論文の内容の要旨

Non-equilibrium dynamics of periodically driven active colloids

（周期的に駆動されるアクティブコロイドの非平衡ダイナミクス）

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In this dissertation, nonequilibrium dynamics of periodically driven self-propelled colloids was studied experimentally and numerically. In the last two decades, studies on self-propelled particles have been intensively conducted including numerical simulations and experiments of collective motion as a nonequilibrium physics. Many studies dealt with self-propelled particles moving unidirectionally by constant propulsion forces. In contrast, time-dependent propulsions and various ways of self-propulsions such as apolar, reciprocating, run-and-tumble, and helical motions have been experimentally realised. Especially in these cases, not only the collective dynamics but the single-particle dynamics has been of interest. In this study, reciprocating motions were focused on. For example, *Myxococcus xanthus* are known to reciprocate in nature. Self-propelling droplets reciprocate spontaneously at their natural frequencies. In these systems, the frequency and phase of the reciprocation cannot be controlled. In the systems driven by global external fields, the time-dependent propulsions were mostly on-off signals. To investigate sinusoidally driven self-propelled particles which are expected to reciprocate, Quincke rollers, which are dielectric particles driven by electrorotation induced in conducting liquid, were selected and studied experimentally with an AC field.

First, the single-particle dynamics of a Quincke roller under an AC field was investigated. The peri-

odicity in the velocity at the frequency of the external field below the Maxwell-Wagner frequency was confirmed. Then, the reciprocation of the particle was numerically explained by a generalisation of the theory on the Quincke roller under the DC field to that under the AC field. It was found that the peak at the external frequency and its odd higher harmonic peaks appeared in the velocity power spectrum both experimentally and numerically. The periodic motion was confirmed to be a limit cycle in a wide range of frequency values. Also, the existence of peaks at frequency lower than the external frequency and anomalous MSD behaviour were discovered experimentally, which were considered to be due to a DC component of the velocity.

Secondly, the locomotion of a doublet and a triplet which appeared spontaneously as a part of dynamic clustering in the AC experiment was studied. Not only the periodicities in the velocities at the frequency of the external field and the odd higher harmonics but also even harmonics were found, which is considered to be a result of the dipolar-dipolar interaction. Furthermore, periodic changes of configuration within typical interparticle distances were observed in the doublet and the triplet. Also, heterogeneity of the mean propulsion angle around a particle was revealed. This research can be an experimental example of periodic self-propelled particles and highlight characteristics of multi-particle dynamics made of a small number of interacting particles.