PARAPSYCHOLOGY, QUANTUM LOGIC, AND INFORMATION THEORY*

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Parapsychology and quantum mechanics are still in too unfinished and controversial a stage to admit of generally agreed or acceptable connecting bridges. In particular, the applicability of quantum laws to biology has led to endless disputes. E. P. Wigner,[1] who has provided much of the point and counterpoint of the controverted epistemology of quantum mechanics, argued that, on the basis of present-day quantum theory, the "probability of the existence of a self-reproducing unit" is zero. The argument has been extended and modified by Landsberg[2] using different conditions and contested by Eigen[3] on the ground that Wigner's random symmetric matrix does not provide molecular biology with even a starting point. Glansdorff and Prigogine[4] have offered a new approach to an understanding of biological phenomena by postulating a dynamical dissipativity, stability, and evolution of structures in the framework of a macroscopic level of quantum mechanics.

I have recently suggested[5] that we may perchance learn something from the breakdown of the commonly accepted interpretations of probability logic in quantum mechanics[6] as well as in parapsychology. In this paper I shall envisage the departures from generally accepted logic in an information-theoretic framework.

SECTION I

Broadly speaking, there are three types of information that are of importance in biological systems. First, there is a genetic information which does not have feedback to the individual organisms but is passed on from generation to generation.[7] Second, there is environmental information organized directly in nervous systems which has pronounced feedback, positive and negative, generalized and

* In Dr. Chari's absence, his paper was read by Dr. Harold Puthoff.

specific, into the storage systems of individual organisms; but the information is not passed on from generation to generation. Third, at the distinctively human level, we have communicated data which have considerable feedback and are also passed down to the next generation by a written language or by a recorded system of symbols.

Whether the three information storage and transfer systems of biology are "reducible" to a common type or whether they represent irreducibly unique "emergent levels" in biological evolution is a fundamental issue. Much of the debate over "Holism" and "Mechanism" could perhaps be resolved into the basic questions about information systems.[8] I shall not discuss the problem here, since I hold[5] that parapsychology goes far beyond all this controversy. Whatever the truth about "Emergentism" and "Holism," it is undeniable that the genetic information system and the human communication system share some features. In an n-dimensional world, a template or mold cannot ordinarily be more than $(n - 1)$-dimensional. We inhabit a three-dimensional world and structures exist in it as three-dimensional objects. Nevertheless, information in the nucleotide bases found in the DNA or messenger RNA of the biological cell forms a one-dimensional array.[9] This is a familiar mechanism of information coding in human communication systems. It is the basis for writing in systems that use an alphabet; it is also used in the Morse code and in a computer tape. The conformation of proteins is an expression of biological information in a three-dimensional form. The "stream of life" may be pictured as an alternation between DNA and protein, genotype and phenotype, information and conformation.

In the attempt to make the findings of parapsychology more intelligible than they appear, we may hypothecate a psi-information over and above the three types of biological information familiar to orthodox science. Biological psi-information may be organized as part of a more general psi-system including a psi-energetic system which provides for PK and allied manifestations (alleged telekinesis, teleplasticity, psi-healing, "Raudive" or "electronic" voices, etc.). In this paper I shall confine myself to the psi-information system. Controlled experiments conducted by investigators belonging to three different nationalities suggest that precognitive ESP can trigger rodent behavior. The indications are that psi-information interacts with, and modifies, the operation of the more common biological information systems. The interaction is infrequent, irregular, and limited, though by no means negligible, especially for theory.

It may not be fanciful to postulate a psi-informational network connecting organisms with all those parts of the material and spatio-

temporal environment which are relevant or significant for organismic behavior. The greater the range of behavior, the wider is the potential sweep of the psi-informational network. The theory has affinities to, but also serious differences from, some proposed "field theories" of psi. It could be set forth as a very generalized type of systems theory. It could also be exhibited as a generalized alternative to W. G. Roll's "psychometric object" theory, Rýzl's "psi impregnation" theory, and Pratt's "psychological conditioning" theory, all proposed to account for Pavel Stepanek's "focusing effect."[10] Up to a point, we may think of the psi-informational network on the analogy of the more familiar communication networks used by man. A channel with many sources and many destinations forms a network. If there are N incoming lines and N outgoing lines, we have to reckon with a N-N matrix. In a single-stage configuration, the number of cross-point switches will be N^2. The number of switches can be reduced by a multistage network. Something like this may conceivably operate in spontaneous "psychometric ESP" or "psychoscopy."

