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Grimm
Stoker
Molière
Wilde
Maupassant
Byron
Schiller
Garnett
Einstein
Fitzgerald
Engels
Smith
Goethe
Hawthorne
Kafka
Cotton
Dostoyevsky
Hall
Baum
Kipling
Doyle
Willis
Leslie
Dumas
Henry
Nietzsche
Flaubert
Turgenev
Balzac
Stockton
Vatsyayana
Crane
Burroughs
Whitman
Verne
Curtis
Tocqueville
Gogol
Vinci
Homer
Widger
Tolstoy
Busch
Darwin
Thoreau
Potter
Freud
Zola
Twain
Plato
Scott
Lawrence
Kant
Jowett
Stevenson
Dickens
Andersen
Burton
Hesse
Harte
London
Descartes
Cervantes
Poe
Aristotle
Wells
Voltaire
Hale
James
Hastings
Cooke
Bunner
Shakespeare
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Chekhov
Chambers
Irving
da
Doré
Swift
Dante
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The New Physics and Its Evolution

Lucien Poincaré

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Prefatory Note

M. Lucien Poincaré is one of the distinguished family of mathematicians which has during the last few years given a Minister of Finance to the Republic and a President to the Académie des Sciences. He is also one of the nineteen Inspectors-General of Public Instruction who are charged with the duty of visiting the different universities and *lycées* in France and of reporting upon the state of the studies there pursued. Hence he is in an excellent position to appreciate at its proper value the extraordinary change which has lately revolutionized physical science, while his official position has kept him aloof from the controversies aroused by the discovery of radium and by recent speculations on the constitution of matter.

M. Poincaré's object and method in writing the book are sufficiently explained in the preface which follows; but it may be remarked that the best of methods has its defects, and the excessive condensation which has alone made it possible to include the last decade's discoveries in physical science within a compass of some 300 pages has, perhaps, made the facts here noted assimilable with difficulty by the untrained reader. To remedy this as far as possible, I have prefixed to the present translation a table of contents so extended as to form a fairly complete digest of the book, while full indexes of authors and subjects have also been added. The few notes necessary either for better elucidation of the terms employed, or for giving account of discoveries made while these pages were passing through the press, may be distinguished from the author's own by the signature "ED."

THE EDITOR.

ROYAL INSTITUTION OF GREAT BRITAIN, April 1907.

Author's Preface

During the last ten years so many works have accumulated in the domain of Physics, and so many new theories have been propounded, that those who follow with interest the progress of science, and even some professed scholars, absorbed as they are in their own special studies, find themselves at sea in a confusion more apparent than real.

It has therefore occurred to me that it might be useful to write a book which, while avoiding too great insistence on purely technical details, should try to make known the general results at which physicists have lately arrived, and to indicate the direction and import which should be ascribed to those speculations on the constitution of matter, and the discussions on the nature of first principles, to which it has become, so to speak, the fashion of the present day to devote oneself.

I have endeavoured throughout to rely only on the experiments in which we can place the most confidence, and, above all, to show how the ideas prevailing at the present day have been formed, by tracing their evolution, and rapidly examining the successive transformations which have brought them to their present condition.

In order to understand the text, the reader will have no need to consult any treatise on physics, for I have throughout given the necessary definitions and set forth the fundamental facts. Moreover, while strictly employing exact expressions, I have avoided the use of mathematical language. Algebra is an admirable tongue, but there are many occasions where it can only be used with much discretion.

Nothing would be easier than to point out many great omissions from this little volume; but some, at all events, are not involuntary.

Certain questions which are still too confused have been put on one side, as have a few others which form an important collection for a special study to be possibly made later. Thus, as regards electrical phenomena, the relations between electricity and optics, as also the theories of ionization, the electronic hypothesis, etc., have been treated at some length; but it has not been thought necessary to dilate upon the modes of production and utilization of the current, upon the phenomena of magnetism, or upon all the applications which belong to the domain of Electrotechnics.

L. POINCARÉ.

Contents

tion—Photometric units. § 7. *Measure of Physical Constants:* Constant of gravitation—Discoveries of Cavendish, Vernon Boys, Eötvös, Richarz and Krigar-Menzel—Michelson's improvements on Fizeau and Foucault's experiments— Measure of speed of light.

