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磁気リコネクションにおける特異な速度分布に関するシミュレーション研究の進展

Progress in simulation studies of anomalous velocity distributions during magnetic reconnection

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Magnetic reconnection is a fundamental process through which energy is rapidly released. Plasma heating is one of the important issues in magnetic reconnection. We investigate ion heating mechanism during magnetic reconnection in the presence of a guide magnetic field by means of particle simulations.

So far, our simulations have demonstrated that various types of anomalous, i.e., non-Maxwellian ion velocity distributions. Figure 1, for example, shows circle [1, 2], circular arc [3], and circle with attached/separated arc structures [4]. The motions of ions forming such anomalous velocity distributions are the Pick-Up-like. Upon entering the downstream across the separatrix, ions behave as nonadiabatic. Thus, their entry velocities are much different from the reconnection outflow velocity. Thus, their motion is the ExB drift while rotating around the guide magnetic field. This means that ions are effectively heated in the downstream, because velocity distribution is broadened compared with a Maxwellian distribution in the upstream [1-4].

In this work, we report recent progress in studies of the anomalous velocity distributions associated with effective heating. In our simulations, we discover another type of non-Maxwellian velocity distributions as shown in Fig. 2. Although an attached arc is formed as a sub-part, it seems as if a Maxwellian distribution holds as the main part. However, we clarify that this distribution is a “pseudo-Maxwellian”, not a genuine-Maxwellian.

The formation process also is explained by the Pick-Up-like motion. In the previous work, we have ignored a finite thickness of circle/arc-shaped distributions. By considering the thickness of a circle (see Fig.3), the Pick-Up-like motion accounts for the formation of pseudo-Maxwellian distribution. In the simulation case of Fig.2 (B_g ~1), the circle radius is close to the thickness, and hence the hole of the circle does not appear. Consequently, we can see pseudo-Maxwellian structure.

The pseudo-Maxwellian is indistinguishable from a genuine-Maxwellian in shape. Hence, this finding suggests that pseudo-Maxwellian distributions would have been overlooked in particle simulations and observations.

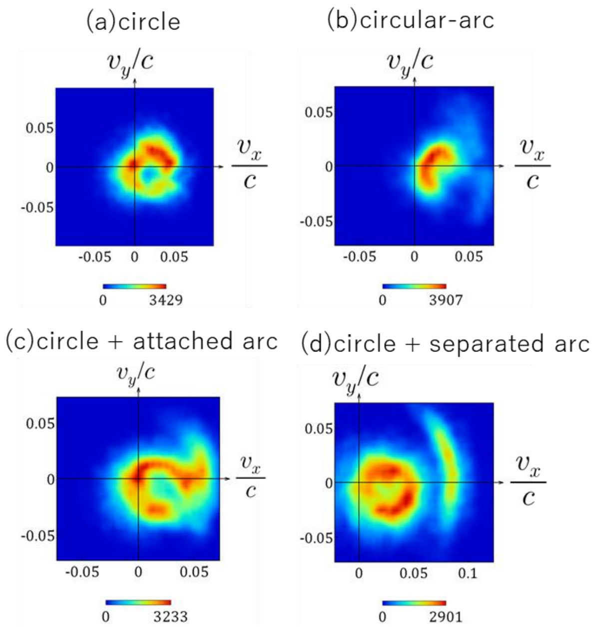

Fig.1: Various types of anomalous velocity distributions.

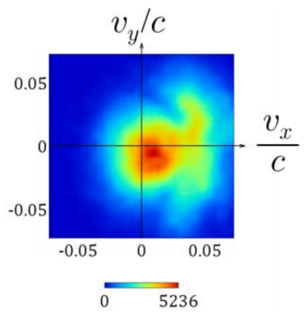

Fig.2: Pseudo-Maxwellian distribution.

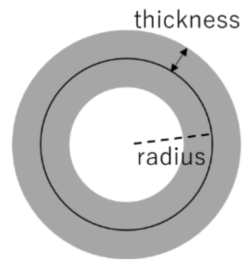

Fig.3: Schematic diagram of a circle with a thickness.

References

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