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# 論 文 要 約

系・コース：物理学系物理学コース
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Recently, nonlinear fluctuating hydrodynamics (NLFHD) was proposed as a phenomenological method to analyze physical quantities of one-dimensional non-equilibrium systems. NLFHD was first introduced to explain anomalous heat transport observed in one-dimensional anharmonic chains including the Fermi-Pasta-Ulam chain based on microscopic dynamics. In other words, for such models, NLFHD predicts that the two-point correlation function of the currents of conserved quantities shows super-diffusive behavior in the long time limit. Besides that NLFHD has so far been applied to some other models such as the Arndt-Heizel-Rittenberg (AHR) model and the classical XXZ spin chain, and these results have been confirmed by some numerical methods such as the Monte Carlo method and the molecular dynamics method. However, there are some physical assumptions in the derivation of governing equations of NLFHD and this implies that NLFHD does not have a foundation based on microscopic dynamics. We have achieved the first theoretical confirmation of NLFHD for the AHR model, which is a multi-species integrable stochastic particle system, taking advantage of its integrability. One of the main purposes of this thesis is to give full detail of the confirmation of NLFHD for the AHR model. We also provide representations of eigenstates for the AHR model for a parameter region of transition rates which has not been studied before in the context of NLFHD yet. In the following, we will explain these main results in more detail.

The first main result is the confirmation of NLFHD for the AHR model. The AHR model is a continuous time Markov process in which two kinds of particles aligned on a one-dimensional lattice move stochastically in opposite directions each other interacting exclusively. In this thesis, the kinds of particles that move only to the right and left are called plus and minus particles, respectively. The AHR model has a remarkable property called integrability based on the Yang-Baxter equation which guarantees that one can solve the eigenequation for the Markov matrix using some techniques such as the nested coordinate Bethe ansatz and the nested

algebraic Bethe ansatz. Since we have the exact formula for the wave function, which is a component of the eigenvector of the Markov matrix, we can also obtain the exact solution of the master equation, which governs the time evolution of the Markov process. By performing a summation of these solutions, we can derive the probability distribution in a multi-fold integral formula for the event where all plus and minus particles aligned to the left and right of the origin, respectively, at the initial time have passed the origin by the final time. By taking the scaling limit for the particle numbers of this probability distribution where the initial particle configurations are specialized in some ways, we can confirm the prediction of NLFHD with the step-Bernoulli initial condition which states that the probability distribution asymptotically becomes a product of two independent cumulative distribution functions. It is difficult to carry out such asymptotic analysis as far as this probability distribution is written in a multi-fold integral formula because taking this scaling limit corresponds to making the numbers of integrations infinity. We overcame this difficulty by rewriting them as a Fredholm determinant in a similar way to the case of a single species model, and this is one of the novelties of this thesis. On the other hand, another difficulty in asymptotic analysis for this model is that the multi-fold integrals concerning two series of variables, which correspond to two kinds of particles, are not divided into two independent integrals whereas the prediction is written as a product of two independent functions. As the second main novelties in this thesis, let us emphasize that we removed this difficulty by putting a part of the kernel in Fredholm determinant corresponding to the part of the integrand of the integrals concerning two series of variables that makes them not independent into a rank-one matrix.

The second main result is a conjecture for the wave functions for the AHR model with general transition parameters as long as the model is integrable. The confirmation of NLFHD for the AHR model mentioned above was carried out only when the transition rates of two kinds of particles are restricted on a certain condition. That is because, on this condition, the wave functions can be derived in almost the same way as the well-known nested coordinate Bethe ansatz, i.e., they can be represented as simple formulae like a mixture of two different series of particles that move in opposite directions. In case this condition does not hold, while the integrability of the AHR model is preserved, the concrete formula for the wave functions is not written as simple formulae like those of the case where the condition is satisfied and no one had known how they are represented. We derived the wave functions of the AHR model with general transition rates

for some cases where the numbers of particles are specialized in some ways, and we obtained the conjectures that give the formulae of the wave functions for arbitrary numbers of particles.