From Quantum theory to Quantum theology: A leap of faith

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Abstract
This article is aimed at introducing multivalued logic as an epistemic model for theological thought within the reformational-dialectic paradigm. Nowadays, reformational-dialectic theology is challenged by postmodern culture, interreligious exposure and scientific discoveries, which subsequently lead to new and unaccounted world-views. As a result, an epistemological shift based on an expanded rationality is called for. It is in this regard that multivalued logic emerges as an epistemic model specifically developed to accommodate diversity, uncertainty and probability as well as, to restore hope and faith in the hearts of millions.

1. INTRODUCTION

The basic assumption of this article is the paradigmatic shift from modernity to postmodernity, with all its accompanying presuppositions (cf Schoeman 1990; Van Aarde 1990). Postmodernity has already influenced both theology and science perceptibly, not only respectively but also interactively (cf the theological interpretations and applications of quantum theory by Drees 1991; Ammer 1992; Van der Lubbe et al 1992; Wasserman 1992). Furthermore, our world-view is inevitably influenced by our picture of the universe and our corresponding interpretation of reality (cf Martin 1987; Van Arkel 1988; Hawking 1988; Pannenberg 1991). During the first half of this century scientific discoveries were made that would change our world-view dramatically, especially the special and general relativity theories and[1] quantum theory. The change from classical physics to new or quantum physics has been clearly illustrated (cf Hawking 1988; Penrose 1989; Polkinghorne 1989; Lucas 1992), although numerous traces of classical physics are still evident in science and theology (cf Van Aarde 1988:61; Vorster 1988:45; Penrose 1989:167). In this paper I expriment with multivalued logic

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as a postmodern interpretation of quantum mechanics, and its application in contemporary theology. First of all, though, it is necessary to briefly review the road that led to a quantum world-view.

2. OUR QUANTUM WORLD

2.1 Newtonian legacy

Brown describes the period of classical physics as follows:

> The age of reason brought with it the giants of scientific thought who laid the groundwork for classical physics. Copernicus, Bruno, Kepler, Descartes and Galileo provided Isaac Newton with all he needed to explain motion in the universe. The astounding discovery that a multitude of physical facts could be explained by a few mathematical equations helped to reclassify the age of reason as the age of certainty.
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> It was not long before a mechanical philosophy of the universe dominated scientific thought. The universe, once unknown and capricious, became a huge clock ticking along inexorably. Every event was easily explained as a combination of known forces. If an event seemed out of the ordinary, the discovery of more facts held the answer to a complete explanation.
>
> (Brown 1990:478)

Clarity of description, reductionism and a relentless determinism was the hallmark of Newtonian physics[1]. Even the more ambiguous nonphysical world (history, psychiatry, theology) was couched in terms of extreme determinism and the notion that truth was based upon unchangeable absolutes. Van Arkel (1988:223) asserts that we do not always recognise how profoundly our present theologising is influenced by this line of thought.

Brown (1990:479) summarised the basic assumptions of classical physics as follows:

> (1) objective realism — observed phenomena are caused by a physical world that exists independent of human observation; (2) physical sufficiency — each act of motion or change in the universe can be explained by an analysis of all of the physical factors involved; (3) inductive validity — drawing inferences from consistent observations is a valid means of obtaining knowledge; (4) upper limit — no influence of any kind can be made faster than the speed of light.

In a sense Einstein's work can be considered the transition between classical and quantum physics. Although his findings were based upon the notion of fixed natural laws, he also opened the door to a new world of uncertain, elusive qualities.

2.2 Quantum physics

Newton's laws of motion put an end to the idea of absolute position in space[2]. He was very concerned by this lack of absolute position, because it did not accord with his idea of an absolute God (Hawking 1988:18) and the philosophical belief in absolute truths.

In 1915, Einstein's theory of relativity changed the concept of absolute time[3]. The remarkable consequences of this theory however, were not fully understood until a few years later. Where space and time were previously thought of as fixed values, they were now dynamic quantities: when a body moves, or a force acts, it affects the curvature of space and time, and in turn the structure of space-time affects the way in which bodies move and forces act. Space and time not only affect, but are also affected by everything that happens in the universe (Hawking 1988:33).

Max Planck's quantum hypothesis[4] was the first indication that the inexorable determinism of classical physics had to be abandoned. Again, the implications of this hypothesis were not realised until 1926 when Werner Heisenberg formulated his famous uncertainty principle[5]. Particles no longer had separate, well-defined positions and velocities that could be observed; they had a quantum state, a combination of position and velocity. The uncertainty principle held profound implications for the way in which we view the world: 'In general, quantum mechanics does not predict a single definite result for an observation. Instead, it predicts a number of different possible outcomes and tells us how likely each of these is' (Hawking 1988:55). Polkinghorne (1989:44) comments correspondingly: 'Instead of the clarity and precision of Newtonian mechanics, we have to be content with a more fuzzy account of affairs'.