Switching circuits and the propositions of an ordinary logic display the same algebra, namely the algebra of a two-valued Boolean logic. Any given proposition in this logic is, in principle, true or false, carries, say, the value 1 or 0. A switch is open or closed, not both. The Boolean operations of negation, disjunction, and conjunction have their counterparts in communication networks. A switch is an electronic gate placed across the path of an electric current. The constants or connectives of a two-valued logic are paralleled by the "And" gate, the "Or" gate, and the "inverter" gate. All this, of course, is an exercise in the axiomatization of communication theory. Very few empirical theories have been axiomatized with anything like thoroughness, perhaps a few fundamental physical theories and isolated theories of biology, psychology, and economics. In any formalized theory, we have to distinguish the uninterpreted calculus from its interpretation, the formal axioms and rules from the empirically relevant descriptions. Axiomatics tells us how one sentence follows from another; it does not tell us what the supporting evidence is.[11] Many scientific theories have a hybrid character; they contain theoretical terms (T-terms) and factual knowledge. Definitions of T-terms can be explicit, conditional, or partial. In a formalized empirical theory, a single-headed arrow $\rightarrow$ conveniently symbolizes the logical connective "if-then," "implies" and the two-headed arrow $\leftrightarrow$ symbolizes equivalence. "$a \leftrightarrow b$" may be interpreted as saying that "a implies b" and "b implies a." Model theory is the study of the relation between formalized languages and the world, or more precisely the study of formal languages and their empirical interpreta-

tion. In the behavioral sciences, a causal relation or significant connectivity is any demonstrable relation that is not spurious.[12] A dependent variable may change according to a law of connectivity and the changes in the independent variable. Recent studies[13] have elicited various recursive models of two or more variables, deductions from axiomatic theory, path coefficients, and path regressions. Parapsychology is using increasingly sophisticated multivariate analysis and regression analysis. The work of Karlis Osis and his colleagues is significant here.

I suggest that the psi-informational system presents the paradox of a "logic" in which the "if-then" implicative relation of a formalized empirical science sheds its unambiguous significance. The analogy of an electronic communication network fails at a crucial point. The psi-information system extends into the future as well as into the past of the spatio-temporal environment of organisms, which is an anomaly for all current themodynamic theories of recordable information.[14] Suppose a rat has to utilize precognitive ESP to be able to avoid an electric shock; it could conceivably derive the information via the experimental cage, the electric grid, fellow rats, the mind of the experimenter. All these are conceivably "links" (cross-switches, so to speak) in the psi-communication network. But not one of them is demonstrably the unique cause or condition of ESP. The psi-communication network, like other networks, may have many sources and a common destination. Yet its logic cannot be assimilated to a two-valued Boolean logic in which alone the conditional of mathematical logic can be assigned a conventional interpretation. I would urge that the breakdown of an ordinary formalized logic of connectives in our scientific interpretation of the world is as evident in parapsychology as in quantum mechanics. I regard Jung's "synchronicity" theory as an arresting way of describing the breakdown of ordinary space-time description. What one misses in the theory is an account of the interaction of the psi-informational system with other informational systems. An absolute disjunction of psi and the space-time-cause world does not permit any further speculation.

SECTION II

C. A. Hooker, who has recently edited a volume on contemporary research into the mathematical and philosophical foundations of quantum mechanics, shows by a very sustained analysis that "the problem of measurement" is fundamental in the domain and looms large on almost any interpretation. The problem arose originally for the "Copenhagen School" from the "collapse of the

wave packet," since prior to measurement all physical possibilities were open whereas after measurement we know which of these was realized. Hooker[15] maintains that the problem goes much deeper than the usual "Copenhagen interpretation," for it is not simply that a "collapse" of the wave packet occurs or that "complementarity" of descriptions prevails, but that the logical method of calculating probabilities, especially conditional probabilities, in quantum mechanics is a radical departure from traditional theory.

