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New wave heating process of heavy ions in multi-component plasmas

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Preferential heating of heaver charged particles than protons is observed in several collisionless plasma circumstances. The observations of the SOHO satellite indicate that in the polar coronal holes O5+ ions are preferentially heated [e. g., Cranmar et al., SSR, 1998]. FAST and Freja satellites observed preferential heating of He+ and O+ ions through a cyclotron resonance with electromagnetic ion cyclotron (EMIC) waves [e. g., Lund et al., GRL, 1998]. 2-component plasma which consists of electrons and ions can not explain these observations. Multi-component plasma which consists of electrons, ions, and heavy ions has the properties which 2-component plasma does not have, and the relation between the properties and the preferential heating is recently discussed.

We have discussed the preferential perpendicular heating of heavy ions paying attention to a wave-particle interaction in the multi-component plasma. In the multi-component plasma, there is a Super-Alfvenic EMIC wave (SPA) which has very faster phase velocity and very longer wavelength than Alfven wave. We have discussed the wave-particle interaction existing both SPA and normal EMIC wave which we call Sub-Alfvenic wave (SBA). We have found that heavy ions are preferentially, strongly and non-stochastically heated to the perpendicular direction using test particle simulations. The quasi-linear theory, second ordered Fermi acceleration and so on cannot explain the heating ratio of this 'strong' heating because the particles are non-stochastic and the 'diffusion' idea cannot explain this phenomenon. In other hand, purely electric and magnetic wave theory [Mizuta and Hoshino, GRL, 2001] agree with the heating ratio. From more discussions, we find that,

1; If one of two waves does not exist, the preferential strong heating does not occur,

2; SPA phase-bunches the particles to the electric field direction,

3; SBA prevents the particles be pitch-angle scattered by SPA, and persists the phase-bunching.

From these discussions, we obtain the conditions of the wave amplitudes for the preferential strong heating, and the conditions agree with test particle simulations.

To obtain more applicable models in many plasma circumstances, we discus the wave-particle interaction existing weak turbulence and a coherent SPA. It is nessecary for the strong heating that SPA is coherent because SPA phase-bunches the particles, but SBA is not needed to be coherent. Therefore, one can consider that the weak turbulence roles same as SBA. In this case, we also confirmed the preferential strong heating occurs. Now, we are analyzing details, and we will show the results.