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Virtual Element approximation of 2D magnetostatic problems

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Abstract

We consider the use of nodal and edge Virtual Element spaces for the discretization of magnetostatic problems in two dimensions, following the variational formulation of Kikuchi. In addition, we present a novel Serendipity variant of the same spaces that allow to save many internal degrees of freedom. These Virtual Element Spaces of different type can be useful in applications where an exact sequence is particularly convenient, together with commuting-diagram interpolation operators, as is definitely the case in electromagnetic problems. We prove stability and optimal error estimates, and we check the performance with some academic numerical experiments.

Keywords: Finite Element Methods, Virtual Element Methods, Magnetostatic problems, Serendipity.
AMS Subject Classification: 65N30

1. Introduction

This paper is a first step towards the application of the Virtual Element technology, VEM, (see e.g. [10, 12, 13]) to the numerical solution of Electromagnetic problems.

Virtual Elements, introduced in [10], originate from the Mimetic Finite Difference methods, MFD, (see for instance [46, 49, 17, 27, 16] and the references therein), and their main difference with respect to MFD is that, instead of dealing only with degrees of freedom (as in classical Finite Differences), Virtual Elements deal with subspaces of the infinite dimensional spaces, in the traditional framework of Galerkin methods.

Presently, VEMs can be seen as being part of the wider family of Galerkin methods based on decompositions of the computational domains in polygons or polyhedrons, as Discontinuous Galerkin (see e.g. [5, 9, 33], or recently [40], and the references therein) or Hybridizable Discontinuous Galerkin and their variants (see for instance [36],[34], or the much more recent [35] and the references therein) based on one or more local polynomial spaces). But one could also take into account that VEMs deal, in fact, with non-polynomial basis

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