The question whether there can exist a consistent rule for obtaining a quantum mechanical operator from its classical counterpart (i.e., a "correspondence rule") and the question whether there exists a legitimate joint distribution function are intimately connected. The "correspondence rules" proposed by Born and Jordan, Weyl, von Neumann, Dirac, Groenewold, and Shewell are all open to serious doubt.[16] There seem to be observables in quantum mechanics which have no classical counterparts at all. Again, according to the superposition principle, if ψ_1 and ψ_2 represent two states of a system, then a linear combination of the two also represents a state of the system. The interpretation of this principle in quantum mechanics is so radically different from its interpretation in classical physics that many theorists hold that the glaring anomalies of quantum theory, the Einstein-Podolsky-Rosen paradox, the Schrödinger "cat paradox," the paradox of "Wigner's friend,"[17] stem from its superposition. Gudder[18] claimed not long ago that, in classical mechanics, mixtures can result from superposition, never a pure state, and that the so-called separable algebras lead to a similar result.

Many quantum physicists, untroubled by the subtleties of philosophy, seem content with relying on a crude fusion of von Neumann's language of "state vectors" and "wave packet collapse" and Bohr's language of "complementarity" and "correspondence." Hooker[15] explains that the interpretation of the "quantum mechanical state" varies in a disconcerting fashion according to the predilection of the writer. For some authors, it is a physical state of the individual system; for others, it is an ensemble state or synonymous with the probability measure itself. For still others, "state" is an elliptical phrase; it refers to the quantum mechanical lattice. Hooker concludes from his survey that quantum states are neither states of individual systems, as in classical particle mechanics, nor individual global states as in classical field theory.

Professor Jeffrey Bub[19] has proposed a radical solution of the quantum paradoxes. According to him, the logical space of micro-events is non-Boolean. Relativity theory showed that the problem of

the geometry of events cannot be solved *a priori*. Bub argues that the logic of probability is not *a priori* but empirical. To take the Hilbert space of quantum mechanics as a nonclassical logical space is more than an invitation to change our linguistic conventions, our rules of inference, or our scientific idiom. Logic, Bub maintains, is about the world and not about language.

One startling figure of "quantum logic" as expounded by Chen,[20] Deliyannis,[21] Finch,[22] Greechie and Gudder,[23] Gudder,[18,24–26] Horst,[27] Jadczyk,[28] Mittelstaedt,[29] Moroz,[30] Maçzyński,[31] Holger Neumann,[32] and Stolz[33] is that, in its framework, the conditional "p implies q," "$p \rightarrow q$," can no longer be defined. It can be proved that every implicative lattice is distributive and that the distributive law is not unconditionally valid in quantum mechanics.[17] Jauch and Piron[34] contend that adaptations of von Weizsäcker's infinitely-many-valued logic and Lewis's logic of "strict implication" are also unsatisfactory in quantum mechanics. G. Ludwig[35] distinguishes carefully the mathematics of quantum mechanics from the domain of reality *(Wirklichkeitsbereich)*. There is a mapping of the first into the second *(Anwendungsvorschrift)*. Ludwig concludes that what is "physically meaningful" in the smaller theory may not be so in the larger theory. Karl Popper[36] has questioned the presumed non-Boolean character of quantum lattices. But Jauch and Piron,[34] in their rejoinder, claim that Popper comes nowhere near the operational terms of the von Neumann–Birkhoff interpretation. J. S. Bell and his co-workers have struck a blow at most versions of the "hidden variables" theory.[24]

SECTION III

During the last decade there has been a considerable interest in the axiomatic development of the concepts of information and entropy. Shannon's original axioms for informational entropy have been replaced by newer conditions.[16] Rényi has resorted to the concept of generalized probability distributions. Ingarden and Urbanik,[37] De Fériet and Forte,[38] and Forte and Pintacuda[39] have provided axiomatic definitions of information without using probability measures. Kolmogorov[40] showed that the basic information-theoretic concept can be formulated without recourse to probability theory. P. Weiss[41] gave an axiomatic interpretation of subjective information which was almost identical with the subjective probability of Raiffa *et al.*[42] and the "utility" of L. J. Savage.[43] Yet, as is evident from a recent axiomatic treatment of information by Zoltan Domotor,[44] all these theoretical developments have been confined to a Boolean

framework. Ingarden and Urbanik need to assume for their definition of entropy a sufficiently large pseudometric space of finite Boolean rings. Kolmogorov uses the concept of a recursive function. Little attempt has been made to develop a non-Boolean theory of information applicable to quantum mechanics.