As scientists continued to explore the vast complexities of the subatomic world, more startling discoveries were made. Even the idea of an external world that can be objectified, observed and measured without changing it, had to be abandoned. According to quantum mechanics it is not possible to observe reality without altering what you see. From now on the subject would play an inseparable part in his/her relationship with reality. One can never be exactly sure of both the position and the velocity of a particle. The more accurate one measures or knows the position of a particle, the less accurate one can know the other and *vice versa*. Another interesting concept in quantum mechanics is that there is no distinction between waves and particles; particles may sometimes behave as waves and waves as particles, the so-called wave/particle duality[6]. The most interesting part of this concept, however, is that the state of the particle or wave is determined by the observer. If you look for particles, you find particle-like qualities, and if you look for waves, you find wave-like qualities (Polkinghorne 1989:60). The Schrödinger equation[7] is another example: everything can be smooth and in continuity, until you try to extract some information by means of a measurement. The moment you intervene with a measurement, the traumatic discontinuity of the collapse of the wavepacket takes place. These and other similar examples have led some interpreters to believe that human consciousness affects the nature of reality and that it even plays a part in creating reality (Polkinghorne 1989:60-69).

The mysteries and puzzles of our quantum world are numerous (cf Penrose 1989: 225-301). For the purpose of this paper I will confine myself to one more. In 1935 the EPR-experiment[8] was conducted. The name comes from the first letters of its authors, Einstein, Podolsky, Rosen. The experiment suggests that certain events are connected, even though they do not physically interact and are quite some distance apart. An instantaneous connection between particles is formed, that travels faster than light (the concept of nonlocality). In conflict with Einstein's general relativity theory, according to which nothing can travel faster than the speed of light, the theory suggests an influence between two particles that are not within each other's reach. 'What happens at one place has got something to do with what happens at the same moment at some distant place' (Sharpe 1992:138).

Lucas (1992:18) illustrated that the EPR-experiment can be used to demonstrate the single, interconnected wholeness of the universe. Martin (1987:370) argues that twentieth century revolutions in, among others, physics and cosmology, signify a basic shift from a mechanical (Newtonian) to a holistic (quantum) paradigm, a thirst for a renewed sense of the whole. Allen Utke (1986:137-141) illustrates the theory of relativity and quantum theory to be the two main contributors to the cosmic holism concept. The connotation between quantum theory and holism is evident and specialist work within the holistic paradigm has been done (cf Van Aarde 1988; Vorster 1988; Van Arkel 1988). However, the way we interpret quantum theory most certainly will have an epistemological disposition on our theology.

3. INTERPRETATIONS

3.1 Bivalence vs Multivalence

Bivalence means two-valuedness, two ways to answer each question, true or false. Multivalence means three or more values, perhaps an infinite spectrum of options instead of two extremes only. Because of their explicit meanings, bivalence and multivalence can be categorised under the headings of mechanistic and holistic paradigms respectively. In this paper I argue that all the different interpretations of quantum theory can also be categorised under these two headings. I am convinced that there are many scientists who wish to explain the uncertainty and relativity of quantum theory in terms of a bivalent world, using the bivalent epistemology of our Newtonian legacy — an interpretation that trades accuracy for simplicity (Kosko 1994:21). All these interpretations will be listed as bivalent. Accordingly, there are also those scientists who find bivalent logic inadequate to describe and interpret the quantum uncertainties and therefore call for an epistemological shift. The latter are rather inclined to perceive quantum theory as a proof of a multivalued reality — an interpretation seeking more precision, a product more true to reality (Kosko 1994:34).

Polkinghorne describes two possible lines of attack: either a positivist or a realist tone, both of which use a bivalent epistemology. 'The positivist approach lays stress on perceptions which can be inter-subjectively agreed; its test of meaning and truth rely upon the specification of observable procedures ... the realist lays stress on the belief that the world has an existence independent of any observer ....'(Polkinghorne 1989: 78).

According to Brown (1990:482-484), three of the more popular interpretations are (1) the positivistic view (we create our own reality), (2) the view of a finite theism (a theory about a god with limited power), both which are bivalent, and (3) a pantheistic view (the universe as an undivided whole, seen through the eyes of eastern mysticism), which is multivalent. The multivalent interpretation, however, also opens the possibility for a Christian world-view and I therefore continue my experiment.

