Comments on Mendel Sachs' "The Future of Physics ?"

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ABSTRACT. Following Mendel Sachs' invitation to initiate a discussion in the physics community concerning our present understanding in the field, I comment shortly on: a) the conflict of logical positivism versus realism; b) the "irreductible subjectivity" in the role of the measuring apparatus versus full objectivity; c) indeterminism versus determinism; d) linear mathematics versus non-linear mathematics in the unapproximated forms of the theories. I state also that research workers must ban the concept "logical" from their reasoning.

RÉSUMÉ. A la suite de l'invitation de Mendel Sachs de provoquer une discussion sur la compréhension actuelle de notre science, je commente brièvement ses conceptions sur: a) le conflit entre le positivisme logique et le réalisme; b) l'irréductible subjectivité du rôle de l'appareil de mesure et l'objectivité totale; c) l'indéterminisme et le déterminisme; d) la mathématique linéaire et la non-linéaire dans les (formes non-approximatives des) théories. J'affirme aussi que les chercheurs doivent bannir de leur raisonnement le concept "logique".

In the condensed paper, "Future of Physics ?" [1], Mendel Sachs gives a short description of his research "pursuing a field approach in general relativity on the way that quantum theory emerges as a mathematical approximation for an entirely different field theory of matter -a theory rooted in Einstein's theory of general relativity- both mathematically and conceptually."

That is a vast programme and I am not competent to comment on it. But at the begining of his paper, Mendel Sachs proposes to initiate a discussion in the physics community concerning future directions in physics, on the basis of our present understanding of the field. He asks some general and fundamental questions, gives his own answers, and invites the reader to respond if he does not agree. I believe that a majority of the physics community can find merit in his questions and also his answers. Although I have no particular knowledge concerning these issues, I accept his invitation and I will comment, perhaps naively, on some of his answers.

In my opinion, our present difficulties stem, partly, from an overly loose utilization of current and imprecise concepts that are frequently inappropriate to the situation, as are concepts of classical physics applied to microphysics [2]. Moreover, our language mirrors our macroscopic everyday life, and is not designed to describe submicroscopic events. It is evident, that if we do not start from a precise and correct understanding of the present, we will extrapolate to a hazy future.

I agree with Mendel Sachs' point 1). Maybe could I add that "to assert is to state positively with great confidence but with no objective proof" (Webster's). We know that the mathematical formulations of quantum theory and relativity theory give correct and precise predictions. Therefore, perhaps, some of our assertions concerning their *bases* require a reformulation that will not affect the predictions of these theories concerning experimental results.

In his point 2), Mendel Sachs gives examples of the logical and mathematical incompatibilities between quantum theory and the theory of relativity. Section C) says: "In our approach to what we can truly 'know' about a material system, we have the conflict of logical positivism versus realism - the former asserting that all that we can possibly know is what we can directly verify in measurements, the latter asserting that there is a real world, independent of whatever we may do to find out about it, and that indeed we may acquire new knowledge about the material world that is not directly verifiable in measurements, though it may be inferrable from the logical structure of our theories, if the latter also predict correctly the empirical facts."

Mendel Sachs' definition of logical postivism is that of the physics community. I have no particular

philosophical knowledge, but I remark that Webster's (New World Dictionary, Third College Edition) definition is much wider: "logical positivism a movement in philosophy which tests all statements by reference to experience or the structure of language and is concerned with the unification of the sciences through a common logical language. Also called logical empiricism."

