An Introduction to

Scale Coordinate Physics

WILLIAM BENDER

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SCALE COORDINATE PHYSICS

An Introduction to the Formalization of the Macro Operational Point of View

by

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PREFACE

In this essay, which I have called AN INTRODUCTION TO SCALE COORDINATE PHYSICS, a point of view is adopted which, among other things holds that: *Comprehension of quantum empirics is possible in terms of concepts which need go no further than those associated with the macro configurations of, and macro operations on, apparatus.* This statement implies a long and arduous program. It does not deny the existence[a] of the neutrino; nor does it deny the existence of the electron; it does not deny the existence of the L mesons[b], it does not deny the existence of the K mesons[c]. Neither does it deny the existence of the proton, the neutron or the neutral hydrogen atom. Nor does it deny the existence of the Hyperons[d], The existence[a] of such twentieth century particles in terms of which quantum empirics is comprehended are neither denied nor affirmed. What this essay *does imply* is that there may be an *alternative* scheme of comprehension based on the recognition that our arbitrary measuring devices are giving us *ordinal sequences* of position and intensity (and other physical attributes)/ forming what might be called *natural scales.* Examples of such "natural scales" are spectra, (the term is used to include visible, infra-red, ultra-violet and X-ray spectra); mass spectra; Laue patterns, optical and microwave diffraction patterns; Daltonic stoichiometrical scales, Faradian electrochemical scales, etc. One of the objects of scale coordinate physics is to eliminate the man-made arbitrary scales by which these natural scales are usually measured, thereby producing relationships among these natural scales. Ultimately an algorithm—in the nature of a macro operational quantum principle of broad scope—must be invoked in order to attain this objective.

This essay is, on last analysis, of a highly introductory nature. It purports to make a beginning toward macro operational comprehension of quantum empirics. We have called its programmatic aspects the *macro operational program.* To implement this program we have invented a form, $B(n+\theta)$, which we have called a *scale coordinate.* This scale coordinate implies a *scale coordinate geometry* whose development must parallel, or perhaps, precede the physics of the subject.[e]

To try to keep one's thinking wholly on a macro operational level, when almost all of current physics is comprehended in terms of micro inferential particles, has not always been easy. But I have consciously adopted a partisan and even intransigeant attitude in favor of the macro operational point of view, so that whatever shortcomings such a point of view may possess, they may be made evident the more quickly.

I am aware of the fact that the great Wilhelm Ostwald tried to maintain a *macro* point of view until in his preface to his *Outlines of Chemistry* he wrote[f]: "...The isolation and counting of gaseous ions on the one hand...and on the other the agreement of the Brownian movements with the requirements of the kinetic hypothesis...justify the most cautious scientist in now speaking of the experimental proof of the atomic theory of matter. The atomic hypothesis is thus raised to the position of a scientifically well-founded theory."

The fact remains that we do *not* "count gaseous ions" in a direct macro operational sense. We do *not* count electrons in Millikan's oil drop experiments. In Millikan's experiment we *infer* the acquisition or loss of electrons by the "directly sensed" (as we use this term in this essay) *oil drop,* and their macro spectrum of velocities, when these oil drops appear in a certain type of well defined macro environment. In short, a *philosophy of gross apparatus performance* may lead to a comprehensive theory which ac-

a. Later we call this the "micro inferential existence". We make no attempt to define the term "existence" in this essay, but do recognize, and attempt *to distinguish* between two categories of existence: "micro inferential existence" and "macro operational existence".

b. $\mu^{\pm}$, $\pi^{\pm}$, π^{0} mesons.

c. $\tau^{\pm}$, θ^{0}.

d. Λ, Σ, Ξ mesons.

e. See "The Nature of Scale Coordinate Geometry", *Proc. So. Dakota Acad. Sci. XXXV* (1956) p. 232, *et seq.*
f. See: R. A. Millikan, *Electrons (+ and −), Protons, Photons; Neutrons, Mesotrons and Cosmic Rays,* University of Chicago Press, Chicago, Ill.

counts for and relates apparently separate phenomena and may *predict* a whole host of verifiable physical effects. No matter how well developed the micro atomic points of view may become there always remains the possibility of formally relating macro effects, shunting around the micro inferential particles as elements of comprehension. We do not deny quantitization. Rather, we assert that when it occurs it has not only its micro inferential, but also its macro operational relevancies. The macro quantum effects might be called ***macro atomistic*** or simply "atomistic" in contradistinction to "atomic" an adjective used in the realm of comprehension on the ***micro inferential*** level.

