4th Asia-Pacific Conference on Plasma Physics, 26-31Oct, 2020, Remote e-conference

Fluid and kinetic aspects of magnetic reconnection and some related magnetospheric phenomena

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Magnetic field reconnection plays a key role in determining the magnetic field topology and in the conversion of magnetic energy into kinetic energy in cosmic plasmas. Magnetic reconnection was proposed by solar physicists in an attempt to explain solar flares. The concept of magnetic reconnection was extended to Earth's magnetosphere to explain auroral substorms. In this review, we first briefly review the classical fluid steady models with small separatrix angle. We then report magnetic reconnection with a large separatrix angle, and the time-dependent multiple X line reconnection (MXR) associated with flux transfer events. The transition from a single X line reconnection to MXR is examined. The particle pressure gradient associated mainly with the electron (ion) off-diagonal pressure tensor terms, P_{xy} and P_{zy}, is shown to play an important role for electron (ion) dynamics to balance the reconnection electric field (E_y) near the X line. In addition, various plasma waves and instabilities may occur near the ion diffusion and electron diffusion regions, including the lower hybrid drift instability, ion-ion beam instability, electron beam instability, whistler waves and kinetic Alfvén waves. The layered structure of outflow region of magnetic reconnection is examined. These layered structures include slow shocks, rotation discontinuities, expansion waves and plasma jets. Recent observations of magnetic reconnection in the Earth and planetary magnetospheres are also discussed. The polar cap electric field associated with magnetic reconnection at the Earth's magnetopause and the energy flow in the polar cap region are examined.

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