



On Physical Lines of Force (Philosophical Magazine Book 21)

James Clerk Maxwell

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Contents:

Part I

The Theory of Molecular Vortices applied to Magnetic Phenomena

Part II

The Theory of Molecular Vortices applied to Electric Currents

Part III

The Theory of Molecular Vortices applied to Statical Electricity

Part IV

The Theory of Molecular Vortices applied to the Action of Magnetism on Polarized Light

An excerpt from the beginning of:

Part I - The Theory of Molecular Vortices Applied to Magnetic Phenomena

IN all phenomena involving attractions or repulsions, or any forces depending on the relative position of bodies, we have to determine the magnitude and direction of the force which would act on a given body, if placed in a given position.

In the case of a body acted on by the gravitation of a sphere, this force is inversely as the square of the distance, and in a straight line to the centre of the sphere. In the case of two attracting spheres, or of a body not spherical, the magnitude and direction of the force vary according to more complicated laws. In electric and magnetic phenomena, the magnitude and direction of the resultant force at any point is the main subject of investigation. Suppose that the direction of the force at any point is known, then, if we draw a line so that in every part of its course it coincides in direction with the force at that point, this line may be called a line of force, since it indicates the direction of the force in every part of its course.

By drawing a sufficient number of lines of force, we may indicate the direction of the force in every part of the space in which it acts.


Thus if we strew iron filings on paper near a magnet, each filing will be magnetized by induction, and the

consecutive filings will unite by their opposite poles, so as to form fibres, and these fibres will indicate the direction of the lines of force. The beautiful illustration of the presence of magnetic force afforded by this experiment, naturally tends to make us think of the lines of force as something real, and as indicating something more than the mere resultant of two forces, whose seat of action is at a distance, and which do not exist there at all until a magnet is placed in that part of the field. We are dissatisfied with the explanation founded on the hypothesis of attractive and repellent forces directed towards the magnetic poles, even though we may have satisfied ourselves that the phenomenon is in strict accordance with that hypothesis, and we cannot help thinking that in every place where we find these lines of force, some physical state or action must exist in sufficient energy to produce the actual phenomena.

My object in this paper is to clear the way for speculation in this direction, by investigating the mechanical results of certain states of tension and motion in a medium, and comparing these with the observed phenomena of magnetism and electricity. By pointing out the mechanical consequences of such hypotheses, I hope to be of some use to those who consider the phenomena as due to the action of a medium, but are in doubt as to the relation of this hypothesis to the experimental laws already established, which have generally been expressed in the language of other hypotheses.

I have in a former paper endeavoured to lay before the mind of the geometer a clear conception of the relation of the lines of force to the space in which they are traced. By making use of the conception of currents in a fluid, I showed how to draw lines of force, which should indicate by their number the amount of force, so that each line may be called a unit-line of force and I have investigated the path of the lines where they pass from one medium to another.

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