CHAPTER III

PRINCIPLES

§ 1. *The Principles of Physics:* The Principles of Mechanics affected by recent discoveries—Is mass indestructible?—Landolt and Heydweiller's experiments —Lavoisier's law only approximately true—Curie's principle of symmetry. § 2. *The Principle of the Conservation of Energy:* Its evolution: Bernoulli, Lavoisier and Laplace, Young, Rumford, Davy, Sadi Carnot, and Robert Mayer—Mayer's drawbacks—Error of those who would make mechanics part of energetics—Verdet's predictions—Rankine inventor of energetics—Usefulness of Work as standard form of energy—Physicists who think matter form of energy— Objections to this—Philosophical value of conservation doctrine. § 3. *The Principle of Carnot and Clausius:* Originality of Carnot's principle that fall of temperature necessary for production of work by heat— Clausius' postulate that heat cannot pass from cold to hot body without accessory phenomena—Entropy result of this—Definition of entropy—Entropy tends to increase incessantly—A magnitude which measures evolution of system—Clausius' and Kelvin's deduction that heat end of all energy in Universe—Objection to this— Carnot's principle not necessarily referable to mechanics —Brownian movements—Lippmann's objection to kinetic hypothesis. § 4. *Thermodynamics:* Historical work of Massieu, Willard Gibbs, Helmholtz, and Duhem—Willard Gibbs founder of thermodynamic statics, Van t'Hoff its reviver—The Phase Law—Raveau explains it without thermodynamics. § 5. *Atomism:* Connection of subject with preceding Hannequin's essay on the atomic hypothesis—Molecular physics in disfavour—Surface-tension, etc., vanishes when molecule reached—Size of molecule—Kinetic theory of gases—Willard Gibbs and Boltzmann introduce into it law of probabilities—Mean free path of gaseous molecules—Application to optics—Final division of matter.

CHAPTER IV

THE VARIOUS STATES OF MATTER

§ 1. *The Statics of Fluids*: Researches of Andrews, Cailletet, and others on liquid and gaseous states— Amagat's experiments—Van der Waals' equation—Discovery of corresponding states—Amagat's superposed diagrams—Exceptions to law—Statics of mixed fluids—Kamerlingh Onnes' researches—Critical Constants— Characteristic equation of fluid not yet ascertainable. § 2. *The Liquefaction of Gases and Low Temperatures*: Linde's, Siemens', and Claude's methods of liquefying gases—Apparatus of Claude described—Dewar's experiments—Modification of electrical properties of matter by extreme cold: of magnetic and chemical— Vitality of bacteria unaltered—Ramsay's discovery of rare gases of atmosphere—Their distribution in nature—Liquid hydrogen—Helium. § 3. *Solids and Liquids*: Continuity of Solid and Liquid States—Viscosity common to both—Also Rigidity— Spring's analogies of solids and liquids—Crystallization —Lehmann's liquid crystals—Their existence doubted —Tamman's view of discontinuity between crystalline and liquid states. § 4. *The Deformation of Solids*: Elasticity— Hoocke's, Bach's, and Bouasse's researches—Voigt on the elasticity of crystals—Elastic and permanent deformations—Brillouin's states of unstable equilibria—Duhem and the thermodynamic postulates— Experimental confirmation—Guillaume's researches on nickel steel—Alloys.

CHAPTER V

SOLUTIONS AND ELECTROLYTIC DISSOCIATION

§ 1. *Solution*: Kirchhoff's, Gibb's, Duhem's and Van t'Hoff's researches. § 2. *Osmosis*: History of phenomenon—Traube and biologists establish existence of semi-permeable walls—Villard's experiments with gases—Pfeffer shows osmotic pressure proportional to concentration— Disagreement as to cause of phenomenon. § 3. *Osmosis applied to Solution*: Van t'Hoff's discoveries—Analogy between dissolved body and perfect gas—Faults in analogy. § 4. *Electrolytic Dissociation*: Van t'Hoff's and Arrhenius' researches—Ionic hypothesis of—Fierce opposition to at first—Arrhenius' ideas now triumphant —Advantages of Arrhenius' hypothesis—"The ions which react"—Ostwald's conclusions from this—Nernst's theory of Electrolysis—Electrolysis of gases makes electronic theory probable—Faraday's two laws—Valency— Helmholtz's consequences from Faraday's laws.