In brief, then, this essay is devoted to advancing the macro operational point of view in contradistinction to the micro inferential point of view in physics held so widely today.

One cannot hope that in an essay as highly personalized as this one is, (in some respects) to be free of errors——errors of fact, errors of judgment, errors of computation, etc. I shall appreciate being made aware of them.

Finally I might say that I am engaged in a further development of the points of view expressed in embryo form in this work. I hope this essay will encourage others whom I know to be unhappy about certain aspects of modern quantum theory to continue their own researches more or less along macro operational lines with ever greater energy and enthusiasm. It would be good to see a journal launched, called by some such name as, The *Journal of the Philosophy of Macro Apparatus Performance*, for such a journal could bring together the work of many researchers with certain attitudes and objectives sympathetic to macro operational approaches to quantum empirics and kindred matters.

ACKNOWLEDGEMENTS

It would be impossible, in any simple way, to express my indebtedness to all the physicists whose works I have consulted during the writing of this essay. They would range from Galileo to the most modern writers on quantum mechanics. But two physicists must be mentioned explicitly: The first is Albert Einstein, the second, Percy W. Bridgman. I have sensed a large area of common ground in their attitudes toward physical comprehension and the desire to codify this common ground has been one of the prime motivations for writing this essay. Consequently I am greatly indebted to both of these great physicists. Neither of them has endorsed this essay. One, alas, is beyond such endorsing. The other has not seen it at the time of this writing.

I wish also to thank my old friends, Mr. Carl C. Lienau and Dr. John M. Reiner, for their constant encouragement and many satisfying conversations extending over many years during the preparation of this essay. Both of these scientists have enlightened me on many matters, but, of course, they are not responsible for the shortcomings of the attempt, in this book, to widen the scope of macro operational comprehension.

I want to thank also my Chicago friends—friends of very long standing—Dr. and Mrs. Samuel B. Shanoff for their constant interest and encouragement. Neither of them are physicists, but they have repeatedly expressed their interest and sympathy during the progress of this work.

Then I wish to thank Mr. Martin C. Predoehl who while an undergraduate student at the University of South Dakota spent his spare time drawing many of the figures in this book and many more which I hope some day to use. Later Mr. O. Maurice Lyso also at the time an undergraduate student at the University of South Dakota took up the work of figure drawing. Recently Mr. Lindsey E. Waldorf, a graduate assistant in the physics department, lent a skillful hand at figure drawing and helped in other ways to prepare the final manuscript. I wish to thank all of these men for their contribution to the realization of this essay.

I want also to thank Professor Robert H. Knapp, Dean of Student Personnel Services, University of South Dakota, for giving me certain storage facilities in his office during the preparation of the Vari-Typed manuscript.

Last, but certainly not least, I want to express my thanks to our departmental secretary, Mrs. Mildred Rowan, who typed my hand written manuscript on an ordinary typewriter, then typed this typewritten copy on the Vari-Typer. All of this was done while carrying on the usual secretarial work of the physics department at the University of South Dakota. Without her efforts the publication of this essay would have been long delayed. I wish to take this opportunity to say that her expert secretarial work is very much appreciated.

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CHAPTER I

INTRODUCTION TO THE MACRO OPERATIONAL POINT OF VIEW IN PHYSICS

1.1 Introductory remarks——One of the major objectives of this essay is to lay the foundations of a point of view in physics upon which the empirical data of quantum mechanics may be comprehended in terms of the *gross operations on, and gross configurations of, physical apparatus.* As of today, the data of quantum physics is almost universally comprehended in terms of *inferred or postulated micro particles* such as the electron, the positron, the proton, the neutron, the neutrino, a number of different species of mesons, and several other elementary particles.

The point of view which we shall develop may be called *macro operational.* The definition of this term will undergo a process of development as the purposes of this essay unfold. Throughout, the emphasis will be on the macro aspects of physical phenomena. The macro operational point of view implies a program for physics. This program will be developed on the formal side by means of *scale coordinate geometry.* Scale coordinate geometry was invented for the specific purpose of giving quantitative substance to the macro operational point of view.

