

**ELEMENTS OF THE
ELECTROMAGNETIC
THEORY OF LIGHT**

Published @ 2017 Trieste Publishing Pty Ltd

ISBN 9780649270712

Elements of the electromagnetic theory of light by Ludwik Silberstein

Except for use in any review, the reproduction or utilisation of this work in whole or in part in any form by any electronic, mechanical or other means, now known or hereafter invented, including xerography, photocopying and recording, or in any information storage or retrieval system, is forbidden without the permission of the publisher, Trieste Publishing Pty Ltd, PO Box 1576 Collingwood, Victoria 3066 Australia.

All rights reserved.

Edited by Trieste Publishing Pty Ltd.
Cover @ 2017

This book is sold subject to the condition that it shall not, by way of trade or otherwise, be lent, re-sold, hired out, or otherwise circulated without the publisher's prior consent in any form or binding or cover other than that in which it is published and without a similar condition including this condition being imposed on the subsequent purchaser.

www.triestepublishing.com

LUDWIK SILBERSTEIN

**ELEMENTS OF THE
ELECTROMAGNETIC
THEORY OF LIGHT**

**ELEMENTS OF THE
ELECTROMAGNETIC THEORY
OF LIGHT**

BY

LUDWIK SILBERSTEIN, Ph.D.

LECTURER IN NATURAL PHILOSOPHY AT THE UNIVERSITY OF WORMS

LONGMANS, GREEN AND CO.

39 PATERNOSTER ROW, LONDON

FOURTH AVENUE & 30TH STREET, NEW YORK

BOMBAY, CALCUTTA, AND MADRAS

1918

212-28-18571

Treatise on Electricity and Magnetism

PREFACE.

THIS little volume, whose object is to present the essentials of the electromagnetic theory of light, was rewritten, at the instance of Messrs. Adam Hilger, Limited, from my Polish treatise on Electricity and Magnetism (3 vols., Warsaw, 1908-1913, published by the kind help of the Mianowski Institution). It consists principally of an English version of chapter viii., vol. ii., of that work with some slight omissions and modifications. In order to make the subject accessible to a larger circle of readers Section 3 was added. The language adopted is mainly vectorial. This is the chief reason of the compactness of the book which, it is hoped, notwithstanding its small number of pages, will be found to contain an easy and complete presentation of the fundamental part of Maxwell's theory of light.

I gladly take the opportunity of expressing my best thanks to Messrs. Hilger for enabling me to submit a portion of my treatise to the English reader.

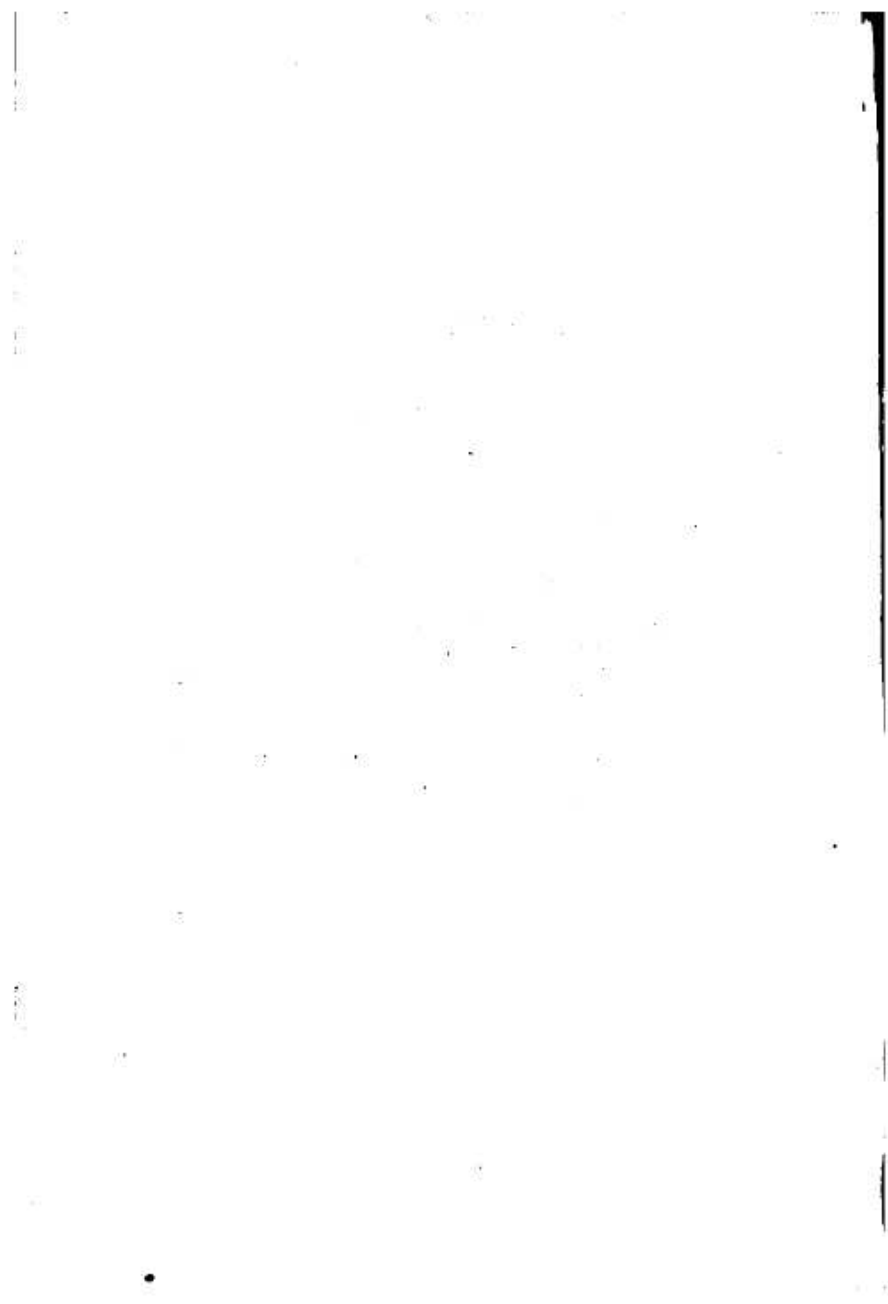
L. S.