CHAPTER VI

THE ETHER

§ 1. *The Luminiferous Ether*: First idea of Ether due to Descartes—Ether must be imponderable—Fresnel shows light vibrations to be transverse—Transverse vibrations cannot exist in fluid—Ether must be discontinuous. § 2. *Radiations*: Wave-lengths and their measurements—Rubens' and Lenard's researches— Stationary waves and colour-photography—Fresnel's hypothesis opposed by Neumann—Wiener's and Cotton's experiments. § 3. *TheElectromagnetic Ether*: Ampère's advocacy of mathematical expression—Faraday first shows influence of medium in electricity—Maxwell's proof that light-waves electromagnetic—His unintelligibility—Required confirmation of theory by Hertz. § 4. *Electrical Oscillations*: Hertz's experiments— Blondlot proves electromagnetic disturbance propagated with speed of light—Discovery of ether waves intermediate between Hertzian and visible ones—Rubens' and Nichols' experiments—Hertzian and light rays contrasted—Pressure of light. § 5. *The X-Rays*: Röntgen's discovery—Properties of X-rays—Not homogeneous—Rutherford and M'Clung's experiments on energy corresponding to—Barkla's experiments on polarisation of—Their speed that of light—Are they merely ultra-violet?—Stokes and Wiechert's theory of independent pulsations generally preferred—J.J. Thomson's idea of their formation— Sutherland's and Le Bon's theories—The N-Rays— Blondlot's discovery—Experiments cannot be repeated outside France—Gutton and Mascart's confirmation— Negative experiments prove nothing—Supposed wave-length of N-rays. § 6. *The Ether and Gravitation*: Descartes' and Newton's ideas on gravitation—Its speed and other extraordinary characteristics—Lesage's hypothesis—Crémieux' experiments with drops of liquids—Hypothesis of ether insufficient.

CHAPTER VII

WIRELESS TELEGRAPHY

§ 1. Histories of wireless telegraphy already written, and difficulties of the subject. § 2. Two systems: that which uses the material media (earth, air, or water), and that which employs ether only. § 3. Use of earth as return wire by Steinheil —Morse's experiments with water of canal—Seine used as return wire during siege of Paris—Johnson and Melhuish's Indian experiments—Preece's telegraph over Bristol Channel—He welcomes Marconi. § 4. Early attempts at transmission of messages through ether—Experiments of Rathenau and others. § 5. Forerunners of ether telegraphy: Clerk Maxwell and Hertz—Dolbear, Hughes, and Graham Bell. § 6. Telegraphy by Hertzian waves first suggested by Threlfall—Crookes', Tesla's, Lodge's, Rutherford's, and Popoff's contributions—Marconi first makes it practicable. § 7. The receiver in wireless telegraphy—Varley's, Calzecchi—Onesti's, and Branly's researches— Explanation of coherer still obscure. § 8. Wireless telegraphy enters the commercial stage— Defect of Marconi's system—Braun's, Armstrong's, Lee de Forest's, and Fessenden's systems make use of earth— Hertz and Marconi entitled to foremost place among discoverers.

CHAPTER VIII

THE CONDUCTIVITY OF GASES AND THE IONS

§ 1. *The Conductivity of Gases*: Relations of matter to ether cardinal problem—Conductivity of gases at first misapprehended—Erman's forgotten researches—Giese first notices phenomenon—Experiment with X-rays— J.J. Thomson's interpretation—Ionized gas not obedient to Ohm's law—Discharge of charged conductors by ionized gas. § 2. *The Condensation of water-vapour by Ion*s: Vapour will not condense without nucleus—Wilson's experiments on electrical condensation—Wilson and Thomson's counting experiment—Twenty million ions per c.cm. of gas—Estimate of charge borne by ion— Speed of charges—Zeleny's and Langevin's experiments—Negative ions 1/1000 of size of atoms—Natural unit of electricity or electrons. § 3. *How Ions are Produced:* Various causes of ionization—Moreau's experiments with alkaline salts—Barus and Bloch on ionization by phosphorus vapours—Ionization always result of shock. § 4. *Electrons in Metals:* Movement of electrons in metals foreshadowed by Weber—Giese's, Riecke's, Drude's, and J.J. Thomson's researches—Path of ions in metals and conduction of heat—Theory of Lorentz—Hesehus' explanation of electrification by contact—Emission of electrons by charged body— Thomson's measurement of positive ions.