What troubles me is the statement "... that indeed we may acquire new knowledge about the material world that is not directly verifiable in measurements, though it may be inferrable from the logical structure of our theories...". I cannot agree, but it is not easy to say why. Let me begin by quoting from Hecht's Physics [3] p. 2, a simple and clear definition: "Theory is the explanation of phenomena in terms of more basic natural processes and relationships. To explain phenomena, we draw on intuition and imagination and guess at what is happening. We propose hypotheses, and leap beyond what we know to what might be. A construct of definitions, hypotheses, and laws that explains some observed order in nature is the essence of theory. A powerful theory allows us to deduce already known laws, as well as to predict new occurences and relationships that, *once tested and confirmed*, (emphasis mine) may become new laws." Here, I agree. I think that the "test" and the consequent "confirmation" must be the results of measurements. Physics being an experimental science, the domain of validity of a physical theory reduces to the domain in which it has been confirmed by experiments. Therefore, I do not see how new *physical* knowledge can be inferred from the logical structure of theories without a measurement that transforms (what I call) a metaphysical speculation into a physical fact. Someone has said, I believe incorrectly: that transforms mathematics into physics. If the "realistic" view were correct, there would be no difference between metaphysics and physics, because that part of a theory that has not been confirmed by measurements is inevitably a metaphysical speculation. More generally, this would mean also that one of the two concepts (physics or metaphysics) is superfluous. Let me add that if we extrapolate a theory from its (necessarily experimentally confirmed) domain of validity, we are doing metaphysics as long as an experiment does not corroborate the result. Remember, experiments are the physicist's "touchstone" and physics is an experimental science.

I have trouble also with the word "logical". Logical means "of or used in the science of logic" (Webster's), but also more currently, "necessary or to be expected because of what has gone before; that follows as reasonable" (Webster's). Let me say that "what follows as reasonable" in a given physical situation is not time-invariant: in physics, what followed as not reasonable in 1900, may follow as reasonable in 1998. This means that we humans cannot know, before performing an experiment, whether its result will be considered to follow as physically reasonable or not: I believe that, for Nature, everything that happens in the universe is "logical or follows as reasonable", but may appear as non-reasonable for humans, at least, before they have understood, or assimilated, the new fact. We call "reasonable" what follows in a given physical situation, only if we have understood this situation and integrated it into our mental vision of the universe. As an example, let me remark that any normal terrestrial says that it is "logical" that when he releases something it drops to the ground. A child, born and living in a space ship, would say that it is "illogical" because his life experience has taught him that if he releases something it stays where he releases it.

Remember also the photon concept (with its so called wave-particle duality): for the great majority of the physics community the photon concept, with its (macroscopically) bizarre properties, does not "follow reasonably" from the diverse experiments performed, but for Nature it surely does. That means that the majority of the physics community has not yet understood and assimilated, the photon concept. which proceeds from the pragmatic definition that condenses all the results of the experiments performed. A photon is nothing but a photon. Full stop.

I affirm that the concept "logically" (or "what follows as reasonable") is an ambiguous tool for physicists and cannot be used to roll back the frontiers of physical knowledge, because it is just at those frontiers - a kind of no man's land- that the concept "logically" (or what follows as reasonable) is not suitable.

Hence I conclude by saying, provocatively, that from my point of view, it is "logical and it follows as reasonable", that

realism is, for the physicist, nothing more than a philosophical speculation.

In section D) I read: "Irreducible subjectivity in the role of the measuring apparatus as a fundamental ingredient in our understanding of matter versus full objectivity, in which the "subject" and the "object" of an interacting system are truly interchangeable in the overall description of the system, without losing its objective truths."

I think that the "irreducible subjectivity" needs some explanations, but let us first look at the concept "subjective". My Webster's says: "of, affected by, or produced by the mind or a particular state of mind; of or resulting from the feelings or temperament of the subject, or person thinking; not objective; personal [a subjective judgement]." It is evident that physics is a proper science because it does not result from

the feelings or temperament of a physicist. It is also clear that what is written in texbooks under the title "physics" and results from human activity, is not "objective". This means that we had better specify what "subjectivity" means in physical science. It should be kept in mind that what gives the character of scientific truth to an experiment, is not the experiment itself, but the fact that any human, anywhere, can reproduce the experiment, with results that superimpose sufficiently (the results always have the form $R\pm$error). This implies that the "subject" who does physics is a hypothetical person representing what all physicists have in common, a kind of 'mean value human' in whom all personal feelings have been "smoothed out". The "observer", who plays a fundamental role in physics, is not a proper subject but simply this "mean value human". B. d'Espagnat[4] coined the word "inter-subjectivity" to label the concept that corresponds to (what Mendel Sachs and many others call) subjectivity in physics: it differs from philosophical objectivity and from philosophical subjectivity. Remember also that what is written in textbooks under the title "Physics" is the whole of our present knowledge of the physical universe, the body of physical facts accumulated by mankind. Without humans there would be no language, nor physics (and also no philosophy) [5]. The physicist requires merely that his conclusions be intersubjective, i. e., reproducible by, and valid for, every physicist. The question as to whether extraterrestials with a different mental structure from ours, arrive at the same conclusions that we do, is a question, not of physics, but of philosophy [2].