The efforts made to extend the usual probability and information to quantum mechanics stop short of the real problem. C. D. Cushen and R. L. Hudson[45] seek a quantum mechanical counterpart of the Central Limit Theorem of classical statistics. Paul Benioff[46] considers how far we can go with the decision procedures of decision theory in quantum mechanics. Fritz Baumann,[47] in a special monograph, sets out from entropy regarded as a measure of "ignorance." He notes the convexity of the skew information of Wigner and Yanase but is content with the usual interpretation of the tensor product Hilbert space. He makes no attempt to prove the Robinson-Ruelle conjecture about conditional entropies in quantum mechanics. Even the implications of classical ergodicity for quantum mechanics are far from clear.[48]

Danieri, Loinger, and Prosperi have tried to formulate a relation between statistical mechanics and the quantum theory of measurement by using the idea that the "collapse of the wave packet" may result from an increase of information or an irreversible process involved in measurement. They set out from the premise that quantum mechanics describes a microsystem only through its interaction with a macrosystem.[49] Wigner[1] remarks that, in these theories, the terms "classical description" and "macrosystem" are nowhere defined. The examples of laser action and superconductivity current may be regarded as macroscopic quantum effects. Professor Bub has also commented on the Danieri-Loinger-Prosperi dualism of "microscopic" and "macroscopic."[49]

Quantum mechanics suggests that there are radical limits to our conception of the logical space of events as Boolean. Parapsychology suggests that organisms acquire information in ways not warranted by current theories of information regarded as the negative of entropy. The breakdown of the classical logic of connectivity in our scientific description of the world is of strategic importance for some novel and radical reassessment of the status of life and consciousness in the universe.

One of the reasons assigned by responsible parapsychologists like John Beloff[50] for the highly controversial status of the psi domain of research is "the lack of a coherent theory of psi." What are the requirements of theory in a revolutionary domain? Scientific

theories have often been regarded as complex universal generalizations to be validated by generally accepted logical and empirical techniques of verification. I have pointed out elsewhere[5] that T. S. Kuhn's work on "scientific revolutions" indicates that our criteria for adopting very general scientific theories may be quite different from those for our accepting simpler generalizations and limited empirical hypotheses. It may seem bad science to decide which hypothesis to accept and then to evaluate evidence concerning the hypothesis in the light of the hypothesis itself. But is this not just what many orthodox scientists seem to be doing when they reject psi imperiously in the name of the scientific "world-view"? P. W. Bridgman has said that parapsychology is the only domain of research in which the supporting considerations are wholly statistical and probabilistic. But the crux of quantum mechanics surely lies in its statistics and probability concepts. On a certain interpretation of "subjective probability," possibly of relevance to parapsychology, we may be able to change some very general beliefs about the universe only retroactively, so to speak, after seeing to what further beliefs they lead.[51] There is far too great a divergence of standpoints, solutions, and approaches in the current logic of empirical theories for us to complacently dismiss parapsychology as a minor scientific aberration. Model theories have been largely confined, I suspect, to elementary (first-order) calculi. The semantics of quantum mechanics and parapsychology calls for more elaborate considerations. A new concept of "biological information" is a minimal demand if we decide to go far enough with our parapsychological research.

Note added in proof: Since submitting my paper, and the supplementary note commenting, *inter alia,* on Professor Feinberg's theory, I have come across the report of an experiment conducted by R. B. Partridge ["Absorber theory of radiation and the future of the universe," Nature **244,** 263 (1973)] to test the "advanced effects" posited by the Wheeler-Feynman "absorber theory" of radiation. Partridge moots the hypothesis that, in all open, ever-expanding cosmological models, one would expect less than complete absorption along a future cone. He argues that "advanced effects" of at least 1 in 10^8 parts should be detectable. The experiment yielded a completely null result. Partridge concludes: "It seems either that the analysis in terms of the Wheeler-Feynman theory is incorrect or that absorption along the future cone is complete to better than one part in 10^8." A later note by D. T. Pegg ["Effect of a local absorber in absorber theory," Nature: Physical Science **246,** 40 (1973)] would seem to suggest that, with a static, local absorber, "advanced effects"

and "retarded effects" will inevitably cancel out. We seem to be as far off as ever from any solution of the precognition problem along these experimental lines.