LONDON, *May*, 1918.

330641

CONTENTS.

	PAGE
1. THE ORIGIN OF THE ELECTROMAGNETIC THEORY	1
2. ADVANTAGES OF THE ELECTROMAGNETIC OVER THE ELASTIC THEORY OF LIGHT	5
3. MAXWELL'S EQUATIONS. PLANE WAVES	16
4. REFLECTION AND REFRACTION AT THE BOUNDARY OF ISOTROPIC MEDIA; E IN PLANE OF INCIDENCE	22
5. REFLECTION AND REFRACTION; $E \perp$ PLANE OF INCIDENCE. NOTE ON THE TRANSITION LAYER	28
6. TOTAL REFLECTION	31
7. OPTICS OF CRYSTALLINE MEDIA: GENERAL FORMULAE AND THEOREMS	35
8. THE PROPERTIES OF THE ELECTRICAL AXES OF A CRYSTAL	41
9. OPTICAL AXES	43
10. UNIAXIAL CRYSTALS	45
INDEX	47



1. The Origin of the Electromagnetic Theory.

The electromagnetic theory of light, now for many years in universal acceptance, was proposed and developed by James Clerk Maxwell about the year 1865.* By elimination, from his classical differential equations, of the electric current Maxwell has obtained, for the "vector potential" \mathfrak{A} ,† a differential equation of the second order which in the case of a non-conducting isotropic medium has assumed the form

$$K\mu\frac{\partial^2\mathfrak{A}}{\partial t^2} = \nabla^2\mathfrak{A} \quad . \quad . \quad . \quad [M]$$

where ∇^2 is the Laplacian (Maxwell's $-\nabla^2$, borrowed from Hamilton's calculus of quaternions). Maxwell's coefficients, the "specific inductive capacity" K , and the magnetic "permeability" μ , are not pure numbers. Let c be the ratio of the electromagnetic unit of electric charge to the electrostatic unit of charge. Then Maxwell's coefficients are such that, for air (or vacuum),

$$K = 1, \mu = \frac{1}{c^2}, \text{ in the electrostatic system,}$$

$$K = \frac{1}{c^2}, \mu = 1, \text{ in the electromagnetic system.}$$

* *Phil. Trans.*, 1865, p. 459 *et seq.*, reprinted in *Scientific Papers*. See also *Treatise on Electricity and Magnetism*, vol. ii., chap. xx.

† Which, in absence of a purely electrostatic potential, gives the electric force by its negative time derivative, i.e. in the notation to be adopted throughout this volume, $\mathbf{E} = -\partial\mathfrak{A}/\partial t$.

Thus, in either system, $K\mu = 1/c^2$, for air. Now, from his above equation which in the case of plane waves, for instance, reduces to

$$K\mu \frac{\partial^2 \mathfrak{M}}{\partial t^2} = \frac{\partial^2 \mathfrak{M}}{\partial x^2},$$

Maxwell concluded at once that the velocity of propagation of electromagnetic disturbances should be

$$v = \frac{1}{\sqrt{K\mu}}$$

in any medium, and therefore, in air, $v = c$.

Thus Maxwell has arrived at the capital conclusion that "the velocity of propagation in air [or in vacuo] is numerically equal to the number of electrostatic units contained in an electromagnetic unit of electric charge". The dimensions of this "number" c , or ratio of units, are obviously those of a velocity. For, by what has just been said, we have the dimensional equation

$$[c^2 t^2] = [x^2]$$

where x is a length and t a time.

Now, the experimental measurements of Kohlrausch and Weber,* famous in those times, have given for the ratio of the two units of charge the value

$$c = 310740 \text{ km. sec.}^{-1} = 3 \cdot 107 \cdot 10^{10} \text{ cm. sec.}^{-1},$$

or rather, after account has been taken of W. Voigt's corrections (*Ann. d. Phys.*, vol. ii.), $3 \cdot 111 \cdot 10^{10}$ cm. sec.⁻¹. Maxwell quotes also the value obtained from a comparison of the units of electromotive force † by William Thomson (1860),

* Kohlrausch and Weber, *Elektrodyn. Maassbestimmungen, etc.*; W. Weber, *Elektrodyn. Maassbestimmungen, insbesondere Widerstandmessungen.*

† An electromagnetic unit of electromotive force contains $1/c$ electrostatic units.