論　文　の　要　旨

題　目 Study of Numerical Stochastic Perturbation Theory toward the high-order perturbation of matrix models

（行列模型の高次摂動計算のための数値確率過程摂動理論の研究）

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In this thesis, I study the high-order perturbative behavior of a QCD-like matrix model called the twisted reduced principal chiral model using numerical stochastic perturbation theory (NSPT). Recently, resurgence theory in mathematics has provided a way to extract non-perturbative information, such as instantons and renormalons, from perturbation theory by recognizing the divergent perturbative series that carries non-perturbative effects in its asymptotic behavior in some quantum mechanics and quantum field theories. Consequently, we could extract the non-perturbative component, provided we possess sufficiently high-order perturbative coefficients. This task proves challenging using conventional methods such as Feynman diagrams, as the number of diagrams exhibits factorial divergence with a given perturbative order. One way to alleviate this is called NSPT. Even though NSPT reduces the computational cost from $O(N_{PT}!)$to $O(N_{PT}^2)$, where N_{PT} represents the maximum truncated order in perturbation calculation, it still requires considerable computational time to achieve it. In this thesis, I developed a new algorithm called the Paterson-Stockmeyer (P-S) method to accelerate the bottleneck of the NSPT simulation. Moreover, using the newly developed method combined with large N factorization, I have investigated the high-order perturbative behavior of TRPCM and observed a signal indicating the existence of renormalons in the numerical results. In conclusion, I extracted non-perturbative information using high-order calculations of perturbative coefficients for this specific model. The same workflow can be applied to other complicated theories, such as full QCD, which is our target, yielding similar results.