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DISCUSSION

ANGOFF: Our discussion period is naturally a little different this time. We would be glad to have your observations on Dr. Chari's paper. We shall send these observations to him, and he will perhaps have his own observations on your observations. Are there any comments on the paper by Dr. Chari?

TARG: I'd like to inquire how his theory of a psi informational network could be tested? The falsification of a theory is essential for the theory itself to have any meaning. From listening to the presentation I get the idea that Chari says it's not a contradiction to say that there are psi phenomena. But I don't know what could be done specifically to test the requirements to show by experiment that what he says is true.

BASTIN: I don't even know what the theory is yet, so I certainly would not be able to know whether it was true. I don't know if anybody has an idea what the connection is between this new logic he wants—if that is what he's saying—and the informational network?

PUTHOFF: He is saying that the psi informational network that he hypothesizes is a channel above and beyond those that we're used to. It connects all elements of space-time basically with an organism.

He is also not saying that any given stimulus causes a particular response. Rather he hypothesizes that in a given situation there's an integration of inputs, in some unusual sense, to produce a given response in the organism. And I think that's as far as he goes. He really doesn't get into what the logical requirements are and hasn't formulated the logical resources.

Now, in response to Russell Targ's question about testing the theory, it seems to me the only way to test whether his information network is required, as opposed to, say, the models that Gerald Feinberg mentioned, would be to set up an experiment in which all other theories were negated. This would be a very difficult thing to do. But I think

other theories can one by one be specifically negated in the sense that Gerald Feinberg described. For example, if an individual precognized something that he never gets information about, that aspect is negated. Then you could set up similar tests for other theories. Basically, the only way to say his theory is true would be if all competing theories were negated. So, I don't actually think there is a way specifically to test and negate his theory. In that sense it doesn't satisfy the usual requirements. However, this is what you'd be forced to as an end result, if all other channels were eliminated.

FIRSOFF: However, I can see his chief objection is to the principle of the excluded middle—that there must be a yes or no answer to every question. But in most cases there are in fact intermediate answers, and finally, any theory is only serviceable in *Popperian* terms: it is neither true nor false. It may be more serviceable or less serviceable. In other words, it includes a margin of uncertainty, describes events up to a certain point, but not beyond it.

WHITEMAN: I would like to make a few remarks on my personal reactions to attempts to apply information theory to this subject. I think we should consider very carefully the basis of our thinking when we try to apply a theory of this very formal and mechanistic character to a subject so vital and all-embracing as parapsychology. It seems to me, in particular, that the theory of "bits" suffers from the same defects as Bertrand Russell's theory of atomic facts, atomic logic, and so on, which he himself found it necessary to abandon later.

A procedure of this kind, which attempts to divide up the whole of life, its operations and effects into atomic facts may seem necessary for clear-cut logic. But powerful movements of thought had already come in which showed that life cannot be reduced in this way. These movements of thought began with Gestalt psychology, Husserl's phenomenology, and group theory in mathematics, and are now seen also in structuralism applied to educational theory and anthropology.

All these theories are distinguished from information theory by the fact that they recognize that the atomic approach is inadequate and misleading.

A brief illustration from geometry may help to show how I think the situation should be conceived. Geometry is not, these days, presented on an axiomatic basis, because this is logically unsound. The very first axioms must go back to undefined terms, and the attempt to set down a linear development of isolated features leaves the real nature of a straight line, for instance, in the air. Since the Erlangen

program of Klein in 1872 it has been recognized that geometry is based on groups, so that, for instance, rotations and translations are all logically interconnected, and we cannot mention one of these without implying the whole set.

As we know, this idea of wholeness is quite indispensable in quantum theory. One cannot deal with quantum theory on the basis of atomic facts, if only because the entire field of potentialities is involved in each actualization.

I said I would present my personal viewpoint. This is that parapsychology is a living subject, which touches on every level of our being, intention, will, perception, the subconscious, past, present, and future. Its phenomena manifest a complete life state involving other life states, and this seems to be just the sort of thing that information theory is incompetent to handle.

PUTHOFF: I'd like to direct a question to Harris Walker. Do your C_i's, your hidden variables, correspond to Dr. Chari's idea of a psi channel that is not accounted for in regular statistics and physics?

WALKER: I really would have to look over this in detail. Dr. Chari's prior paper on psi phenomena and quantum mechanics stated flatly that psi phenomena could not be accounted for within the framework of quantum theory.

