【Grant-in-Aid for Scientific Research(S)】
Science and Engineering (Engineering Ⅱ)

Title of Project : Current Drive by Lower Hybrid Wave in Spherical Tokamak Plasmas

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Research Area : nuclear fusion

Keyword : core plasma

【Purpose and Background of the Research】

In the tokamak plasma confinement device, a current flowing in the plasma (plasma current) is necessary. The plasma current is usually driven by the CS coil located in the central part of the torus. If tokamak operation without the CS were possible, more compact and economically competitive tokamak fusion reactors could be realized. This is the most critical issue for spherical tokamaks (ST) with limited space in the central part of the torus. The formation of ST plasma with low plasma current by electron cyclotron wave (ECW) has been demonstrated on TST-2 at the University of Tokyo. This project aims at demonstrating further plasma current ramp-up by adding current drive by the lower hybrid wave (LHW). Such a demonstration would enhance the feasibility of ST fusion reactors dramatically.

【Research Methods】

The TST-2 spherical tokamak and the 200 MHz, 400 kW RF generator installed at the University of Tokyo will be used. LHW excitation will be studied using several antennas in stages. By comparing the results of these experiments, it would be possible to separate the pressure driven current due to plasma heating from directly driven current due to asymmetric deformation of the electron velocity distribution function by waves. A comparison of exciting the fast wave or the slow wave gives information on mode conversion, and the necessity of direct LHW excitation could be judged. In addition, by synthesizing simultaneous measurements of waves at many locations, measurements of the electron distribution function, equilibrium reconstruction based on magnetic measurements, and density and temperature measurements, the mechanism of current drive could be clarified. By comparing with the results of the state-of-the-art wave analysis code TORICLH, or nonlinear calculations of parametric decay processes, important contributions to the understanding of wave physics and wave-particle interaction could be made.

【Expected Research Achievements and Scientific Significance】

In tokamaks, LHW has the highest current drive efficiency. Since ST plasmas have very high dielectric constants, current drive by LHW is believed to be inefficient. However, the plasma produced by ECW has low density and the dielectric constant is of order 1. It should be possible to achieve current ramp-up, if such a low density plasma could be maintained. Such an experiment is nonexistent worldwide, and unique, original results are expected. For ST reactors, plasma formation and non-inductive sustainment of steady-state burn utilizing the self-driven current are believed to be feasible, but how to reach a steady-state burn from the initially formed plasma remains a serious issue. If current ramp-up by LHW with high enough efficiency were demonstrated, such a concern could be dispelled. There is great significance in such achievement, since dramatic improvements in the economic competitiveness of conventional tokamak fusion reactors could also be realized.

【Publications Relevant to the Project】

・Y. Takase, T. Fukuda, X. Gao, et al, “Plasma current start-up, ramp-up, and achievement of advanced tokamak plasmas without the use of ohmic heating solenoid in JT-60U,” J. Plasma Fusion Res. **78**, 719-721 (2002).
・Y. Takase, A. Ejiri, S. Shiraiwa, Y. Adachi, et al., “Plasma current start-up experiments without the central solenoid in the TST-2 spherical tokamak,” Nucl. Fusion **46**, S598-S602 (2006).

【Term of Project】 FY2009-2013

【Budget Allocation】 74,100 Thousand Yen

【Homepage Address and Other Contact Information】

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