

# Immersed Boundary Analysis of Models with Internal State Variables: Applications to Hydrogels

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Research on soft active materials has flourished in recent years driven mainly by potential applications to actuation systems, tissue engineering, and soft robotics. These applications benefit from the unique properties of soft active such as large deformations, a wide range of stimulants, and high motion complexities. Hydrogels are among the dominant members of this group of materials. The highly nonlinear chemo-mechanical transient behavior of these is described by partial differential equations that advance in time through internal state variables representing the swelling state of the gel. Hence, the analysis of components/devices using these materials require intricate mathematical models that accurately predict their response and stabilization schemes capable of handling the mentioned model intricacies. This presentation will introduce an immersed boundary analysis technique suitable to simulate models with internal state variables for accurate and stable computation of gradients of the materials response. The proposed analysis framework uses level sets for describing the material layout in a background fixed mesh and a generalized version of the extended finite element method ([1]) for predicting the response. Computational aspects of the implementation of this approach for a highly nonlinear, transient, couple-physics hydrogel model ([2]) are discussed. The effect of the internal state variable on the stability of physical analysis is examined with numerical examples in 2D and 3D. Despite focusing on hydrogels, the presented theory can be extrapolated to similar applications using models with internal state variables (e.g., shape memory polymers) and immersed boundary analysis technique (e.g., CutFEM).

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## REFERENCES

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