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A Nonconforming Virtual Element Method for the Stokes Problem on General Meshes

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ABSTRACT

In this paper, a nonconforming virtual element method for the Stokes problem is proposed and investigated. This method gives a unified scheme for two and three dimensions simultaneously. In addition, it provides an attractive computational feature–treatment of general elements including non-convex and degenerate elements. Moreover, by choosing a proper low order velocity and pressure pair, we prove the discrete inf-sup condition for this method to obtain its solvability and stability. Furthermore, we show optimal energy norm error estimates for velocity and L^2 norm error estimates for both velocity and pressure. Finally, a series of numerical experiments are performed to validate that this method has good stability and accuracy for the Stokes problem.

KEY WORDS: Nonconforming Virtual Element Method, Stokes Problem, General Elements, Inf-Sup Condition, Optimal Error Estimates

1. INTRODUCTION

The Stokes flow applies to a number of physical problems, such as sedimentation, modeling of bio-suspensions, construction of efficient fibrous filters, development of energy efficient micro-fluidic devices and fluid flow in porous media [4, 41]. In order to simulate the Stokes flow numerically, the finite element methods [2, 3, 4, 5] have been a good choice, which rely on triangular and quadrilateral meshes. However, in complex simulations one often encounters general polygonal and polyhedral meshes [1, 6]. Thus various methods that can handle non-traditional meshes (e.g., general polygons, pyramids, and polyhedra) have been developed over the last years [7, 8, 9, 10, 11, 12, 13]. Among them, the mimetic finite difference (MFD) method not only preserves the fundamental properties of partial differential equations, such as conservation laws, solution symmetry, maximum

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