Research area in Strategic Objective *"Comprehensive understanding and advanced prediction and control of complex transport phenomena"*

New fluid science for understanding, prediction and control of complex flow and transport phenomena

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Overview

This research area aims to build a foundation for new fluid science that will help us to fundamentally clarify complex flow and transport phenomena and to establish more accurate predictions and advanced methods of control. To do this, we will make full use of environments and techniques for numerical flow simulation, which have undergone remarkable development in recent years; flow measurement techniques; and applied mathematical techniques that analyze the vast amounts of data obtained through these.

More specifically, we target research on all kinds of flow and transport phenomena, including momentum, heat, and materials transport due to turbulence; flow accompanying chemical reactions such as combustion; various environmental flow phenomena; flow and transport phenomena in living organisms; the transport and transfer phenomena of a variety of complex fluids; and transport phenomena of electromagnetic fluids. We will apply traditional fluid mechanics analysis techniques to these phenomena, but we will also make use of applied mathematical analysis, data science, numerical simulations, new experiments and measurement techniques, and more. By then mutually applying the knowledge gained by increasing the depth of research, we will contribute to the discovery of clues relating to the clarification of complex flow and transport phenomena, as well as the development of new fluid science that makes use of the strengths of each field.

Taking complex flow and transport as keywords, we will introduce perspectives with overarching views of several fields related to fluid dynamics in a broad sense, and encourage proactive interdisciplinary exchange between young researchers.

Research Supervisor's Policy on Call for Application, Selection, and Management of the Research Area

1. Background

The world around us is full of materials (i.e. fluids) that flow. One of the major characteristics

of the flow of fluids is that it transports materials, heat, momentum, etc., very efficiently. Consequently, when it comes to flow transport and transfer phenomena, there is strong demand for the formation of a foundation for a variety of techniques that will support our daily lives, the direct connection of these to environmental and energy issues, and the accurate predictions and highly efficient control thereof. However, when dealing with the flow and transport phenomena that surround us, the state of the flow may be complex, typified by turbulence, or the fluid itself may be complex, typified by multiphase flow; these complexities make it difficult to understand these phenomena.

On the other hand, fluid mechanics is subject to continuous research in a variety of fields—not just in aerospace engineering or mechanical engineering, of which fluid mechanics is one of the foundational fields, but also in subjects such as applied mathematics, physics, medical engineering, geophysics, meteorology, plasma engineering, and chemical engineering—and knowledge is accumulated in each field. Remarkable development is also being achieved, including the dramatic improvement of numerical environments, measuring techniques of flow, and data science.

Thus, by creating a place in which researchers from a variety of fields that deal with complex flow and transport phenomena can meet, we anticipate the creation of new fluid science, the fundamental understanding of complex flow phenomena based on the latest knowledge gained in each field, and the development of predictions and control methods thereof.

2. Application and selection policies

(1) Basic principles

We have set up this field with a focus on researching everything that flows and we are calling for research projects based on individual research with excellent originality that emphasizes integration with other fields. We are looking for ambitious research projects that will pioneer new fluid science without being limited by conventional fields of research: approaches that newly incorporate data science and applied mathematical techniques in current research on flow and transport phenomena; those that extend the theoretical, experimental, or numerical methods in current research to other flow phenomena; and those that discover and build “laws” for flow phenomena from the data gained via experiments or numerical simulations using a mathematical science perspective.

(2) Assumed research fields

A. Eligible research

We have raised the following phenomena as examples, but any phenomenon is eligible for research as long as it is a complex flow and/or transport phenomenon.

・Turbulence and turbulent transport phenomena
・Material and/or thermal transport phenomena in a variety of systems
・The flow phenomena of complex fluids
・Various phenomena of environmental fluids
・Flow within living organisms, and various phenomena of biological fluids
・Transport phenomena within electromagnetic fluids
・Transfer phenomena

B. Research techniques

Research techniques may include numerical simulations, experiments and measurements, applied mathematical analysis, and/or data science, etc. We are calling for research proposals that incorporate new techniques in research currently being carried out on flow and transport phenomena, or, conversely, research proposals that apply original analysis techniques, simulation techniques, and/or experimental techniques to eligible research in A. Please note that PRESTO research is to be carried out individually, but you do not have to cover all of your proposed ideas by yourself. In this case, please be aware of the details set down in "4. Points to note when applying."

3. Management policies

The management policies of this research area will prioritize the construction of a foundation for the creation of new fluid science by combining individual research in the truest sense, to enable us to achieve the abovementioned basic principles. Therefore, the selected research projects should promote unique research that is on par with world's most advanced research, as well as be constantly aware of the potential of joint research within this PRESTO research area and outside of it. We will create a foundation for new fluid science by ensuring that young people with ability acquires many different perspectives regarding the various flow and transport phenomena topics that have been difficult to solve in the past.

To accomplish this, this research area as a whole will support participating researchers so they can share new perspectives on fluid science without being confined to their different specialist fields. We will also promote collaboration with other research areas and external academic exchange through the workshops, symposiums, and other meetings that we hold.

4. Points to note when applying

As stated in our policies for application and selection, we will proactively assess your goal of integration with other fields. Thus, please state how you will integrate your own research with other fields during or after the PRESTO research period, and your vision for doing this in

the summary of your research project or in your research idea. When you do so, please clearly delineate the research points and details that you will carry out while at PRESTO, and the points and details for which you will need cooperation, such as joint research outside of PRESTO. We believe that PRESTO research envisages new content, and so do not mind if researchers make the concrete decision that, at this point in time, there is no need for joint research.

5. Research period and research costs

The research period is three years and six months or less. Budgets will have an upper limit of a total of 40 million yen (not including indirect costs).