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The development of the new technique which measures the unsteady density field

- The examination on density field reconstruction method -

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Summary: This paper propose the new method called “Random Pattern Refractometry Technique” which is possible to measure the unsteady density fields in stratified flows. In this method, the gradient vector fields of the refractive index can be derived from measured displacements of random pattern between two pictures captured before and after density distribution changed. And density fields can be reproduced by integration of gradient vector field. It is mathematically equal to reconstruction of the surface height from the gradient field problem. We can solve this problem by composing the Poisson equation using measured gradient vectors in experiments. To solve this equation, the source term had been computed from the divergence of measured gradient vectors and discretized by finite difference method or Fourier transform in previous studies. But these solutions have a common problem that the errors of reconstructed results further increase by constituting the source term from the differential of gradient vector with the measurement error. In this paper, we propose a new idea using derived solution of the Poisson equation that source term is assumed as unknown function from potential theory. The derived solution of Poisson equation shows that the surface height can be obtained if strength of each source in the field is determined. Since the number of gradient values is twice as that of source intensities, we can determine their strength by making overdetermined linear systems from the condition that gradient vectors from the derived solution corresponds to measured ones. And, we can expect an effect to reduce the impact of measuring errors when solving these overdetermined linear systems with least squares method. We validate this method by applying to simulated data and observation data from a lock-exchange flow.

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