Simulations demonstrate ion heating by plasma oscillations for fusion energy

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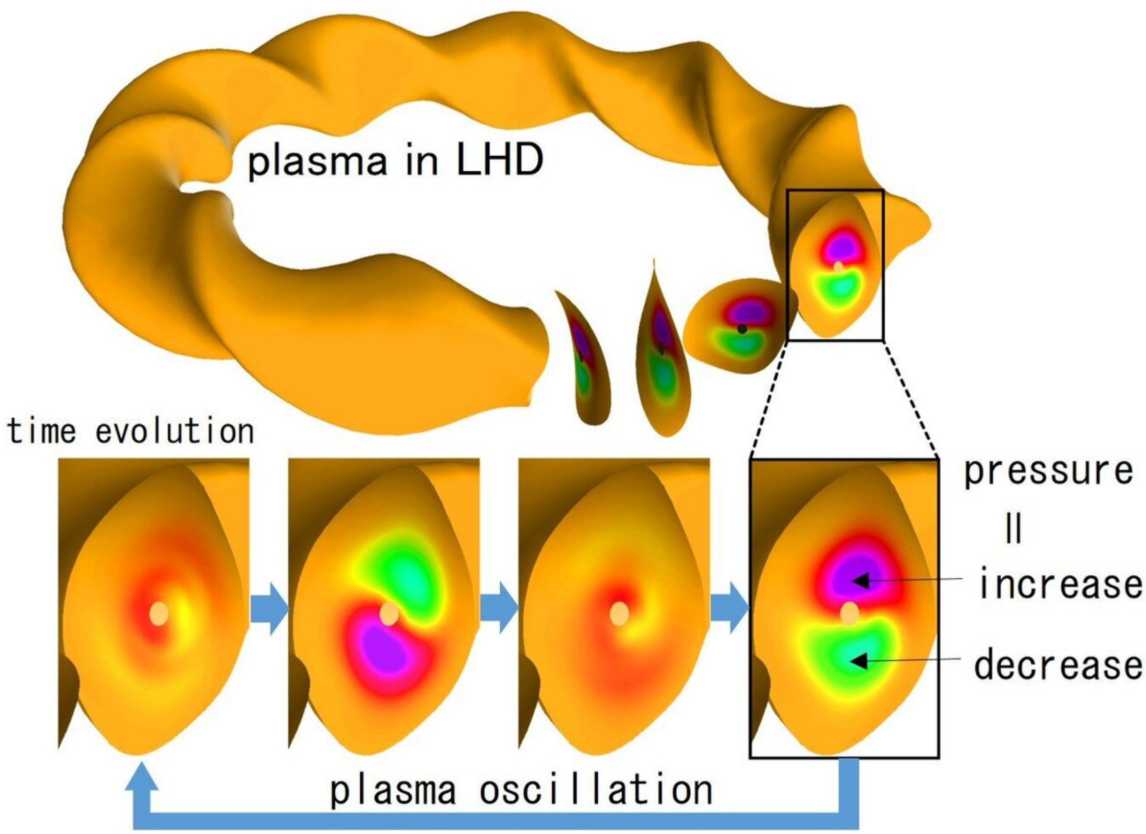


