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REMARKS ON THE CONVERGENCE OF THE SCIENCES

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Discussion Paper

on

Peter Munz's

THE UNITY OF SCIENCE AND THE DUBIOUS CREDENTIALS OF POSITIVISM

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Remarks on the Convergence of the Sciences

As we see, there is a diversity of sciences, so much so that everyone looking for an inherent consensus could easily dispair. Yet on a more remote level behind the stages there is, I think, more coherence and convergence than is usually acknowledged. It is a worthwile, a necessary endeavor to exhibit and to work out this latent reality and its possibilities.

In the first place, we have some welcome unity through the method of rational problem-solving, including such values as consistency, truth, clarity, accuracy. We agree on rationality, but we should try harder to spell out what we mean when invoking this kind of illumination. Kant's analysis of reason is now about two centuries old and in large parts not adequate to our science, ethics, spirituality. In our own century there was and is much philosophical talk about languages — ordinary ones and more artificial ones. But they pose a fundamental part of the problem no less than keys to its solution. We badly need rationality and reason in order to overcome the detracting prejudices inherent in the Babylonian multitude of our languages (be they more of the Indo-Semitic or more of the Hopi-Indian or of the Chinese type.)

A main vehicle for the promotion of rational speech and thought are, since the days of Thales and Pythagoras, the mathematical sciences including (formal) logic and the arts of measurement and quantitative observation (in astronomy or music). They were always and are up to this day in touch with the physical sciences, and with economy. On the other hand, there is a remarkable distinction between (theoretical) mathematics and (experimental) physics. This epistemological hiatus goes sharply through theoretical physics (my own field of research and teaching): though not splitting this rather coherent scientific discipline it is, nevertheless, keenly sensed from a logical or gnoseological point of view. Mathematical theorems hold a quite unusual kind of certainty and durability. Classical examples are the existence proofs for the infinitude of the prime numbers or for the five (and no more) regular polyeders in

Euclidean or any other Riemannian space of constant curvature. What is the reason for this special quality of mathematical reasoning? It seems, mathematics was not only at the beginnings of rational philosophy and research but that somehow it is their ruler and compass, steadily pointing (during all those stormy times) to a limiting value of convergence. The philosophies of Descartes, Leibniz, and Newton at the link and vintage era between the Middle Ages and our more Modern Times could serve as central expamples for such a contention.

But this does not answer our question asking for the reason why mathematical propositions are so very reliable. Why is it that a proof is a mathematical proof, or no proof but a more or less plausible argument or suggestion only? The analytical (or logico-empiricist) epistemology of Carnap and his company proposed an answer which, I hold, solves the problem to a high degree of philosophical approximation. This solution is based on a sharp distinction between analytical and synthetical sentences which goes back to Leibniz in his contemplations of necessity and liberty. An analytical statement is true because its negation would lead to an internal inconsistency; and logical or mathematical propositions are true because they are of an analytical character, void of any sensually real content. This formalistic position has been challenged by the more holistic pragmatism of Quine, a former student and lifelong friend of Carnap's, and since forty years one of our leading logicians. According to Quine there is nothing purely analytical, logic and mathematics being no other than the central parts of our whole conceptual scheme, which is to be perceived as homogeneous in substance. Though admiring Quine's writings, their language as well as their analysis, I am afraid he has not done proper justice to the distinctness of mathematics. Luckily, I had the opportunity of a long talk with Williard Quine, during which he agreed with my defense of truth by definition, adding only that when he had objected to it, he did so in the context of Carnap's regrettably dogmatic empiricism (or positivism).

I have no intention to defend positivism, or an empiricism balanced merely by analyticity. What we have heard from Peter Munz and William Bartley in this respect sounds convincing to me. Positivism needs some skeptical negation, and some supplementation by a critical rationality which is not confined to analysis and experiment only. Our sciences do and should comprise a liberal discussion of ideas and values — like in Plato's early dialogues, but unlike the monologues