The macro operational program points to a way of interpreting the quantitative performance of apparatus, (from which the micro particles today are inferred[1]) which is *alternative* to the micro (or ''elementary'' particle) interpretation. In short, the emphasis is shifted from the micro particles as mental constructs for comprehension, to certain macro mental constructs which refer to the gross apparatus itself. Instead of the neutron, we shall speak of the *''neutronic'' type of macro performance of apparatus*; etc. This terminology leaves something to be desired but its usage seems to be called for——at least as a temporary measure——so that the break with current terminology may not be too drastic. Eventually, we feel the macro point of view will need no such micro references. This brings us to another objective of this essay.

The macro operational point of view has other purposes, besides that of laying the foundations of a scheme alternative to the ''elementary-particle'' approach to modern quantum physics. By shifting emphasis from the more highly postulational and/or inferential aspects of physics to the more operational ones ——particularly the more *macro* operational ones——certain traditionally troublesome aspects of classical physics receive a modicum of clarification.

A point of view in physics must be accompanied by a formal concomitant for purposes of computing ordinal and cardinal relationships amongst properly dimensionalized physical entities. For such purposes we have invented a mathematical tool, which we have called the *scale coordinate.* In terms of this ''scale coordinate'' we have developed (to a limited extent in this essay) ''scale coordinate geometry''. Some of the early chapters of this essay will be devoted to this mathematical development. The scale coordinate is a three-symbol coordinate in contradistinction to the one-symbol coordinate first introduced by Descartes. One of these symbols (of this three-symbol coordinate) represents an *ordinal number,* **n**. **n** is, of course, an integer.

One of the most urgent questions that seems to arise when the macro operational point of view is asked to comprehend the concept of a quantum——*not on a micro level,* but *rather on a macro level*——is this: What is there about gross apparatus, the operations on it, and the configurations of it, which are likely to suggest quantum numbers? The answer appears to be: ***The ordinal numbers which we assign to scale marks on gross scales appear to play the role of quantum numbers. Therefore one of the symbols, n, of the ''scale coordinate'' is interpreted as a quantum number. This proposition is valid for a proper dimension-***

1. Occasionally a micro particle is first postulated; then calculations are made from empirical data arising from an experiment designed to ''realize'' this micro particle; then certain new inferences may be made with regard to this particle, based on further calculations demanded by a theory. (See Tables 1.3 and 1.4.)

alization and proper magnitude assignment of the scale mark interval of a gross scale.

This essay will be devoted, in large measure, to an elucidation of the meaning and demonstration of the validity of this proposition.

1.2 Note on the elementary particles of physics as of 1953-54 and their concomitant gross apparatus——In Table 1.1 is given a list of elementary (micro) particles[2] most of which are generally recognized as valid inferences from gross (macro) experimentation.

The gross (macro) apparatus whose ''performance'' is comprehended[3] in terms of elementary particles consists of *familiar* unit configurations of matter, but the formal manner in which these unit gross configurations are juxtaposed is hardly treated at all in modern physics. We notice that in a catalogue of gross apparatus for micro particle determination there appear such familiar items as:

1. Time meters (clocks of various descriptions).
2. Electrometers of several different types.
3. Galvanometers of several different types.
4. Magnetometers of several different types.
5. Gravitostatic meters[4].
6. Gross scales of different dimensional relevancies.
7. Hookean deformable bodies.
8. Developed patterns in special types of ''photographic'' emulsions.
9. Specially shaped metal ''containers'' with their internal and external conducting, semiconducting and non-conducting relata (e.g. ionization chambers, dees of a cyclotron, etc.).
10. Counters (Geiger-Mueller, scintillation).
11. Glass enclosed multi-electrode structures.
12. Wires, cables, and specialized configurations of conductors and non-conductors (e.g. capacitors, inductors, and resistors).
13. All those creations in glass——some veritable *objects d'arte*——which characterize the modern chemical laboratory (flasks, condensers, beakers, pipettes, funnels, etc.——calibrated and otherwise).
14. A whole host of devices which *connect* one part to another, which *position* parts relatively; which give relative *orientation* of apparatus parts[5]. Examples are right-angled clamps, rods, universal joints, etc. These are frequently looked upon as non-relevant attributes of the physical concept whose macro or micro attributes are being investigated or discovered. From a macro operational point of view they often serve as an essential category of entities in a macro operational definition of a concept.
15. Optical devices such as telescopes, microscopes, interferometers, photometers, etc.
16. Sources: e.g. light sources, radioactive sources, ion sources, x-ray sources.
17. Data-recording devices for a realization of permanent record, manual and/or automatic.
18. Groups of observers[6], generally called physicists, physical chemists, chemists, psychophysicists, biophysicists, technicians, etc.