CHAPTER IX

CATHODE RAYS AND RADIOACTIVE BODIES

§ 1. *The Cathode Rays:* History of discovery—Crookes' theory—Lenard rays—Perrin's proof of negative charge—Cathode rays give rise to X-rays—The canal rays—Villard's researches and magneto-cathode rays— Ionoplasty—Thomson's measurements of speed of rays —All atoms can be dissociated. § 2. *Radioactive Substances:* Uranic rays of Niepce de St Victor and Becquerel—General radioactivity of matter—Le Bon's and Rutherford's comparison of uranic with X rays—Pierre and Mme. Curie's discovery of polonium and radium—Their characteristics—Debierne discovers actinium. § 3. *Radiations and Emanations of Radioactive Bodies:* Giesel's, Becquerel's, and Rutherford's Researches—Alpha, beta, and gamma rays—Sagnac's secondary rays—Crookes' spinthariscope—The emanation —Ramsay and Soddy's researches upon it—Transformations of radioactive bodies—Their order. § 4. *Disaggregation of Matter and Atomic Energy:* Actual transformations of matter in radioactive bodies —Helium or lead final product—Ultimate disappearance of radium from earth—Energy liberated by radium: its amount and source—Suggested models of radioactive atoms—Generalization from radioactive phenomena -Le Bon's theories—Ballistic hypothesis generally admitted—Does energy come from without—Sagnac's experiments—Elster and Geitel's *contra*.

CHAPTER X

THE ETHER AND MATTER

§ 1. *The Relations between the Ether and Matter:* Attempts to reduce all matter to forms of ether—Emission and absorption phenomena show reciprocal action— Laws of radiation—Radiation of gases—

Production of spectrum—Differences between light and sound variations show difference of media—Cauchy's, Briot's, Carvallo's and Boussinesq's researches—Helmholtz's and Poincaré's electromagnetic theories of dispersion. § 2. *The Theory of Lorentz:*—Mechanics fails to explain relations between ether and matter—Lorentz predicts action of magnet on spectrum—Zeeman's experiment —Later researches upon Zeeman effect— Multiplicity of electrons—Lorentz's explanation of thermoelectric phenomena by electrons—Maxwell's and Lorentz's theories do not agree—Lorentz's probably more correct—Earth's movement in relation to ether. § 3. *The Mass of Electrons:* Thomson's and Max Abraham's view that inertia of charged body due to charge—Longitudinal and transversal mass—Speed of electrons cannot exceed that of light—Ratio of charge to mass and its variation—Electron simple electric charge—Phenomena produced by its acceleration. § 4. *New Views on Ether and Matter:* Insufficiency of Larmor's view—Ether definable by electric and magnetic fields—Is matter all electrons? Atom probably positive centre surrounded by negative electrons—Ignorance concerning positive particles—Successive transformations of matter probable —Gravitation still unaccounted for.

CHAPTER XI

THE FUTURE OF PHYSICS

Persistence of ambition to discover supreme principle in physics—Supremacy of electron theory at present time—Doubtless destined to disappear like others— Constant progress of science predicted—Immense field open before it.

INDEX OF NAMES

INDEX OF SUBJECTS

The New Physics and its Evolution

CHAPTER I

THE EVOLUTION OF PHYSICS

The now numerous public which tries with some success to keep abreast of the movement in science, from seeing its mental habits every day upset, and from occasionally witnessing unexpected discoveries that produce a more lively sensation from their reaction on social life, is led to suppose that we live in a really exceptional epoch, scored by profound crises and illustrated by extraordinary discoveries, whose singularity surpasses everything known in the past. Thus we often hear it said that physics, in particular, has of late years undergone a veritable revolution; that all its principles have been made new, that all the edifices constructed by our fathers have been overthrown, and that on the field thus cleared has sprung up the most abundant harvest that has ever enriched the domain of science.

It is in fact true that the crop becomes richer and more fruitful, thanks to the development of our laboratories, and that the quantity of seekers has considerably increased in all countries, while their quality has not diminished. We should be sustaining an absolute paradox, and at the same time committing a crying injustice, were we to contest the high importance of recent progress, and to seek to diminish the glory of contemporary physicists. Yet it may be as well not to give way to exaggerations, however pardonable, and to guard against facile illusions. On closer examination it will be seen that our predecessors might at several periods in history have conceived, as legitimately as ourselves, similar sentiments of scientific pride, and have felt that the world was about to appear to them transformed and under an aspect until then absolutely unknown.

Let us take an example which is salient enough; for, however arbitrary the conventional division of time may appear to a physicist's eyes, it is natural, when instituting a comparison between two epochs, to choose those which extend over a space of half a score of years, and are separated from each other by the gap of a century. Let us, then, go back a hundred years and examine what would have been the state of mind of an erudite amateur who had read and understood the chief publications on physical research between 1800 and 1810.

Let us suppose that this intelligent and attentive spectator witnessed in 1800 the discovery of the galvanic battery by Volta. He might from that moment have felt a presentiment that a prodigious transformation was about to occur in our mode of regarding electrical phenomena. Brought up in the ideas of Coulomb and Franklin, he might till then have imagined that electricity had unveiled nearly all its mysteries, when an entirely original apparatus suddenly gave birth to applications of the highest interest, and excited the blossoming of theories of immense philosophical extent.

