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Physics of highly autonomous high beta plasma

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Physics research of high beta plasmas using the spherical tokamak (ST) is being carried out, supported by the Interdisciplinary International COE Program of National Institutes of Natural Sciences. ST research in Japan was reorganized as All-Japan ST Research Program. Nationally coordinated research is carried out by mostly university researchers, and in collaboration with the MAST group in UK, and NSTX and MRX groups in the US. MAST and NSTX are capable of plasma currents in excess of 1 MA, and can produce high beta plasmas with higher temperature and lower collisionality. In such plasmas, self-driven current becomes dominant and a highly self-organized state is realized, presenting a typical example of a complex system. To understand and develop a control method for such a state is important not only for realization of a fusion reactor, but also for contributions to other fields of science. Specific examples of international collaboration include high beta ST plasma formation using plasma merging, magnetic reconnection, and physics of divertor and scrape-off plasma in MAST; research on autonomy and self-organization in high beta plasmas with high fraction of self-driven current in NSTX; and basic reconnection experiments in MRX. In Japan, research aimed at broadening of future possibilities is carried out focusing on ultra-high beta plasmas, ultra-long pulse discharges, and development of new current drive methods, utilizing a variety of small but unique ST devices. In addition to ramifications to complexity science, research aimed at understanding the physical process of magnetic reconnection is a common research topic with astrophysics, and important contributions as a laboratory astrophysics experiment are anticipated. Understanding of physical processes such as new form of energy conversion, anomalous resistivity, fast reconnection and shock formation, through reconnection experiments in high beta plasmas with very high magnetic Reynolds number not realized in laboratory experiments up to now would become possible, and important contributions to the vast areas of solar, celestial, and magnetospheric plasmas can be expected. In addition, applications of physical understandings developed in these areas to fusion physics using high beta plasmas would help promote development of interdisciplinary research.