The above list is simply indicative of the kinds of entities one finds in experimental physics to-

2. F. J. Dyson, *Scientific American* 188 57(1953); *High-Energy Particles*, by B. Rossi, Prentice-Hall, Inc., New York (1952).
3. By ''comprehended'' we mean explained, accounted for, predicted, correlated with, etc., in short, all those satisfying attributes of a discipline which characterize the term ''science'' in contradistinction to a mere compendium of facts. Note: The term ''gross'' will be replaced by the more systematic term ''macro'' as we continue to develop the macro operational point of view.
4. See Chapter VI for the meaning of this term.
5. In Chapter VI we have called these ''connectors'', ''positionors'', and ''orientors''.
6. A group of observers may contain only one observer.

Table 1.1 PRINCIPAL ELEMENTARY PARTICLES OF PHYSICAL THEORY AS OF 1953-54*

Name of Particle	Symbol	Charge (electron charge as unity)	Rest Mass (electron rest mass as unity)	Spin	Kind of Statistics	Mean lives in seconds	Decay scheme
Photon	γ	0	0	1	Bose-Einstein	Stable	
Graviton	G	0	0	2	Bose-Einstein	Stable	
Neutrino	ν	0	0	½	Fermi-Dirac	Stable	
Negatron (Electron)	e^- (or e)	−1	1	½	Fermi-Dirac	Stable	
Positron	e^+ (or p)	+1	1	½	Fermi-Dirac	Stable	
Positive Mu Meson	μ^+	+1	210	½	Fermi-Dirac	2.1×10^{-6}	$\mu^+ \rightarrow p + 2\nu$
Negative Mu Meson	μ^-	−1	210	½	Fermi-Dirac	2.1×10^{-6}	$\mu^- \rightarrow e + 2\nu$
Neutral Pi Meson	π^0	0	265	0	Bose-Einstein	10^{-15}	$\pi^0 \rightarrow 2\gamma$
Positive Pi Meson	π^+	+1	276	0	Bose-Einstein	2.65×10^{-8}	$\pi^+ \rightarrow \mu^+ + \nu$
Negative Pi Meson	π^-	−1	276	0	Bose-Einstein	2.65×10^{-8}	$\pi^- \rightarrow \mu^- + \nu$
Zeta Meson ?	ζ	±1	550	?	?	10^{-12}	$\zeta \rightarrow \pi + ?$
Neutral V-Particle	V^0_2	0	850	?	?	10^{-10}	$V^0_2 \rightarrow \pi^+ + \pi^- + ?$
Tau Meson	τ	±1	975	?	Bose-Einstein	10^{-8}	$\tau \rightarrow 3\pi$
Kappa Meson	κ	±1	1100	?	?	?	$\kappa \rightarrow \mu + ?$
Positive Chi Meson	χ^+	+1	1400	?	?	10^{-9}	$\chi^+ \rightarrow \pi^+ + ?$
Negative Chi Meson	χ^-	−1	1400	?	?	10^{-9}	$\chi^- \rightarrow \pi^- + ?$
Proton	P	+1	1836	½	Fermi-Dirac	Stable	
Neutron	N	0	1838.5	½	Fermi-Dirac	750	$N \rightarrow P + e + \nu$
Neutral V-Particle	V^0_1	0	2190	?	Fermi-Dirac	3×10^{-10}	$V^0_1 \rightarrow P + \pi^-$
Positive V-Particle	V^+	+1	2200	?	?	10^{-9}	$V^+ \rightarrow P + ?$

* See F. J. Dyson ''Field Theory'', *Scientific American*, April, 1953; *High-Energy Particles*, by B. Rossi, Prentice-Hall, Inc., New York (1952).

