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磁気リコネクションにおけるイオンの特異な速度分布と加熱機構の関係
Relationship between anomalous ion velocity distributions and heating mechanisms in magnetic reconnection

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Magnetic reconnection is a fundamental process through which energy is rapidly released, and has been actively studied by theories, simulations, laboratory experiments, and satellite observations. By means of particle simulations, we have investigated various types of non-Maxwellian ion velocity distributions such as circle-shaped and arc-shaped structures displayed in Figs. 1 (a) and (b), which are formed in the downstream of magnetic reconnection [1-3]. In this presentation, we will suggest that the studies of non-Maxwellian velocity distributions in our simulations can be collaborated with satellite observations in the Earth magnetosphere and laboratory experiments in spherical tokamaks (STs).

First, we discuss potential collaboration with satellite observations. We point out that circle-shaped and arc-shaped velocity distributions can be observed directly by satellites in the Earth magnetosphere. Furthermore, our particle simulations have recently found crescent-shaped velocity distributions of ions coexisting with the circle-shaped distributions, shown in Figs. 1 (c) and (d). On the other hand, the Magnetospheric Multiscale (MMS) satellite mission observed crescent-shaped velocity distributions of electrons on the dayside magnetopause [4], and theory and particle simulations suggested its formation mechanism [5,6]. Crescent shapes found in our work and ones discovered by MMS have many different characteristic features and situations. Our crescent shapes are responsible for ions and are formed under guide-field reconnection, while crescent shapes observed by MMS are responsible for electrons and are formed under asymmetric antiparallel reconnection. Nevertheless, we will demonstrate that the two kinds of the crescent distributions contain some common features based on the same theory.

Next, we discuss applications to laboratory experiments. The presence of non-Maxwellian velocity distributions means that the system does not relax to thermal equilibrium state. To such situations, however, we can introduce the effective temperature by defining the effective thermal velocity as the standard deviation of particle velocities. Accordingly, the formation of the non-Maxwellian distributions is applied to plasma heating in STs. Actually, we have shown that the circle and arc velocity distributions simply account for tendencies reported in TS-6 (previous TS-3) experiments, i.e., the heating energy is proportional to the square of the reconnection field and the temperature is decreased as the guide filed is intensified [7,8].

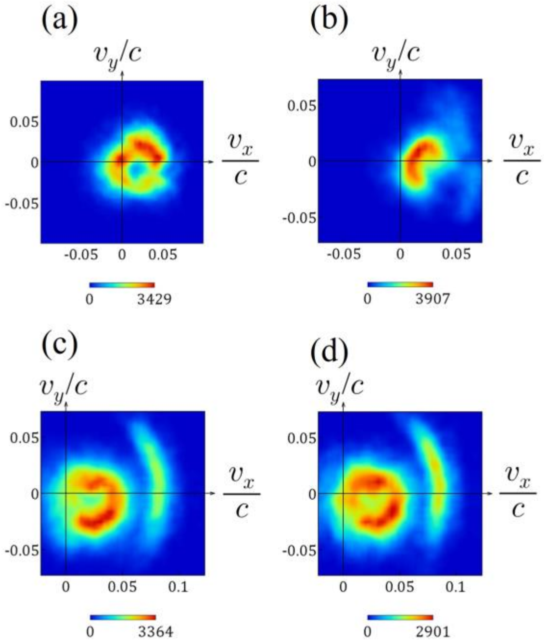

Fig. 1: Various types of non-Maxwellian velocity distributions found in our particle simulations.

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