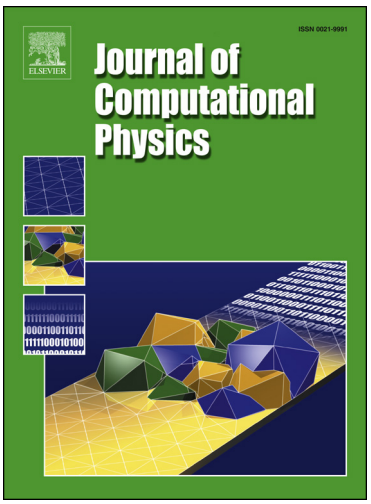
Accepted Manuscript



A numerical method for interaction problems between fluid and membranes with arbitrary permeability for fluid

Suguru Miyauchi, Shintaro Takeuchi, Takeo Kajishima

PII: S0021-9991(17)30375-3
DOI: http://dx.doi.org/10.1016/j.jcp.2017.05.006
Reference: YJCPH 7353

To appear in: *Journal of Computational Physics*

Received date: 21 November 2016
Revised date: 7 April 2017
Accepted date: 5 May 2017

Please cite this article in press as: S. Miyauchi et al., A numerical method for interaction problems between fluid and membranes with arbitrary permeability for fluid, *J. Comput. Phys.* (2017), http://dx.doi.org/10.1016/j.jcp.2017.05.006

A numerical method for interaction problems between fluid and membranes with arbitrary permeability for fluid

Suguru Miyauchi[1], Shintaro Takeuchi[2] and Takeo Kajishima[2]

[1] Institute of Fluid Science, Tohoku University,
2-1-1 Katahira, Aoba-ku, Sendai, Miyagi, 980-8577, Japan

[2] Department of Mechanical Engineering, Osaka University,
2-1 Yamada-oka, Suita, Osaka, 565-0871, Japan

Abstract

We develop a numerical method for fluid-membrane interaction accounting for permeation of the fluid using a non-conforming mesh to the membrane shape. To represent the permeation flux correctly, the proposed finite element discretization incorporates the discontinuities in the velocity gradient and pressure on the membrane surface with specially selected base functions. The discontinuities are represented with independent variables and determined to satisfy the governing equations including the interfacial condition on the permeation. The motions of the fluid, membrane and permeation flux are coupled monolithically and time-advanced fully-implicitly. The validity and effectiveness of the proposed method are demonstrated by several two-dimensional fluid-membrane interaction problems of Stokes flows by comparing with the analytical models and numerical results obtained by other methods. The reproduced sharp discontinuities are found to be essential to suppress the non-physical permeation flux. Further, combined with the numerical treatment for the solute concentration across the membrane, the proposed method is applied to a fluid-structure interaction problem including the osmotic pressure difference.

keywords: Fluid-membrane interaction, Permeation, Discontinuity, Finite element method, Fixed grid method

1 Introduction

Interaction between fluid and flexible membrane plays an important role on a continuum scale of biological and chemical issues, in particular the cases involving a membrane with permeability for the fluid. For