day, and is by no means exhaustive; nor is the list characterized by any clearcut ***system*** of selection and/or ordering according to specific criteria. Nevertheless all the entities mentioned ***lie on a direct sensory level.*** The macro point of view implies a sensory level of observations; minimal discrimination by the sensory organs is involved in our definition of the macro operational point of view. For example the minimal interval of discrimination between ***two adjacent scale marks*** on a galvanometer scale, or a length scale, or an ''action scale'' of a presumed ''action meter'', are important considerations for the macro operational point of view. In observing——in a somewhat detached fashion——a group of experimenters in a modern physics laboratory ''interacting'' with their apparatus, where perhaps a new elementary particle is in the process of being reified, one is exposed to a complicated array of stimuli, whose responses may be listed in the following manner:[7]

a) A large part of the time of the experimenters (not counting the time consumed in the computation of data) is spent in ''lining-up'' apparatus, i.e. to say, there frequently is an obvious engrossment in the relative positioning of apparatus parts. Certain criteria are to be realized in this geometric activity, such as sharpest focusing of optical lines; sharpest focusing for concentrations into spots and lines on photographic plates or plates containing substances sensitive to the particular type of ''beam'' under consideration, (the focusing being tested by subsequent image development); focusing by probe testing, the probes acquiring (e.g.) different maximal or minimal potentials, etc. Thus, one aims at special configurations through the ''lining-up'' process, effected by locating concentrations of energy into spots, lines and thin lamina. These spots, lines and thin lamina are in the nature of patterns of distinguishing marks, standing out from their backgrounds so prominently ***that they may be assigned ordinal numbers.***

These arrays of distinguishing marks whether directly visible optical spectra, or developed lines in sensitized emulsions, or point- or line-probes whose temperature, electrical potential, or, etc. is maximized or minimized and registered on a suitable meter, are of two kinds: Those (i) naturally occurring, such as a spectrum of optical lines; or a mass spectrum from a mass spectrograph; or developed photographs of Laue spots, or etc., or (ii) man-made sequence of lines whose cardinal interval values have a high degree of arbitrariness. These man-made sequences of distinguishing marks, together with a set of assigned ordinal numbers (one for each mark of a sequence of marks) are usually called ***scales.*** It is clear that the naturally occurring sequences of distinguishing marks such as the spectrum of hydrogen when assigned ordinal numbers become scales, too. We shall call them ***natural scales.***

Speaking with utmost detachment we might say that the physicist attempts, ***inter alia,*** to codify his experiments by giving the ordinal numbers of naturally occurring scales as functions of the ordinal numbers of man-made scales, these man-made scales having quite arbitrary magnitudes assigned to their minimal scale mark intervals. Frequently, in this attempt at codification, two essentially different functions of the same man-made scale reading are related by eliminating the man-made scale readings. It shall be one of our purposes to develop ways of making the man-made scales less arbitrary, thus bringing two naturally occurring ''spectra of values'' in closer relationship ***ab initio.*** This remark will be explained more fully in the sequel.

b) The ordering of physical distinguishing marks, i.e. the assignment of order numbers to any array of distinguishing marks——not necessarily scale marks in the usual sense——is another pervasive activity of experimentalists——although occasionally this is carried out on an almost unconscious level.

c) Every experimental set-up entails, generally speaking, at least one scale; more frequently a ***system of N scales.*** Most of these scales are integral parts of meters. The galvanometer has its galvanometer scale; the electrometer its electrometer scale; the clock its time scale; etc. At any rate these scales generally have a specific and obvious dimensionality assignment, whether they are parts of a meter or not. This being the case, a system of scales of a piece of apparatus is quite characteristic of modern physical apparatus, regardless of the physical entities being measured.

d) Dimensionality of an ***apparatus system*** deriving from individual dimensionalities of components of an experimental array, seems to inhere in, and be characteristic of the configurations of, and operations

7. The responses of an observer observing a group of experimenters will certainly vary from one individual to another. The whole religious, social, cultural, scientific, etc. background of the observer watching ''a group of experimenters'' is involved.

on, the apparatus under consideration.

e) The macro configurations of apparatus and the macro operations thereon, and the number-data taken from scale readings are the macro raw material for further computational effort. ***These computations are also to be considered as part of the operations on apparatus.*** We look upon symbols of computation—such as the arabic number symbols—as apparatus. (For an explanation of this remark see Section 7.8.)