in his City State or Laws, which unfortunately lead to an anti-holistic, totalitarian government (that has little resemblance to any right republic, or nomocracy). A rational, scientific sentence is a statement which could pass a competent discussion free of any censorship. This applies also, of course, to such a delicate (if gross) dissension as that Chinese people have the highest mean IQ. Maybe there are good political reasons to (temporarily) suppress some branches of science; but then we should try hard not to deceive ourselves and other people to believe in any scientific merit of the gaps or surrogates. "For it is not advisable" as Martin Luther once said before his emperor-king and princely diet "to act against consciousness".Science is and ought to be an integral part of our consciousness in the psychological as well as in the ethical sense of the notion. One main task of good consciousness is to clear itself — with God's help — from a legion of dialectical tricks of self-contradiction. This endeavor is not much beneath listening to God's present will — if you allow me to say so. In any case, straightening the mind has an intellectual component which is the hallmark of logic and mathematics. This is entirely compatible with the creative role of intuition within mathematics no less than without. Exploring the wonderland of all those tenable thought structures is an adventure needing phantasy as much as veracity.

If, under the pressures of new empirical evidence, we decide a change in the more central parts of our conceptual system (as happened for example through Keplerian astronomy, Galilean kinematics, Newtonian dynamics, Maxwell's field theory, Poincaré's relativity theory, Einstein's gravitation theory, or the multinational evolution of quantum theory) we do not change our mathematics (as Quine liked to suggest). We just add a new piece of mathematics compatible to the older ones, of course. Reason: each mathematical theory is no more and no less than a beautiful and useful truism, plain or profound in proportion to the training of the respective spectator. (We thus see mathematics as the queen and at the same time as a maid of the sciences, humanities, and arts.) Any mathematical theorem has a conditional structure (if — then) which makes it independent of any doubtful hypothesis. The premise (the if-statement) is a part of the theorem and not a supposition preceding it. What has been unfortunately called a 'mathematical axiom' is nothing but a basic definition: a convention rather than an assertion. As it has to be perfectly precise, we see that a mathematical definition or

construction is something like an exact delineation of a clear idea (from the Platonic rather than from the Cartesian fold). The codification of a board game like go or chess or of an algorithmic language like FORTRAN or PASCAL may illustrate the point. Accordingly, a mathematical theorem is necessarily true in that its negation would permit an intolerable self-contradiction. If this is the case today, it must be the case tomorrow as well.

The fact that our words vary in meaning through time and space should not be misread as indicating an alleged variability of concepts. We know how easily and accurately scientific notions may be transmitted from another age or to another continent (and likely even to another star). This does not apply analogously to some sort of philosophy, or lyric. The homeliness of most poetry and poetical philosophy adds considerably to their popularity among educated people including scientists. Our private and provincial lives are dear to us, quite rightly so, and they should not be allowed to become unholy sacrifices of any one of those dubious progresses. Yet homeliness should not blind us to the insight that all our ideas of any public import do not essentially depend on our changing languages, exciting and heart warming as they are in all their fine nuances and tunes. Therefore, a normalized language cannot be of much help for the unification of science. If solitary, it could not even be of much help for our simple conversations with the electronic computers. A dialectical double-talk language like the Newspeak of Orwell's 1984 is a severe disservice. Formal logic is the mathematics of true and false sentences (i.e. statements); and mathematics is logic applied to any structure whatsoever Here is no vicious circle, as you will not find any pretension of proof in these short and rough descriptions. Mutual dependences are usually quite <u>virtuous circles</u> of a feedbacking, self-enforcing, strongly consistent unity. Virtuous circles are more lively than the monolithic or centralized structures of the deductive type.

The prominent instance for the application of mathematics — this prototype and core of rationality — is the nature of the cosmos. Here we have already achieved a unification of considerable breadth and depth. Let me remind you of a few highlights illuminating the scene. The structure of the planetary system has been reconstructed with high precision by a theory based on a remarkably small number of 'physical axioms' or postulates. The

evolution of most stars has been simulated numerically by means of nuclear physics and statistical thermodynamics, and the similitude looks convincing. Acoustics has been reduced to fluid dynamics, optics to electrodynamics; and again the number of postulates is surprisingly small in relation to the wealth of the represented phenomena and to the precision of this representation Even more astounding is the success of quantum theory within microscopic as well as macroscopic physics. Using that counter-intuitive (quantum) kinematics and a few dynamical parameters, we may deduce the structures of the atoms, their shells and their nuclei, and also their various interactions. In some of the mathematically easier (but not at all plain or tendentiously selected) cases, the concordance of theory and experiment surpasses in precision even the proverbial accuracy of astronomy. One can barely avoid the impression that the world is somehow made out of a special kind of algebra, one we had never dreamed of before we investigated the details. There is little room for serious doubt of an underlying coherence over a huge area of high complexity.

