

# Accepted Manuscript

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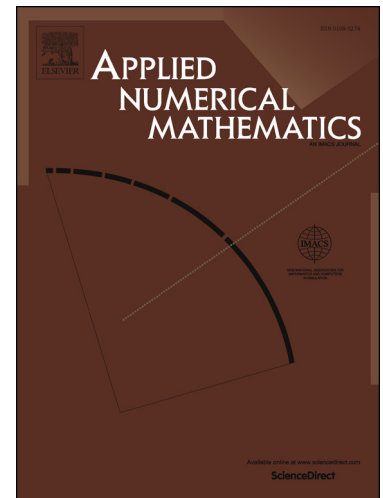
PII: S0168-9274(17)30201-5  
DOI: <https://doi.org/10.1016/j.apnum.2017.09.007>  
Reference: APNUM 3257

To appear in: *Applied Numerical Mathematics*

Received date: 15 March 2017  
Revised date: 11 September 2017  
Accepted date: 19 September 2017

Please cite this article in press as: A. Hazra et al., Numerical simulation of Bloch equations for dynamic magnetic resonance imaging, *Appl. Numer. Math.* (2017), <https://doi.org/10.1016/j.apnum.2017.09.007>

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# Numerical Simulation of Bloch Equations for Dynamic Magnetic Resonance Imaging

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## Abstract

Magnetic Resonance Imaging (MRI) is a widely applied non-invasive imaging modality based on non-ionizing radiation which gives excellent images and soft tissue contrast of living tissues. We consider the modified Bloch problem as a model of MRI for flowing spins in an incompressible flow field. After establishing the well-posedness of the corresponding evolution problem, we analyze its spatial semi-discretization using discontinuous Galerkin methods. The high frequency time evolution requires a proper explicit and adaptive temporal discretization. The applicability of the approach is shown for basic examples.

*Keywords:* Magnetic resonance imaging, Bloch model, FLASH-technology, flowing spins, incompressible medium, discontinuous Galerkin method, explicit Runge-Kutta methods

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## 1. Bloch Model for Magnetic Resonance Imaging

Magnetic Resonance Imaging (MRI) is a non-invasive imaging modality based on non-ionizing radiation [1]. It gives excellent images and soft tissue contrast of living tissues. During the experiment, the object to be studied is placed in a static magnetic field of high strength  $B_0$ . This induces a macroscopic nuclear magnetization  $\mathbf{M}_0$  in the direction of magnetic field, known as the equilibrium magnetization. The direction of equilibrium magnetization is called the longitudinal direction, generally denoted by the  $z$ -axis as in Figure 1.

In order to get a response from the object, the equilibrium magnetization is perturbed by applying a short radio-frequency (RF) pulse  $\mathbf{B}_1$  in the transverse plane (denoted by the  $xy$ -plane in Figure 1) with the excitation carrier frequency of the RF pulse equal to the Larmor frequency of protons. As a result, the equilibrium magnetization is flipped from its initial position towards the transverse plane. The perturbation of equilibrium

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*Preprint submitted to Applied Numerical Mathematics*

*September 26, 2017*

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