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Jukka Tuhkuri · Arttu Polojärvi  
Editors

# IUTAM Symposium on Physics and Mechanics of Sea Ice

Proceedings of the IUTAM Symposium held  
at Aalto University, Espoo, Finland, 3–9 June  
2019

 Springer

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# Preface

The *IUTAM Symposium on Physics and Mechanics of Sea Ice* was held on June 3–7, 2019 at Aalto University in Espoo, Finland. The symposium was the fourth *IUTAM Symposium on Physics and Mechanics of Sea Ice*. The previous ones have been held in 1979 (Denmark), 1989 (Canada) and 2000 (USA). With global warming dramatically changing the sea ice environment, and with an increase in activities in ice covered seas, it was very timely to have an IUTAM symposium on sea ice again.

The objective of the symposium was to bring together scientist who have made significant contributions in the study of sea ice to discuss the recent achievements and ideas for future work. The symposium focused on the following five topics: (1) fracture of ice, (2) thermodynamics of sea ice ridges, (3) global and local ice loads on ships and marine structures, (4) computational ice engineering and ice mechanics, and (5) physical and engineering problems related to ice and waves. About five presentations were given on each topic and the presentations reflected the different perspectives in the research on mechanics of sea ice. This book includes 17 papers based on the talks. All the papers have been reviewed, mostly by the symposium participants.

Fracture of ice has been studied for decades but remains a challenge. We are still struggling to understand the effects of temperature, loading rate, and scale. However, advancements have been achieved in understanding the time dependent fracture of ice, small-scale crushing, strength of ice under cyclic loading, and ice-ice friction on different scales. Still, high quality experiments both in laboratories and in the field are needed to give us answers in these fundamental questions.

Both the mechanical and thermal processes related to sea ice ridges are complicated. Ridges act as energy sinks in large-scale sea ice models and impose large loads on Arctic ships and offshore structures. After forming, ridges consolidate - during spring and summer, ridges decay. The recent work includes experimental studies on the temporal development of ridge properties, including porosity, heat and salt fluxes in ridges, freeze bonds, and numerical modelling of ridge loads on cylindrical marine structures.

Sea ice research is important for naval architects and marine engineers, as the loads from sea ice are large and often dominate the structural design. Although a

large number of measurements have been conducted, and we know that the ice-structure contact is concentrated on a small area, we still do not know how the ship velocity and the ice thickness affect the ice load on a ship; we do not know well enough the link between ice loads and ice conditions. Numerical simulations are getting more and more detailed, interesting models are under development and are used both in research and in engineering work. The recent advancements include multiscale modelling of ice strength, fast 3D simulations using physically based modelling, inclusion of hydrodynamics in the models (still a major challenge), and the use of simulations to create data for statistical ice load studies.

One of the main goals of the symposium was to foster discussions on wave-ice interaction. There is a wealth of literature on analytic methods in wave-ice interaction from the oceanographic perspective and, with global warming, the importance of the topic increasing. However, our knowledge on coupled wave-ice effects on ships and offshore structures is much more limited. It is believed that a close collaboration between disciplines could provide research results that are significant both for oceanography and engineering. In general, in order to understand wave-ice dynamics, we need to understand what the ice cover does to the waves and what the waves do to the ice cover. In more detail, the current research includes studies on floe-floe collision induced wave attenuation, rheologies for marginal ice zone, and viscous effects in wave-ice dynamics. It was discussed if it is worth trying to reach a perfect model, to study the fundamental physics, or to admit that different models are needed to answer different questions. The question remains open.

The symposium program was planned, and the presentations selected, by the Scientific Committee of the symposium nominated by IUTAM. The members of the Scientific Committee were: Jukka Tuhkuri, Aalto University, Finland (chair); John Dempsey, Clarkson University, USA; Robert Gagnon, National Research Council, Canada; Sveinung Løset, Norwegian University of Science and Technology, Norway; Peter Sammonds, University College London, UK; Vernon Squire, University of Otago, New Zealand; Hajime Yamaguchi, University of Tokyo, Japan; and Robert McMeeking, University of California Santa Barbara (IUTAM representative). The practical arrangements of the symposium were taken care by the Local Organising Committee: Hanyang Gong, Ida Lemström, Arttu Polojärvi and Jukka Tuhkuri.

The symposium had in total 42 participants from 13 countries. The speakers represented Canada, Finland, Japan, The Netherlands, Norway, Poland, Russia, UK, USA; the other participants represented, in addition, China, Lebanon, Pakistan, and Sri Lanka.

The symposium was financially supported by IUTAM, the Federation of Finnish Learned Societies, City of Espoo, and Aalto University. The financial support is gratefully acknowledged.

Espoo, Finland  
January 2021

Jukka Tuhkuri  
Arttu Polojärvi



Photo: Adolfo Vera

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