Section E. Mendel Sachs writes: "Indeterminism (all variables of matter are not "predetermined") versus determinism (where all variables of matter are predetermined, irrespective of what measurements may or may not be carried out)." I do not know the profound philosophical signification of these concepts, but as a physicist, I think that indeterminism is nearer to what we see in the laboratory, where we do not know the value of a physical property if we have not directly or indirectly measured it. In an atomistic universe with nucleons, subnuclear particles, etc., it is not easy to believe that all positions, movements and interactions and their consequences are predetermined. Moreover, if humans have free will, then each time they do something, Nature must redetermine everything that humans have put out of order (but let philosophers discuss about free will and determinism). I believe that determinism is a concept used by philosophers and based on the appearance of classical, continuous physics; but it is not easily defensible given the atomistic nature of present-day physics.

Section F. Mendel Sachs: "Linear mathematics versus nonlinear mathematics, in the general, unapproximated forms of the theories." I remind the reader that, first, quantum mechanics has been constructed partly on classical electromagnetic optics (addition of phases, interferences, etc) and secondly, that nonlinear optics explains many phenomena, e. g., second-harmonic scattering, rectification, sum-and-difference frequency generation, third-harmonic scattering, Brillouin scattering, inverse Raman effect, inverse Faraday effect, two-photon absorption, intensity depending refraction, induced opacity and induced reflectivity. I think that these arguments tip the scales in favor of nonlinearity.

It is evident that I do not agree totally with Mendel Sachs when he writes "It is important to know that the empirical agreement with the predictions of a scientific theory, while being necessary for the truth of that theory, is not sufficient to establish its truth. To be a scientifically true theory, its expression must also be both logically and mathematically consistent." What causes difficulty here is principally the last sentence, because the words "logically" and "mathematically" need some explanation. We know that, in physics, the word "logically" designates a biased concept, as I have shown before. The concept "logical" is a function of our knowledge and we cannot know a priori if a new physical result will be considered, for the time being, as logical. And if we refuse to recognize a new (or even bizarre) experimental result as physical knowledge because we consider it at present to be illogical, we close the door without detailed examination or analysis, to an understanding of subsequent fundamental experiments . Remember that in some situations, several generation have passed before knowledge was admitted as logical (e. g., the heliocentric theory). I believe that it is a tautology to say that once the consequences of an experimentally corroborated theory are understood and assimilated they are considered as "logical".

We might also recall that mathematics is a tremendous man-made construct, time-invariant, where new statements must be consistent with former statements, without external constraints. It is an essential and neutral tool for physicists. If a new physical situation cannot be treated with our known mathematics, we create a new chapter of mathematics to treat it. Remember that in 1925, the young Heisenberg, through mathematical ignorance, created a complicated calculus with a strange noncommutative multiplication, which his mentor, Max Born, recognized as matrix algebra.

We are macroscopic beings with a macroscopic vision of the world, a vision based on our everyday experience with static, or slowly moving, objects. We are inclined to believe that in the submicroscopic domain, atoms, molecules, elementary particles and their corresponding forces must behave analogously to what we know from everyday life. When they fail

to meet our expectations, we consider their behavior to be illogical.

Perhaps, if my comments are taken into consideration, we can reduce the number of questions Mendel Sachs asks, and look to the future on a more secure basis.

References

[1] Mendel Sachs, Ann. Fond. L. de Broglie **22**, 271 (1997).

[2] D. Canals-Frau, Ann. Fond. L. de Broglie **20**, 389 (1995).

[3] E. Hecht, *Physics, calculus* , Brooks/Cole Publ. Comp., Pacific Grove, CA, USA (1996).

[4] B. d'Espagnat, *Une incertaine réalité*, Gauthier-Villars, Paris 1985, p.31.

[5] D. Canals-Frau, Physics Essays **10**,no 4, (1997).

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