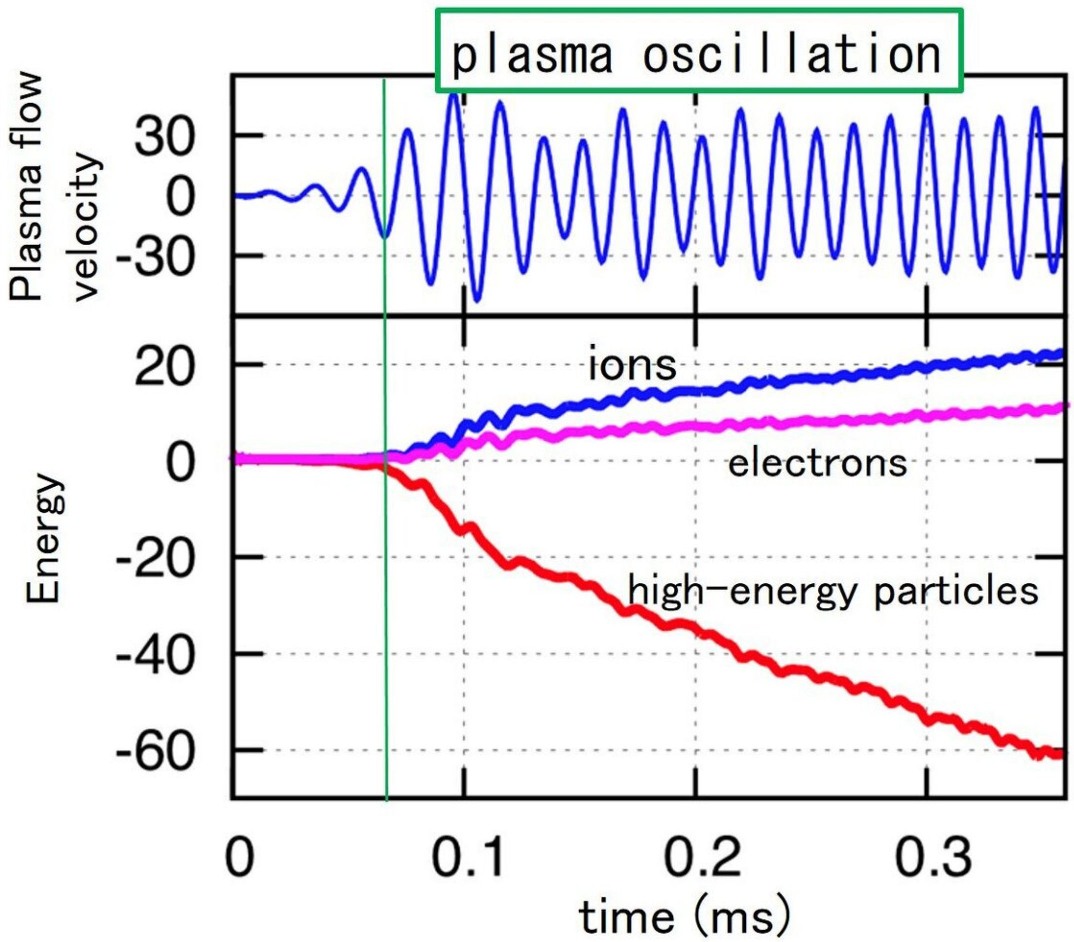
Plasma oscillations driven by high-energy particles in a plasma in LHD. Credit: NIFS

A research team of fusion scientists succeeded in proving that ions can be heated by plasma oscillations driven by high-energy particles. This has been confirmed by performing a large-scale simulation with a newly developed hybrid-simulation program that links calculations for plasma oscillations, high-energy particles and ions. This research will accelerate studies of plasma self-heating for realizing fusion energy.

The fusion reaction between deuterium ion and tritium ion in a high-temperature plasma will be used in fusion reactors in the future. The high-energy alpha particles generated by the fusion reaction give their energy to the plasma, and this plasma self-heating maintains the high-temperature condition required for the fusion reaction. However, we have the problem that the heating of fuel ions is weak because the high-energy particles give most of their energy to electrons through collisions with the electrons. In order to increase the ion heating rate, it is proposed that ions can be heated by the plasma oscillations driven by the high-energy particles. However, this ion heating mechanism has not yet been confirmed.

The research team of Assistant Professor Hao Wang and Professor Yasushi Todo of the National Institutes of Natural Sciences (NINS) National Institute for Fusion Science (NIFS) conducted research on the ion heating by plasma oscillations using computer simulations.

Professor Todo previously developed a computer program that can simultaneously simulate the state of the plasma as a whole, which is treated as fluid, and the movement of high-energy particles in a plasma. This program, because it links and calculates the fluid and the particles, is called the hybrid-simulation program. It enables us to study the interaction between the plasma oscillations and the high-energy particles. The program is highly evaluated among fusion scientists, and several simulation studies using the program are now ongoing.



Time variations of plasma oscillation and energy of ions, electrons, and high-energy particles. Credit: NIFS

However, in order to study ion heating by plasma oscillations driven by high-energy particles, it is necessary to expand the hybrid-simulation program to simulate ion motions influenced by the plasma oscillations. The research team has succeeded in developing a new hybrid-simulation program by calculating ions in a plasma as particles and by linking the three kinds of calculations for the plasma oscillations, the high-energy particles, and the ions. Using the new hybrid-simulation program, they performed a large-scale simulation on the super computer regarding the plasma generated in the Large Helical Device (LHD). (On the LHD, we utilize the high-energy hydrogen particles that are inside the plasma to study plasma oscillations driven by high-energy particles.) The new hybrid simulation clearly shows that ions obtain energy from plasma oscillations excited by the high-energy particles. This indicates that the ion heating rate in a self-heating plasma can be increased by using the plasma oscillations.

Thus, the research team has proved the ion heating by plasma oscillations for the first time in the world. On the basis of the results of this study, the research on self-heating plasma for realizing fusion energy will be accelerated.

This research result was published as Wang, et al. "Simulation of energetic particle driven geodesic acoustic modes and the energy channeling in the Large Helical Device plasmas" in *Nuclear Fusion* in August 2019.

More information: Hao Wang et al, Simulation of energetic particle driven geodesic acoustic modes and the energy channeling in the Large Helical Device plasmas, *Nuclear Fusion* (2019). DOI: 10.1088/1741-4326/ab26e5

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