**Numerical simulation on the cavitating bubbly flows: from IR-DNS to EE-TFM**

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**Abstract**

The homogeneous mixing approach has been widely used in numerical simulations of cavitating flows, which treats the vapor and liquid phases as a mixed phase with a common velocity field. However, our recent experimental measurements based on PIV/PTV technology have shown that there is a significant slipping velocity between the two phases, indicating that there are potential inter-phase momentum exchanges and additional turbulence inside cloud cavitation. It is apparent that the currently used homogeneous mixing method cannot account for these issues. In this study, we follow a research strategy from the interface resolved direct numerical simulation (IR-DNS) to the Euler-Euler two-fluid method (EE-TFM): conducting direct numerical study on bubbly flows, developing inter-phase drag force and liquid sub-grid stress models based on statistical data, and ultimately applying the models to numerical simulations of cloud cavitating flows.

Specifically, we first developed a dynamic body force (DBF) method that constrains the position of the bubbles and extended it to arbitrary bubble numbers by combining with a multiple marker technology. Based on the DBF method, we systematically conducted IR-DNS study of bubbly flow under different flow parameters (Reynolds number, Weber number, and void fraction), analyzed the drag laws of single and multiple bubbles, revealed the bubble deformation mechanism in uniform flows, and studied the statistical characteristics of liquid velocity fluctuations induced by bubbles. Based on statistical data, we obtained explicit closure relationships for the bubble drag force and liquid sub-grid stress, and finally established an EE-TFM framework for the numerical simulation of cavitating flows.