# Performance improvement of physical reservoir computing based on the theory of dynamical systems

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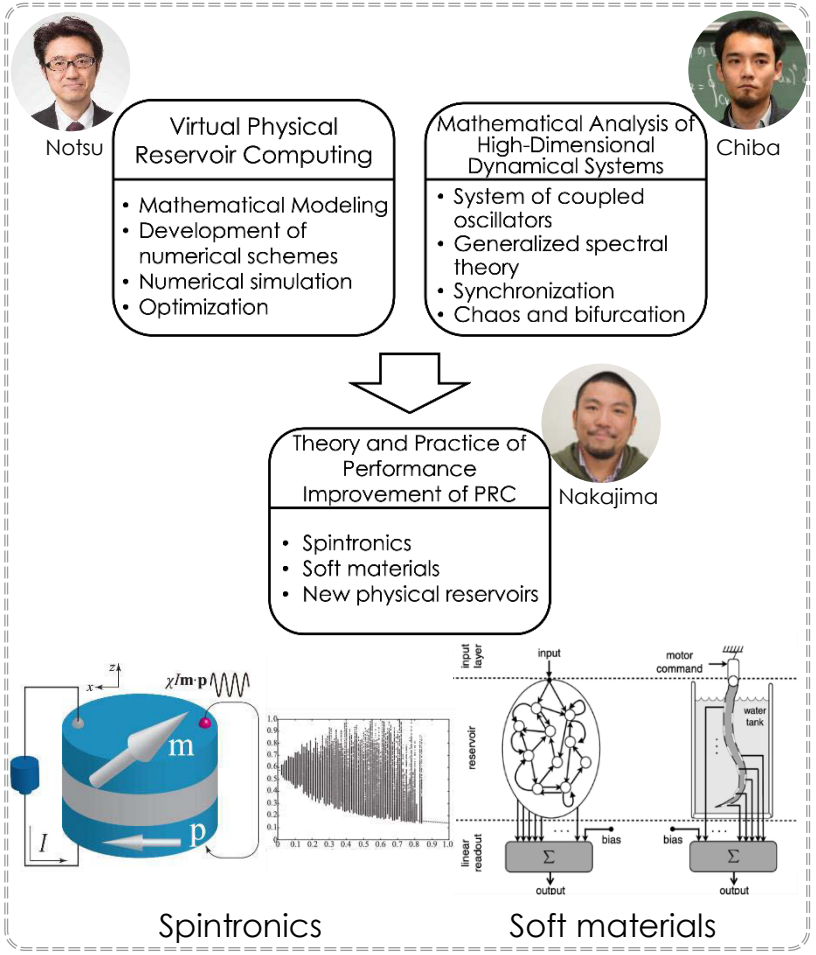
Research Area「Mathematical Information Platform」
（Research Supervisor：Naonori Ueda、Year started: 2019）

**Outline:** Physical reservoir computing is a new information processing technology that uses physical phenomena, which are nonlinear dynamical systems, as computational resources, having the advantages of low computational resources and instantaneous optimization. In this research, with the aim of maximizing the information processing capability of physical reservoir computing, we will develop basic mathematical theory based on dynamical systems theory and conduct research on mathematical modeling and numerical analysis for low computational costs, and will construct a theory to design a high-performance reservoir. Furthermore, we will conduct implementation research with a focus on spintronics and soft materials, aiming to contribute to next-generation technologies such as edge computing.

**Research Goals:** Construction of mathematical theory and method for improving the information processing capability of physical reservoir computing using dynamical systems theory, and contribution to society and academia through implementation research in spintronics, etc.

**Related Work and Challenges:** Although the concept of physical reservoir computing is new in information processing technology, reports on its implementation are already available in various fields, and it is becoming clear that it can be implemented in a wide range of spacetime scale physical systems. However, the setting of the physical systems is mostly haphazard due to the lack of mathematical foundation for predicting the capability of the reservoir. In this research, we aim to improve the information processing capability of the physical reservoir and perform detailed analysis based on a solid mathematical foundation such as dynamical systems theory and numerical analysis for the implementation. In particular, we will take mathematical approaches to the finding that the capability increases at the edge of chaos. Our attempt to apply the theory of coupled oscillator systems and the theory of bifurcation, which have been rapidly developed in recent years, is unprecedented and highly original. By performing this research, it is expected that the results will become a benchmark in this field.




## Future Deployment & Research Plan

(1) Research plan after the end of the CREST research period:
We will apply the method for strengthening the information processing capability of the developed physical reservoir computing to the physical systems that have not yet been examined, predict its potential information processing capability and present physical systems with sufficient information processing capability. We also aim to develop interdisciplinary research fields by series of seminars and research meetings.

(2) Creation of science and technology innovations, acquisition and utilization of intellectual property rights, creation of new industry/social contribution:
We will pioneer application domains in the field of edge computing, apply for patents and construct a protocol for social implementations of new physical reservoirs. We will also contribute to society by producing human resources having the knowledge and ability to combine nonlinear dynamical systems and machine learning.