If one meter reading gives a small number (of definite dimensionality) close to the limit of resolution of scale marks, and another scale reading gives a very large number, then the first number divided by the second may give a very small number defining the magnitude of an entity (with a specific dimensionality such as electric charge) which is far below the level of direct sensory appreciation. In such manner, are many micro particles frequently inferred. The example given is of course an oversimplification; the computation of many of the elementary particles listed in Table 1.1 require a more involved set of operations with measure-numbers, in general. In short if $x_{D_1}, x_{D_2}, \ldots, x_{D_N}$ are separate meter readings ***each macro in content*** and of definite dimensionalities $D_1, D_2, \ldots, D_N$, then a function of $x_{D_1}, x_{D_2}, \ldots, x_{D_N}$ may give the ***magnitude of a micro particle,*** with a specific dimensionality which depends on the nature of the functional involvement of the meter readings $x_{D_1}, x_{D_2}, \ldots, x_{D_N}$.

f) The thought occurs to one that if,

$$e = \frac{1}{n} f(x_{D_1}, x_{D_2}, \ldots, x_{D_N}) \tag{1.1}$$

defines the magnitude and dimensionality of (say) an elementary particle, (for example, electronic charge) then another way of comprehending the data would be to say that two sets of meter readings $x'_{D_1}, x'_{D_2}, \ldots, x'_{D_N}$ and $x''_{D_1}, x''_{D_2}, \ldots, x''_{D_N}$, related as

$$\frac{1}{n'} f(x'_{D_1}, x'_{D_2}, \ldots, x'_{D_N}) = \frac{1}{n''} f(x''_{D_1}, x''_{D_2}, \ldots, x''_{D_N}) \tag{1.2}$$

may also represent the ''physics'' of the phenomena ***without reference to the postulated*** or micro (elementary) particle, whose charge, or mass, or spin, or etc. was represented by, **e**. In passing one may state, however, that certain of the micro properties of particles have macro analogues, such as the mass of the atom of hydrogen and its macro analogue, the gram-atomic mass of hydrogen. In this case the ''elimination'' of the intermediate micro concept, atom, takes on a slightly different significance from the ''elimination'' of the electronic charge concept.

At any rate, all the macro data which the group of experimenters are accumulating may lead to a micro inference; but it may also lead to what might be called a similitude ratio n'/n''. This macro emphasis, too, will be explained in greater detail later.

g) The enormous psychophysical basis of experimentation in physics, such as common recognition of ''unit configurations'' and ''unit operations'' as between groups of experimenters; the formulation of many criteria for the determination of definite physical effects (on the realization of which, a meter reading or group of meter readings are taken); and many more subtle but commonly accepted conventions—these psychophysical studies—are still in their infancy. Even the Weber-Fechner laws and their recent amplifications are but the beginnings, (for physicists) for formulating criteria for resolving power (in its most general sense) between distinguishing marks; for determining coincidences and lack of them; for formulating criteria of physical ''identity'' and ''equivalences''—and the differences between these attributes. All these important subjects and more, are still in the realm of art rather than in science. (But one hastens to add that the line between art and science is fine indeed even in many highly developed disciplines.)

In passing I cannot refrain from stating a belief: The great discoveries for a physics of tomorrow will lie in the findings of psychophysics and its subordinate branch, psychomathematics.

We conclude the above remarks with the observation that: The raw data of physics is macro data and that the length of the table and diameter of an electron (the latter is a necessarily computed quantity; the former *may* be but not necessarily) ***are not on the same levels in a hierarchy of concepts.*** We refrain from characterizing one as more ''real'' than the other, for the reality of a concept in a man's mind, i.e., the intensity of the mental process associated with a concept appears to have no necessary correlation with the hierarchy of concepts which have to do with available resolving power, the numbers taken from macro scales, etc. In short we are not going to deny the reality of (e.g.) the electron; neither are we going to affirm its reality. We shall write chiefly of an alternative way of looking at the operations on, and configurations of, gross apparatus to the macro-particle-way. We leave the subject of greater or lesser degrees of reality to the semanticist and the psychologist.[8]

In brief then, the macro data of a physical experiment may be looked upon as representing a grouping of macro entities which have a single outstanding macro operational concept, the individual entities being in the nature of ''components'' of the abstract (but macro) single concept. Thus every one of the micro particles named in the first column of Table 1.1, is, from the macro operational point of view, a condensed descriptive term for a totality of macro operations on, and macro configurations of, an experimental set-up (or a complex of closely related experimental set-ups). In the future this macro comprehension may find itself in a more satisfactory position than the micro comprehension, if for no other reason than that the number of different ''elementary'' particles postulated to account for macro experience appears to be growing inordinately large——i.e. for a scientific discipline worthy of the name. As we have stated, one of the main purposes of this essay is to advance the program of comprehension of quantum empirics in terms of macro conceptualities relating to macro apparatus.

