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[1], 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].

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

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

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

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

[1] 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.

$$
\begin{aligned}
\nabla \cdot \mathbf{E} &= 4\pi\rho_e & (5)\\
\nabla \cdot \mathbf{B} &= 4\pi\rho_m & (6)\\
-\nabla \times \mathbf{E} &= \frac{1}{c}\frac{\partial \mathbf{B}}{\partial t} + \frac{4\pi}{c}\mathbf{j}_m & (7)\\
\nabla \times \mathbf{B} &= \frac{1}{c}\frac{\partial \mathbf{E}}{\partial t} + \frac{4\pi}{c}\mathbf{j}_e & (8)
\end{aligned}
$$

Acknowlegdements

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

References

[1] J. C. Maxwell, A dynamical theory of the electromagnetic field, Phil. Trans. R. Soc. Lond. 155 (1865) 459. doi:10.1098/rstl.1865.0008.

[2] The MoEDAL Collaboration, Technical Design Report of the Moedal Experiment, Tech. rep. (June 2009).
URL https://cds.cern.ch/record/1181486

[3] P. Dirac, Quantised Singularities in the Electromagnetic Field, Proc. Roy. Soc. 133 (1931) 60. doi:10.1098/rspa.1931.0130.