## TABLE OF CONTENTS

## Preface

Chapter I. Historical development	
1. Introduction	11
2. Development of the non-relativistic theory	17
3. Development of the covariant theory	35
•	
Chapter II. The problem and an outline of its solution. An example	
4. Maxwell's macroscopic and Lorentz's microscopic	
field equations	41
5. Outline of the derivation. The dipole example	43
•	
Chapter III. Non-relativistic theory	
6. Derivation of the atomic field equations	55
6.1. The non-relativistic approximation	55
6.2. The atomic series expansion	56
6.3. The atomic multipole moments	59
6.4. The atomic field equations	61
7 Derivation of the magnegachie field equations	63
7. Derivation of the macroscopic field equations	63
7.1. The macroscopic quantities 7.2. Differentiation commuting with averaging	65
7.3. The Maxwell equations. The influence of motion: convec-	0.0
tion and conduction	67
tion and conduction	٠.
8. Applications	72
8.1. The polarization up to lowest internal coordinate orders	72
8.2. The polarization up to lowest multipole moments	74
8.3. Examples: (i) metals, (ii) insulators, (iii) plasmas, (iv)	
gases, (v) electrolytes, (vi) liquids	77
Chapter IV. Covariant theory	
9. Derivation of the atomic field equations	95
9.1. The covariance	95
9.2. The atomic series expansion	96
9.3. The atomic multipole moments	100
9.4. The atomic field equations	101
9.5. Retarded dynamical quantities	105

8 CONTENTS

<ol><li>Derivation of the macroscopic field equations</li></ol>	107
10.1. The macroscopic quantities: covariant retarded aver ages	- 107
10.2. Space-time differentiations commuting with averagin	g 110
10.3. The Maxwell equations	112
11. Applications	115
11.1. The polarization tensor for dipole substances	115
11.2. The polarization tensor for quadrupole substances: th	
acceleration effect and the multipole fluxion effect	118
11.3. The non-relativistic approximations	122
Chapter V. Outlook	405
12. Achievements and limitations of the theory	127
13. The energy and momentum laws	129
13.1. Non-relativistic statistical theory of the ponderomotiv	<sup>ле</sup> 129
force	
13.2. Relativistic statistical theory of the energy-momentum laws	132
13.3. The constitutive relations	136
13.3. The constitutive relations	100
Appendices	
14. Details of the covariant derivation	141
1. The Lorentz-transformation from the reference frame	
the momentary atomic rest frame	141
2. The retarded fields and the non-relativistic approximation	a-
tion	146
15. Some relativistic properties	150
15. Some relativistic properties 1. Averaged Liénard-Wiechert potentials	150 150
1. Averaged Liénard-Wiechert potentials	
	150
1. Averaged Liénard-Wiechert potentials 2. Some properties of the tensor $\Omega$	150 151 154
1. Averaged Liénard-Wiechert potentials 2. Some properties of the tensor $\Omega$ 3. Thomas-precession	150 151 154
<ol> <li>Averaged Liénard-Wiechert potentials</li> <li>Some properties of the tensor Ω</li> <li>Thomas-precession</li> <li>On the covariance of the four-current and the polarization</li> </ol>	150 151 154 on 157
<ol> <li>Averaged Liénard-Wiechert potentials</li> <li>Some properties of the tensor Ω</li> <li>Thomas-precession</li> <li>On the covariance of the four-current and the polarization tensor</li> </ol>	150 151 154 on 157
<ol> <li>Averaged Liénard-Wiechert potentials</li> <li>Some properties of the tensor Ω</li> <li>Thomas-precession</li> <li>On the covariance of the four-current and the polarization tensor</li> <li>The relativistic polarization tensor to all multipole order</li> </ol>	150 151 154 on 157 ers 160
<ol> <li>Averaged Liénard-Wiechert potentials</li> <li>Some properties of the tensor Ω</li> <li>Thomas-precession</li> <li>On the covariance of the four-current and the polarization tensor</li> <li>The relativistic polarization tensor to all multipole order</li> </ol> References	150 151 154 on 157 ers 160