1.3 On macro operational terminology——Broadly speaking, the macro operational point of view has for its ultimate objective the comprehension of quantum and pre-quantum physics in terms of the macro operations on, and macro configurations of, (macro) physical apparatus. The term macro and micro will have to be given increasingly precise definition as has been indicated. It will be found that to carry out a program of successively improving the definition of the macro operational point of view two desirata (at least) demand attention: 1) The psychophysical basis of the definition of macro; 2) the psychophysical *differences* between the meanings of macro and micro. Now, it is *not* one of the primary purposes of this essay to go into the detailed psychophysical aspects of our problem. Nevertheless as we proceed, the psychophysical aspects of the macro-operational point of view protrudes again and again. Consequently from time to time we shall be compelled to refer to such matters, albeit somewhat superficially. We must however repeatedly take cognizance of the necessity for more precise definitions of the terms ''macro and micro operational''; also ''macro and micro postulational'', even though our definitions are on the lexicographic level.

Actually it is difficult to draw a sharp line between the terms ''operational'' and ''postulational". The fact that we have done so means that we wish to emphasize whatever differences are already recognized in these terms. We do this for methodological purposes. The ''postulation'' is a kind of ''static'' endeavor; operations——so to speak—— connect a sequence of postulations capable of being related. At least, this is what we wish to read into the meaning of these words.

Table 1.2 is a two-by-two ideologic matrix of concepts based on levels of reference system (measuring devices) and levels of concepts deriving from operations, inferences and postulations.

Table 1.3 shows a two-by-two ideologic matrix (showing four categories of concept). This matrix is intended to be helpful in drawing attention to the fact that operations can be contemplated on a micro level, as well as on a macro level.

Table 1.4 shows a two-by-one ideologic matrix which helps to explain the meaning of the term ''inferential'', as we are using it; especially the differences between the terms ''postulational'' and ''in-

8. While we may refuse to define ''reality'' we may safely recognize a *difference* between the stimulating phrases: ''micro reality'' and ''macro reality''; more of this difference, later.

Table 1.2 IDEOLOGIC MATRIX OF CONCEPTS BASED ON TWO LEVELS OF REFERENCE-SYSTEMS, MACRO AND MICRO

Level of Physical Entity \ Level of Reference System		1 Macro	2 Micro
1	Macro	*Length* of an ear of corn measured directly with a yardstick	Integration or summations of micro entities, with emphasis on these mathematical processes. Avogadro's number times atomic mass of lead, for example
2	Micro	*Diameter* of an electron *computed* from macro scale numbers	*Position* coordinates of an electron observed by a ''micro observer'' using a gamma ray microscope with a postulated micro scale

Ideologic matrix showing examples of macro and micro physical entities viewed from macro and micro reference systems

Table 1.8 IDEOLOGIC MATRIX OF CONCEPTS BASED ON DIFFERENCES BETWEEN OPERATIONAL AND POSTULATIONAL ATTRIBUTES

Level of Concept \ Character of Physical Concept		1 Operational	2 Postulational
1	Macro	Area of top of writing desk	The far side of the moon
2	Micro	Momentum or position of an electron	The neutrino (as of 1956)

Ideologic matrix showing examples of macro and micro physical entities, emphasizing the concept of a micro operational as well as a macro operational concept

Table 1.4 IDEOLOGIC MATRIX EMPHASIZING QUALITY AND QUANTITY OF CALCULATIONS RATHER THAN PHYSICALITY OF CONCEPT

Level of concept \ Character of concept		1	2
		Inferential	Non-inferential
1	Macro	Mass or orbit of a planet ***calculated*** from perturbation data of neighboring planets (astronomical)	Possibly operational or postulational
2	Micro	Micro concept based chiefly on extended ***calculations**** involving macro measure numbers. (Electron, proton, neutron, π - and μ-mesons, etc., for example)	Possibly operational or postulational

Ideologic two-by-one matrix giving meaning to the term inferential in contradistinction to postulational. The elements 1,2 and 2,2 strictly speaking, are superfluous for the purposes of this matrix.

