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Low frequency wave excited by magnetic reconnection in plasma merging experiment

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Magnetic reconnection is the topological change of a magnetic configuration through breaking and reconnecting of magnetic field lines. Although this is a localized phenomenon, it often causes fundamental changes in plasma global configuration, such as in solar flares and relaxation process in laboratory plasma. Magnetic energy stored in a plasma is released by magnetic reconnection and converted to plasma kinetic and thermal energies. As well as the reconnection outflow, MHD waves are expected to carry energy away from the reconnection point.
MHD waves, in particular, ion cyclotron range of frequency (ICRF) wave plays important role for plasma heating in solar corona and fusion plasma. In solar corona, low frequency MHD waves excided by magnetic reconnection in the lower solar atmosphere or surface is believed to be responsible for the solar coronal heating. In fusion plasma, ion cyclotron resonance heating is known as one of the efficient plasma heating methods. Thus, we take notice of the excitation of MHD waves by magnetic reconnection and the resulting plasma heating. The primary goals of the present experiment are: to detect low frequency waves autonomously-excited by magnetic reconnection during merging of two torus plasmas and to investigate the wave propagation and damping characteristics.
In plasma merging experiment apparatus (TS-3), we can merge two torus plasmas in relatively-high magnetic Reynolds number (<1000). In counter-helicity plasma merging case (counter-helicity means that toroidal magnetic field lines of two torus plasmas are inverse), both the poloidal and toroidal magnetic fields reconnect. Since the Reconnecting magnetic field lines are anti-parallel without guide field, fast magnetic reconnection takes place and significant ion heating was observed by a Doppler spectroscopy measurement. The plasma ions are heated to 200eV after merging while the initial ion temperature is about 20eV. However, no significant outflow comparable to the ion temperature of 200eV has been detected yet. Therefore, plasma might be heated not by the outflow from the reconnection point but by the MHD waves. Since no significant electron heating has been observed, the ions are expected to be heated directly by the low frequency MHD waves.
We have carried out internal magnetic fluctuation measurement for the counter-helicity merging case by using small pickup coils. Low frequency fluctuation with f < 1MHz is detected near the X-point during the plasma merging period. This fluctuation is assumed to be caused by the global motion of the magnetic field lines. On the other hand, fluctuation with f ~ 1.5MHz is observed at the reconnection outflow regime. This fluctuation arises later than the forementioned fluctuation with f < 1MHz and lasts after the plasma merging is finished. Thus, it is assumable that the later fluctuation is the MHD wave excited by magnetic reconnection. We will present the propagation property of the wave and the relation between the ion heating and the wave damping.

Keywords: magnetic reconnection, MHD wave, magnetic fluctuation, plasma heating, plasma merging, FRC