As I have already mentioned, the fundamentals of chemistry have been correctly deduced from the quantum dynamics of the atoms and ions, delivering their compounds: the small and the big molecules. A similar reduction of physiology to chemistry is going on quickly along its many long ways. The double-helix structure of DNA, a cornerstone in the chemistry of genetical inheritance, has been reconstructed only 30 years ago. In the meantime, the genetic code for most microbes, plants, and animalia including humans, has been broken. Thus we understand the telegram alphabet in which the inherited structures of our bodies — as evidenced by similar twins — is written. We know nowadays a great deal about the library of scores and scripts (called genes or chromosomes) containing the digital information that organizes a biological individual. Knowledge of each detail is neither possible nor necessary. More to the point in our context is the (indivisible) unity of the human individual with regard to body and mind. It means that my and your inherited character is implied by the respective molecular information within the nuclei of our cells.

We thus recognize a far reaching and deep going integrity of our psycho-physical world, based on a small number of strange postulates which have little resemblance with those allegedly self-evident principles or

axioms of former times. It is quite possible that posterity will have to thoroughly modify our postulates in order to achieve an even higher unity accounting for an even larger amount of experimental data. Yet almost certainly such changes will be evolutionary in causing only small variations of the relations presently accepted. Even though formulating a variant structure and understanding, they will likely be almost isomorphic to the relations which approximately represent the experiments and observations of our days. Because of this abstract — though decisively specific — nature, the mathematical unity which we already have arrived at, is far beyond comprehension (in all the entailed details) by any one person. You will remember how vividly and convincingly Eugene Wigner has told us his long experience in this respect. But I do not see and have no hope of any other scientific unity of substance, than this mathematical one.

And even this one is nowadays far from perfection: the number of independent postulates and parameters (as coupling constants) among the many unstable particles is not so low as we like them to be. On the other hand, this relates to a domain of natural philosophy very far from our every day experiences. The number of independent parameters necessary for the comprehension of our common sense physics, chemistry, and physiology is much lower and can probably be counted by the fingers of a couple.

How we are to unite science with intuition and divination, is another question, one we have omitted at this meeting.

Let me add a few words about the main obstacles to fundamental unity within the natural sciences. I am recognizing basically three in number: a microcosmic, a macrocosmic, and a mesocosmic one. The microcosmic problem is that we do not yet have the disired 'grand unification' of all the 'almost elementary' particles, fields, and interactions which have been detected in the cosmic rays and accelerator beams. The macrocosmic problem is that we do not yet know how to combine quantum stochastics with the spacetime field including gravitation, black holes,and global singularities (the initial and the final big bang). Seemingly of another nature is the mesocosmic problem: the polarity of matter and mind. It occupies a central position of extreme complexity,well in between the extreme small and the extreme large dimensions. I like to guess that these three profound mysteries will be resolved somewhere during the coming century (or, maybe, the secular

millenium), in one treble step. The structures of the ultimate microcosmos will be seen to join those of the ultimate macrocosmos at the cardinal structure of the mesocosmos. By this I mean the spiritual unity of mind and matter, of soul and body in any living being, any monad, any individual — be it dynamic, organic, or human. This expectation is, of course, not even a speculation; being a curious daydream only, I hold it nevertheless worthwile enough to be mentioned here.

Yet I prefer to finish with a few words better grounded in our common experiences and speculations. Gerard Radnitzky mentioned plausibly a twofold goal of philosophy: cosmology on one hand,anthropology on the other. Such a view touches also upon the duality of matter and mind, of object and subject: should this (at least relative) duality fail to be of fundamental relevance, the anthropological problem could and should be considered as one part of the cosmological problem only. Radnitzky seems to join here many of his philosophical colleagues, ancient as well as modern ones: ethics is not only a prolongation of ethology; ought cannot be reduced to is; humans transcend the physical universe.

