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Magnetic reconnection studies in High Field Spherical Tokamak

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Magnetic confinement concepts, and tokamak concept in particular, are based on containment of a hot plasma and insolation of it from the wall of the vacuum vessel, where plasma is contained, by the externally applied magnetic field. So, the magnetic field is mainly used for plasma containment and shaping. In the last decade it has been demonstrated [4,5] that there is a way how to transfer energy of the magnetic field directly into the plasma thermal energy with a very high efficiency (up to 90%), thus using magnetic field not only for the containment, but also directly for the plasma heating. This can be achieved using magnetic reconnections during merging-compression formation of the tokamak plasma [3], Fig.1. Applicability of this method of plasma formation in futures devices is under investigation, however, use of merging-compression in ST40 [1,2] and similar scale devices helps to advance the understanding. Magnetic reconnection experiments in laboratory plasma at high temperatures and low collisionality also extend the parameter space of reconnection studies.

Magnetic reconnections can be used both for an efficient plasma formation in tokamaks, and efficient ion heating. New results from ST40 [1,2], a spherical tokamak with high toroidal field, Fig.2, have confirmed empirical scalings for ion heating due to magnetic reconnections, and are in good agreement with the previous experimental results. However, high toroidal field in ST40 (up to 2T) exposed new effects, not clearly seen in low-TF devices. Due to much higher toroidal (guide) field than in previous experiments, fast particles, both electrons and ions, are better confined. We now clearly observe formation of fast electrons, with energies from several hundred keV to up to 10 MeV. We also observe higher ion temperatures, produced due to magnetic reconnections, than in previous experiments and higher plasma currents after formation, without use of the central solenoid, exceeding 0.5 MA.

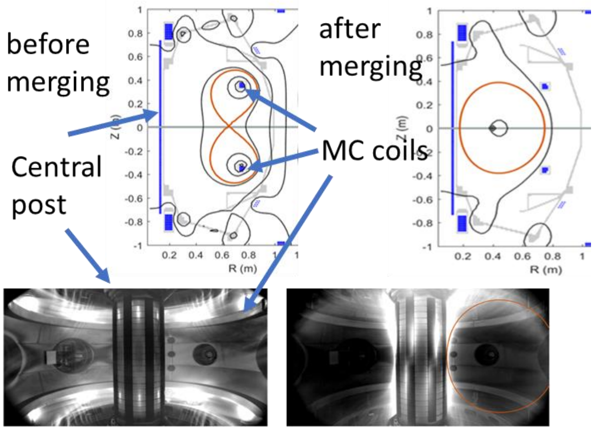

Fig.1. Merging-compression formation: magnetic reconstruction, top, CCD image, bottom.

Although ion temperatures needed to satisfy burning plasma conditions [5] have not been obtained yet, predictions show that with the planned upgrades of ST40, 10 keV range of ion temperatures may be expected. These upgrades, which are currently on-going, include increase in the reconnection poloidal field that will result in expected ~B_{rec}^2 increase in the ion temperature; and the increase in toroidal field up to 3 T that together with the increased plasma current will further improve the fast ion confinement.

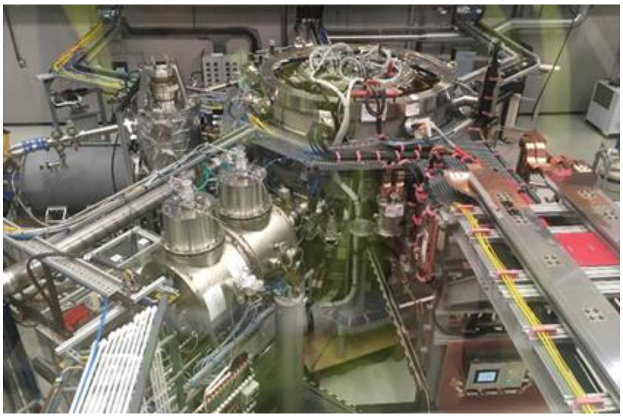

Fig.2. ST40

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