*Thus having a higher physical status than the micro postulational concept such as the "graviton".

Table 1.5 AN IDEOLOGIC MATRIX ON OBSERVABLES, MACRO AND MICRO

Level of concept \ Character of observable		1	2
		Observable	Non-observable
1	Macro	Height of a man	Topographic details of far side of moon as of 1956. (Implies macro observability at some future time)
2	Micro	Position of an electron in an electromagnetic field	A postulated micro entity which on continued computation in terms of macro measure numbers proves to be physically insignificant on the basis of some criterion of probable inference.

A two-by-one matrix which attempts to categorize the much used term ''observable''.

ferential''. The second column of Table 1.4 is, strictly speaking, irrelevant. We must admit that frequently ''inferential'' and ''postulational'' have a large semantic overlap. Inferential implies relatively extensive calculation and/or qualitative ascription before the concept takes shape.

Table 1.5 shows a two-by-two matrix, emphasizing the categorizations of ''macro observable'' and ''micro observable''. (Notice that element 1,2 of this matrix is not intrinsically non-observable.) In the literature of physics today there is an almost total disregard for the distinctness of these categories and ''a γ-ray photon is observed to collide with an electron by using a gamma-ray microscope'' is frequently given on the same level of meaning as the ''observations of the length of the top of a writing desk''. These indiscriminations are indulged in not only by laymen but by professional physicists; not only by empirical physicists but by mathematical physicists. This jumbling of terminology—with concomitant indiscriminate jumbling of concepts—occasionally distorts the nature and quality of mathematical theories designed to comprehend physics. The ''observing'' of a γ-ray photon striking an electron is sometimes made the basis of whole philosophies concerning causality and therefore such micro descriptive terminology must be accepted as something more than a figure of speech.

Frequently the term ''direct observation'' of the half-life of a radioactive isotope or an unstable elementary particle is used when this half-life is found by a series of computations. What is more misleading however is that ''direct measurement gives a mean life of π-mesons of 10^{-8} second''. Such ''direct measurement'' on closer examination, is frequently found to be an end result of many micro postulational forebears and a more or less elaborate set of computations involving macro measure numbers.

Thus we shall attempt to heed the admonitions implied in Tables 1.2 to 1.5 inclusive insofar as we are able.

Finally, we must add that the definitions of such terms as ''micro inference'', etc. are difficult to formulate. Consequently the ideologic matrices given are more in the nature of *initial* semantic endeavors to be ''worked over'' into something more comprehensive. At best one cannot usually ''define'' in terms of single examples, as occur in the boxes of the matrix forms.

1.4 The macro operational point of view and quantum empirics—The macro operational point of view is a point of view with a program. A substantial part[9] of this program consists in giving meaning to the following proposition which relates macro operational physics to elementary-particle physics: *To every well authenticated elementary (micro) particle there corresponds a macro configuration of apparatus, with which is associated a well specified set of macro operations. The configurations of, and operations on this apparatus determine the magnitude and dimensionality of that elementary particle.*

But sometimes two *apparently* distinct apparatus configurations (and operations thereon) may motivate a group of observers[10] to infer what they believe to be one and the same neutron. In other words an elementary particle of one and the same rest-mass, charge, spin, etc. may be computed from the macro data from two different set-ups of macro apparatus having some obvious differences in operational-configurational attributes. With regard to this situation we make the following methodological postulates:

1a) A definite commonality of operational-configurational attributes will obtain for two distinct apparatus set-ups which lead, by inference, to one and the same elementary-particle concept.

1b) The non-commonality features if irreducible (see below) will lead to at least two modifying phrases descriptive of the neutron; e.g. the A-neutron and the B-neutron, where A and B species are inferred from the non-commonality aspects of the macro apparatus involved.

2) The concept implied by the term ''irreducible'' in 1b), above, applied to macro apparatus performance and configuration must be developed. As used above ''irreducible'' implies concepts of necessity and sufficiency of macro operational-configurational attributes of macro apparatus for determining non-commonality between two apparatus set-ups. The question is first raised whether the common ground of two (or more) apparatus set-ups is sufficient to infer one and the same elementary particle. If not, the elementary particle will be of two species whose separate characteristics are determined by the non-common (macro) configurational-operational aspects of the two apparatus set-ups.

9. But only a part.
10. There may, of course, be but one member in such a group.