PUTHOFF: I wonder if you specifically see the hidden variables playing a role?

WALKER: Yes, to some extent I see this. But, in addition, I don't by any means see the need to abandon quantum mechanics, which has been so terribly successful.

You must reach an accord with physics. By introducing hidden variables, I'm doing something which accounts for the data of psi phenomena and which is achieved without going to the extreme of saying that we must supplant so much of ordinary physics.

The holistic approach is a tack that one advocates when one encounters difficulties in achieving an analytic solution to physical problems. Analysis is a very very difficult sort of route to follow, but I think that it's the proper route. All the success in physics suggests that we simply cannot abandon the analytic approach and propose an entirely new basis, a verbal basis; certainly, we cannot do that until we can evidence some hope that it will produce as high a level of achievement as in all the rest of physics. I don't think that such an approach will be successful. I think we have to find an approach that is compatible with physics, and this is why I have taken the particular

path I have presented here, a path that employs the previously proposed hidden variables. The proposal both resolves difficulties in conventional physics and gives us a basis for treating psi phenomena quantitatively.

Yes, I do feel that the hidden variables as I'm using them are very similar to what he would like to have introduced.

BEAUREGARD: I wish to bring up some matters which I believe to be important and very relevant to parapsychology. These pertain to probability as applied, for instance, to statistical mechanics and other fields.

Probability theory is practically always used for blind statistical prediction (using Watanabe's terminology). However, it could logically be used just as well for blind statistical retrodiction. Let me explain this by an example. Suppose you have a collection of excited atoms that can decay. If you use probability calculus blindly in prediction, this will yield the exponential decay law, e^{-at}. But logically it could just as well be blindly applied statistically in retrodiction, yielding the very paradoxical result of an exponential building up, e^{+at}. Generally speaking, the retrodiction problem is termed, in the classical probability calculus, the *problem of probability of causes*. In physics, when discussing retrodictive problems, it is common to use Bayes's conditional probability rule. But one is not logically obliged to do so, and it is conceivable that *anti*physical phenomena exist which build up according to the law e^{+at}. I believe this *anti*probability calculus (where blind statistical retrodiction is applied) is very relevant to such phenomena as precognition and psychokinesis. (Incidentally, I believe that there is no clear-cut difference between precognition and psychokinesis, but they are two distinct aspects of the same phenomenon.)

I think that these matters are very relevant to the problems of which you are speaking. They are also pertinent to those large-scale connections in space-time which may be explained by using simultaneously retarded and advanced waves, because blind statistical retrodiction uses advanced waves at the quantum level.

I will stop here. For I have often discussed these questions, for instance, in two congresses of thermodynamics (Pittsburgh, 1969 and Cardiff, 1970).

FEINBERG: I would like to ask you to go into a little more detail about using probability for retrodiction and getting an exponential buildup.

BEAUREGARD: Well, it is a very obvious logical possibility. Let us suppose there is a set of excited atoms which ordinary physics

predicts will decay in the future. There is nothing in mathematical rules which prevents us from conceiving that the set has built up in the last instance according to the law $e^{+\alpha t}$. Then, instead of having initially a source of decaying atoms, one would have in the future a sink of excited atoms which have been called up from the past.

This goes very much in the direction of your switching of the light bulb this morning.

FEINBERG: Then one would introduce something coming in from infinity to excite the atoms.

BEAUREGARD: Of course. But you must not think of that causalistically, that is, from past to future, but rather finalistically, that is, from future to past. It is the space-time analogue of what is known in hydrodynamics as a *sink*. We must not think of the wave as having been emitted from the past, but rather as being absorbed in the future.

FEINBERG: Nevertheless the external stimulus occurs. Whereas in the case of extrapolating into the future, you do not introduce an external stimulus.

BEAUREGARD: It is an *antistimulus* located in the future, and not a stimulus located in the past.

FEINBERG: Well, that's another way of describing it. But physically it's the same, in the sense that if you surround these atoms by a large collection of detectors at some distance away, then you could have in the past detected this impulse coming in, which is going to excite the atoms.

BEAUREGARD: Yes.

FEINBERG: Just as when the atoms decay in the future, you can observe in principle, I don't say in practice, the decay products by surrounding the atoms with a large detector and observing them as they come off. So the physical situations are also in some sense different. You would say, it was not different, because you do not want the atoms to spontaneously build up without anything having happened to them. That would violate real physics.

