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Maxwell's equations with and without magnetic charge

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Abstract. Maxwell's equations of classical electromagnetism [1] are presented, in Gaussian units†, without (1, 2, 3, 4) and with (5, 6, 7, 8) magnetic charge. Equations 5 to 8 are taken from the front cover of the Monopole and Exotics Detector at the LHC (MoEDAL) Technical Design Report [2], the Large Hadron Collider's seventh major experiment and the latest venture to be undertaken in the search for Dirac's hypothesised magnetic monopole [3].

Contents

† The equations are written in the *Gaussian unit* system, and not SI units, for simplicity; in this system the electric field **E** and the magnetic field **B** have the same units.

1. Maxwell's equations without magnetic charge

$$\nabla \cdot \mathbf{E} = 4\pi\rho_e \tag{1}$$

$$\nabla \cdot \mathbf{B} = 0 \tag{2}$$

$$-\nabla \times \mathbf{E} = \frac{1}{c}\frac{\partial \mathbf{B}}{\partial t} \tag{3}$$

$$\nabla \times \mathbf{B} = \frac{1}{c}\frac{\partial \mathbf{E}}{\partial t} + \frac{4\pi}{c}\mathbf{j}_e \tag{4}$$

Figure 1: Maxwell's equations of electromagnetism [1] with the electric charge and current density terms highlighted (shaded boxes). Note that these are expressed in Gaussian units (not SI) for simplicity.

2. Maxwell's equations with magnetic charge

$$\nabla \cdot \mathbf{E} = 4\pi\rho_e \tag{5}$$

$$\nabla \cdot \mathbf{B} = 4\pi\rho_m \tag{6}$$

$$-\nabla \times \mathbf{E} = \frac{1}{c}\frac{\partial \mathbf{B}}{\partial t} + \frac{4\pi}{c}\mathbf{j}_m \tag{7}$$

$$\nabla \times \mathbf{B} = \frac{1}{c}\frac{\partial \mathbf{E}}{\partial t} + \frac{4\pi}{c}\mathbf{j}_e \tag{8}$$

Figure 2: Maxwell's equations of electromagnetism with additional terms representing magnetic charge and current density, as shown on the cover of the MoEDAL Technical Design Report [2]. Note that these are expressed in Gaussian units (not SI) for simplicity.

References

[1] J.C. Maxwell. A dynamical theory of the electromagnetic field. *Philosophical Transactions of the Royal Society of London*, 155:459, 1865.

[2] The MoEDAL Collaboration. Technical Design Report of the Moedal Experiment. Technical report, June 2009.

[3] P.A.M. Dirac. Quantised Singularities in the Electromagnetic Field. *Proc. Roy. Soc. A*, 133:60, September 1931.

Acknowledgements

This work was supported by the UK Science and Technology Facilities Council (STFC) via grant ST/N00101X/1. The author wishes to thank A. Pontzen for many fruitful discussions.

Version History

Table 1: Version history.

Version	Description	Author
1.0	Initial version.	TW