I follow Bohr, Heisenberg, von Neumann, Pauli, Wigner, Wheeler, Dyson, and many other colleagues in their opinion that quantum theory is likely to provide us with a clew to the subject-object dilemma. The heterodoxy of Planck, Einstein, Popper, and others is certainly known yet not convincing to me. It stems evidently more from an epistemological presupposition (misinterpreting the other side as yielding to operationalism)than from a fresh scientific contemplation. I am well aware of the dubious influence of positivism on many a physicist (as Planck, Einstein, or Heisenberg); but I think it can be rather easily subtracted. No less than the very algebraic structure of quantum theory itself is what so strongly invokes the subject-object-relation. Quantum theory without the observer playing an irreducible role just does not make sense (if we do not arbitrarily distort the clear algebra).

The quantal concepts of state and change have a quite peculiar structure indeed. So we have to distinguish between two radically different notions of change: one is continuous motion, the other discrete mutation. The latter is connected with the holistic structure of the quantal state notion. This strange holism of quantum stochastics is qualitatively known now for more than a semicentury and has been quantitatively sharpened by Bell's celebrated

inequality of 1966, for which Wigner gave a more transparent derivation [1].

One basic aspect of quantal holism is the above mentioned impossibility to completely disentangle an atomic 'object' from the observing 'subject'. Acknowledging this state of affairs has little to do with operationalism or positivism or the like. It is neither 'idealism' in the post-Platonic nor 'realism' in the post-Scholastic sense. It is, rather, a third possibility, well worth the effort of exploration with as little bias as possible. I sense some mutual interdependence of the subjective and the objective poles, some virtuos circle of mind and matter. By the way: the 'ideas' of Berkeley do not necessarily belong to humans. Even than, idealism is implausible when charging the mental aspect of the world with a clear-cut priority before its material aspect. Only the Creator of both, heaven and earth (mind and matter), can claim such an ontological and epistemological priority. But there is no reason to entirely deny spirit and life to preorganic or subhuman creatures. We have almost no idea of, nor feeling for the inner light of an animal or plant, let alone a molecule or electronic computer [2]. The arts seem to be a little closer to the truth here than the sciences.

Remember the great philosophy of Leibniz; it is especially rewarding for our considerations. Leibniz put atoms and individuals — as monads — at the same footing. (The Greek word 'atom' means literaly the same as the Latin word 'individual'.) The continuity principle of Leibniz gradually connects the preconscious reality via the subconscious with the selfconscious one, long before Darwin and Hartmann (or Freud). Quantum theory will add, that 'gradually' means step by step, mutation by mutation. Inspired by Fermat's principle of optics, Leibniz gave a harmonious, functional interpretation of causality long before Hume. In looking for the unity of human understanding it is certainly worthwile to actualize such kind of philosophy. Many details in Leibniz (especially those concerning space and time) are certainly obsolete now. His philosophy of matter reached a final culmination in Hermann Weyl 1927, just before the advent of the systematic quantum theory. The virtuous circle of subject and object, needed for an adequate interpretation of the quantum theoretic formalism, will differ from the mutual reflexions of the monads. But the main character of Leibnizian ontology and epistemology will persist. The ψ function of quantum theory is, I think, as much objective and simultaneously subjective as probability, or information, or any true knowledge is. Well understood quantum theory will be a variant of logic intimately combined with an ontology.

The anthropic principle of recent years point to the same direction [3]. It suggests that the cosmos, from its beginning, somehow knew of the human partner which was to come. (Please do not jump into a confusion of Creator and creation; this distinction is more important than e.g. Heidegger's ontological difference of being and entity.) Cosmography is certainly to the point, but the basic key to fundamental unity will likely be what I have tried to call quantum ontologic. The virtuous circle of matter and mind will become, I hope, an interesting field of study.

[1] B. d'Espagnat: A la Recherche du Rëel (Bordas, Paris 1979; in German: Springer, Berlin 1983)

[2] D.R. Hofstadter: Gödel, Escher, Bach (Vintage, New York 1979)
———"——— & D.C. Dennett: The Mind's I (Bantam, Toronto 1981)

[3] J.B. Carr & J.M. Rees: "The anthropic principle and the structure of the physical world" Nature 278 (1979)605

R. Breuer: Das anthropische Prinzip (Meystre, Wien 1981)

F.J. Dyson: Disturbing Universe (Harper & Row, New York 1979)