Facility, LLNL), which has been used since 2009 for scientific demonstration of fusion ignition.

Our international team has used NIF to demonstrate the generation of collisionless shocks modeled after astrophysical shock waves that accelerate charged particles. When counter-streaming plasmas accelerated to velocities of over 1000 km/s by laser heating collide with each other, a magnetic field is generated due to the Weibel instability. The magnetic field due to the Weibel instability grows nonlinearly and finally becomes turbulent, trapping ions, which act like viscosity and form a shock wave. Theoretical, computational, and experimental aspects of this physics will be presented [1].

Ignition and nuclear burning of imploded hydrogen plasma (DT nuclear fusion fuel) was achieved in the NIF experiment. The DOE stated at a press conference that this is a historic accomplishment and brings us closer to the realization of fusion energy. I would like to evaluate the physics from the scenario of fusion energy realization, as well as the major mission of NIF for SBSS (Science Based Stockpile Stewardship) [2].

Finally, I will briefly introduce the recent top-down project on fusion energy, Moonshot 10 (MS10) Fusion Energy. The MS10 will form an interdisciplinary group that will include plasma, astrophysical, fluid, nuclear and particle, complex systems and so on. This will be primarily a collaborative effort among theoretical and computational researchers. Brief introduction is given [3].

References.

[1] H. Takabe, "Theory of magnetic turbulence and shock formation induced by a collisionless plasma instability." *Physics of Plasmas* 30.3 (2023).

[2] Abu-Shawareb, H., et al. "Achievement of target gain larger than unity in an inertial fusion experiment." *Physical Review Letters* 132.6 (2024): 065102.

[3] https://www.jst.go.jp/pr/info/info1678/index.html