In the treatises on physics published a little later, we find traces of the astonishment produced by this sudden revelation of a new world. "Electricity," wrote the Abbé Haüy, "enriched by the labour of so many distinguished physicists, seemed to have reached the term when a science has no further important steps before it, and only leaves to those who cultivate it the hope of confirming the discoveries of their predecessors, and of casting a brighter light on the truths revealed. One would have thought that all researches for diversifying the results of experiment were exhausted, and that theory itself could only be augmented by the addition of a greater degree of precision to the applications of principles already known. While science thus appeared to be making for repose, the phenomena of the convulsive movements observed by Galvani in the muscles of a frog when connected by metal were brought to the attention and astonishment of physicists.... Volta, in that Italy which had been the cradle of the new knowledge, discovered the principle of its true theory in a fact which reduces the explanation of all the phenomena in question to the simple contact of two substances of different nature. This fact became in his hands the germ of the admirable apparatus to which its manner of being and its fecundity assign one of the chief places among those with which the genius of mankind has enriched physics."

Shortly afterwards, our amateur would learn that Carlisle and Nicholson had decomposed water by the aid of a battery; then, that Davy, in 1803, had produced, by the help of the same battery, a quite unexpected phenomenon, and had succeeded in preparing metals endowed with marvellous properties, beginning with substances of an earthy appearance which had been known for a long time, but whose real nature had not been discovered.

In another order of ideas, surprises as prodigious would wait for our amateur. Commencing with 1802, he might have read the admirable series of memoirs which Young then published, and might thereby have learned how the study of the phenomena of diffraction led to the belief that the undulation theory, which, since the works of Newton seemed irretrievably condemned, was, on the contrary, beginning quite a new life. A little later—in 1808—he might have witnessed the discovery made by Malus of polarization by reflexion, and would have been able to note, no doubt with stupefaction, that under certain conditions a ray of light loses the property of being reflected.

He might also have heard of one Rumford, who was then promulgating very singular ideas on the nature of heat, who thought that the then classical notions might be false, that caloric does not exist as a fluid, and who, in 1804, even demonstrated that heat is created by friction. A few years later he would learn that Charles had enunciated a capital law on the dilatation of gases; that Pierre Prevost, in 1809, was making a study, full of original ideas, on radiant heat. In the meantime he would not have failed to read volumes iii. and iv. of the *Mecanique celeste* of Laplace, published in 1804 and 1805, and he might, no doubt, have thought that before long mathematics would enable physical science to develop with unforeseen safety.

All these results may doubtless be compared in importance with the present discoveries. When strange metals like potassium and sodium were isolated by an entirely new method, the astonishment must have been on a par with that caused in our time by the magnificent discovery of radium. The polarization of light is a phenomenon as undoubtedly singular as the existence of the X rays; and the upheaval produced in natural philosophy by the theories of the disintegration of matter and the ideas concerning electrons is probably not more considerable than that produced in the theories of light and heat by the works of Young and Rumford.

If we now disentangle ourselves from contingencies, it will be understood that in reality physical science progresses by evolution rather than by revolution. Its march is continuous. The facts which our theories enable us to discover, subsist and are linked together long after these theories have disappeared. Out of the materials of former edifices overthrown, new dwellings are constantly being reconstructed.

The labour of our forerunners never wholly perishes. The ideas of yesterday prepare for those of to-morrow; they contain them, so to speak, *in potentia*. Science is in some sort a living organism, which gives birth to an indefinite series of new beings taking the places of the old, and which evolves according to the nature of its environment, adapting itself to external conditions, and healing at every step the wounds which contact with reality may have occasioned.

Sometimes this evolution is rapid, sometimes it is slow enough; but it obeys the ordinary laws. The wants imposed by its surroundings create certain organs in science. The problems set to physicists by the engineer who wishes to facilitate transport or to produce better illumination, or by the doctor who seeks to know how such and such a remedy acts, or, again, by the physiologist desirous of understanding the mechanism of the gaseous and liquid exchanges between the cell and the outer medium, cause new chapters in physics to appear, and suggest researches adapted to the necessities of actual life.

The evolution of the different parts of physics does not, however, take place with equal speed, because the circumstances in which they are placed are not equally favourable. Sometimes a whole series of questions will appear forgotten, and will live only with a languishing existence; and then some accidental circumstance suddenly brings them new life, and they become the object of manifold labours, engross public attention, and invade nearly the whole domain of science.