BEAUREGARD: Well, I do want to violate physics at this point. It is *anti*physics, using a *reversed irreversibility principle*. It is the *anti-Carnot world* which has been discussed by so many people in the 19th century. It involves returning the arrow of the second law of thermodynamics.

FEINBERG: There are people who maintain that this will happen when the universe stops expanding and starts contracting.

BEAUREGARD: Yes, I truly do believe that these two possibilities must be considered symmetrically. I will speak of that in my lecture this afternoon. This sort of symmetry argument has for instance led to the discovery of the positron, which is *de jure* symmetric to the ordinary electron, although much rarer. So I do believe—and this goes in your direction—that advanced waves are *de jure* completely symmetrical to retarded waves. In fact they are rarer, that's all.

FIRSOFF: There is a somewhat similar problem in astronomy, where one may have an extended mass of hydrogen gas at a uniform density and temperature. Theoretically, it could stay that way forever. But statistically, every combination of emission by the atoms in it must occur. Let us then suppose that a certain group of atoms in one part of this extended cloud of gas emits. As this emission is absorbed, the surrounding gas will begin to expand, and you will have a widening circle of increased density. This will lead eventually in the fullness of time to the creation of a new galaxy. It is a very similar situation.

BASTIN: Could I go back to a point made by Professor Whiteman? He suggested that information-theoretic concepts are in principle incapable of dealing with parapsychology, because they fail to grasp the holistic characteristic of things. Now, this seems to me to be rather making a jump. It seems to me that the information-theoretic concepts —although not everyone will agree with this—fail, or don't get us very far, because the basic analogies there are too feeble. The theory is based ultimately on the concept of the telephone line transmitting a linear sequence of signals. Development of the theory from that model is a bit tenuous, and one always really returns to the analogy. It seems to me it doesn't contain the necessary material, whatever the necessary material is, for a real rich theory of parapsychology.

However, I do not think it is inadequate because it is not holistic. After all, if you're going to deal with wholes and you're going to talk about them, you've got to talk about them while dividing them into parts and discussing how the parts interrelate to form wholes. That seems to me to be a logical necessity anyway.

WHITEMAN: I agree very much with what Dr. Bastin has said. I would not say that the information approach is totally unsuitable for parapsychology. Obviously, there are kinds of information that parapsychology supplies which can be suitably dealt with in this linearistic, item by item manner. For instance, one must list the components of

the state vector linearly, if they happen to be discrete. It seems to me, however, that what we should focus our attention on chiefly in parapsychology in relation to quantum theory is the act of observation. Here lie the problems which loom so large in both subjects.

Now, in quantum theory, the observation is a holistic effect, involving the whole environment, even to infinity. What is actually observed at any point is quite undetermined unless we take into allowance every detail of the boundary conditions at the moment of observation.

This same principle of wholeness comes in parapsychological observation, since this is also the actualization of potentialities. If we have the vision of a precognitive scene, what we see is a whole spatial field, with Pythagoras's theorem and other results of geometry applying because of the logic that underlies all these presentations. Everything that appears rests on this pervasive logic of interlocking conceptual operations.

At the same time, I am very ready to say—and I attempt to show it in my paper—that behind the scenes there are sets of discrete elements that make the logic clear-cut, and from these discrete elements we can pass to continuity, rather in the same way as we pass from the sequence of rational numbers to the mathematical continuum. This also is a possibility of logic.

PUTHOFF: I want to address a question to Professor Beauregard, who mentioned that he considered psychokinesis and precognition to be related. There may be a difference between the two, as well as between small and large events. For example, if a subject looks at the output of a strip chart recorder, and says, "I'm going to produce an event now," and then you see a pulse on the recorder, it's not clear for a small event whether he just precognized the appearance of a noise signal, which he then would take credit for in advance. But would you say that this still holds for large PK events, where something happens which you ordinarily would not expect to happen? For example, the bending of a spoon? If one is sitting around waiting for spoons to bend, of course, one could just precognize the fact that one was going to bend, and therefore take advantage of the situation. Does your idea still hold for large events?

BEAUREGARD: I don't think so. I really was not thinking either of spoon bending, or of very detailed prophecy, as Professor Whiteman was speaking of this morning. It seems that psychokinesis and precognition are coincident only in small events.