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FLOW PHYSICS AND CONTROL OF VORTEX-INDUCED CAVITATION

YABIN LIU[*], JUNCHEN TAN[*]
AND YADONG HAN[†]

[*] University of Edinburgh
School of Engineering, University of Edinburgh, Edinburgh, EH9 3BF, UK
Yabin.Liu@ed.ac.uk and https://www.eng.ed.ac.uk/about/people/dr-yabin-liu

[*] University of Edinburgh
School of Engineering, University of Edinburgh, Edinburgh, EH9 3BF, UK
Junchen.Tan@ed.ac.uk and https://eng.ed.ac.uk/about/people/dr-junchen-tan

[†] University of Edinburgh
Depart of Engineering Science, University of Oxford, Oxford, OX1 3PJ, UK
Yadong.Han@eng.ox.ac.uk and
https://scholar.google.com/citations?user=7Xwjly0AAAAJ&hl=enURL

ABSTRACT

Cavitation represents a critical and long-standing challenge in a wide range of underwater applications, including ship propellers, underwater vehicles, and tidal turbines. This phenomenon occurs when localised low-pressure areas within a liquid cause vapour cavities or bubbles to form, which then collapse violently as they move into regions of higher pressure. A specific type of cavitation caused by the local pressure-drops within vortices, such as tip vortices of rotating blades and rapidly moving wings, exacerbating damage and inefficiency to propellers, turbines, and underwater vehicles. These vortices cause the vapour bubbles to form and collapse in areas of high shear, leading to intense noise, vibration, and significant erosion to solid surfaces. The destructive effects of cavitation reduce the efficiency and lifespan of marine structures and propulsion systems, while also posing environmental concerns, such as noise pollution that impacts marine life. Despite years of research, cavitation control remains a key technical obstacle, with ongoing efforts focused on advancing our understanding of flow physics and developing innovative strategies to mitigate its negative impacts.

This invited session will focus on recent advances in understanding the flow physics of cavitation induced by vortices, such as tip vortices and leading-edge vortices, as well as the latest developments in control strategies aimed at controlling these vortices and mitigating its harmful effects. Key topics will include:

i. The fundamentals of vortex formation and its role in cavitation inception and bubble dynamics in high-speed flows; ii. Novel passive/active approaches on controlling vortices and associated cavitation. iii. Advanced computational and experimental techniques for predicting vortex-induced cavitation behaviour in marine environments. iv. Innovative materials and surface treatments designed to minimise cavitation damage. v. Case studies from the fields of ship propulsion, underwater vehicles, and renewable energy applications, such as tidal turbines.