4. MULTIVALUED REALITY

4.1 Multivalued logic

In the 1930s logicians like Jan Lukasiewicz, Bertrand Russell and Max Black conceived multivalued logic to deal with Heisenberg's uncertainty principle and quantum mechanics. It was postulated that all things cannot be measured simultaneously with equal precision. To be precise in an uncertain world means being flexible and adaptable. The principle of multivalued logic determines that indeterminacy defines a continuum, an infinite spectrum of options between falsehood and truth, therefore everything is a matter of degree (Kosko 1994:19). Everything is true and false to some degree. Bivalent logic says everything is true or false, *A or not-A*, you lie or you don't lie, a person is tall or not-tall. Bivalent logic is exact, all or none, there is no overlap, there are exact boundaries, a world of rounded-off simplicity, but it doesn't match reality. The world we live in, however, is one of partial values, blurred boundaries, of *A and not-A*. A cup is both half full and half empty, a person is both tall and not-tall, all to a certain degree.

4.2 Fuzzy sets

In 1965, Lofti Zadeh applied the term *fuzzy logic* to his work on multivalued logic[9]. 'Fuzzy logic, as its name suggests, is the logic underlying modes of reasoning which are approximate rather than exact. The importance of fuzzy logic derives from the fact that most modes of human reasoning — and especially commonsense reasoning — are approximate in nature' (Zadeh 1992:2). According to his fuzzy set theory almost all properties are fuzzy sets and elements belong to sets to different degrees. In mathematical terms a fuzzy set contains its elements to a certain degree. In the same way properties like tallness, redness and happiness belong to their sets to a certain extent and thus define fuzzy sets. A person is not tall *or* not-tall, but tall *and* not-tall to a certain degree (Kosko 1994:292). The sky is not blue *or* not-blue, but to a certain extent blue *and* not-blue. Fuzzy sets don't draw hard boundary lines, but draw curves between A's and not-A's. Fuzzy sets also give linguistic calculus's. Modifiers in front of a set raise or lower a curve[10]. The modifier *very* in front of the set *tall* lowers the curve, while the modifier *more* or less in front of the set *tall* raises the curve (Kosko 1994:146). Where the hard lines of bivalent logic are unable to explain the shift from tall to not-tall, the fuzzy curve shows the smooth change, thus exploring possibilities of coming closer to reality.

> The conventional approaches to knowledge representation lack the means of representing the meaning of fuzzy concepts. As a consequence, the approaches based on first order logic and classical probability theory do not provide an appropriate conceptual framework for dealing with the representation of commonsense knowledge, since such knowledge is by its nature both lexically imprecise and noncategorical. The development of fuzzy logic was motivated in large measure by the need for a conceptual framework which can address the issues of uncertainty and lexical imprecision.
>
> (Zadeh 1992:2)

When fuzzy set theory is applied to theological terms, it opens an infinite spectrum of options, thus broadening the rationality behind our understanding of theology.

> The problem of the shaping of rationality in theology to a great extent centres on the possible role of explanatory justification in theological thought and will therefore eventually force us to address the difficult

> epistemological issues of degrees of truth and the objectivity — if any! — of our statements .... Rationality as such is complex, many-sided, extensive and as wide-ranging as the domain of intelligence itself.
>
> (Van Huyssteen 1993:436)

In this sense fuzzy logic moves beyond a fundamentalistic, relativistic and even dialectic understanding of theology. Knowledge is interpreted as a collection of elastic, or equivalently, fuzzy constraints on a collection of variables. Accordingly, inference is viewed as a process of propagation of elastic constraints (Zadeh 1992:2). The rejection of the biblical literalism of foundationalism, and of the relativism associated with non-foundationalism, subsequently lead to the development of a postfoundationalist model of rationality (Van Huyssteen 1996:111). It is within this model with its appreciation for interdisciplinary discussion, intersubjective discussion and an experiential epistemology that the multivalued reality can find expression in our theological reflection. 'A postfoundationalist notion of rationality ... honors the provisional, contextual and fallibilist nature of all human knowledge while at the same time enabling us to retain our ideals of truth, objectivity, rationality and progress' (Van Huyssteen 1996:123). Personal understanding, personal experience and personal commitment become values shaping the rationality of religion, and it is in fact this diversity of personal values that are represented in fuzzy sets. The divine will of God and human freedom, viewed as fuzzy sets, open up an unlimited possible understanding between the two extremes of complete determinism and absolute human freedom. There is no hard line drawn between God's grace and his wrath, but a curve which indicates the smooth change. In Christian ethics one is not right or wrong, but right to some degree, and wrong to some degree.

5. EPISTEMOLOGICAL SHIFT

In another recent article, Van Huyssteen (1993:430) emphasized the importance of searching for an epistemological relation between theology and science: 'There is no way that we could be content with a plurality of unrelated languages if they are in fact languages about the same world — especially if we are seeking a coherent interpretation of all experience'. According to him the basic epistemological questions should therefore explore the nature and status of explanations and of explanatory claims in both theology and science, and he warns against the epistemological fallacy of directly inferring from contemporary science to theological doctrine (for example from Big Bang to creation, from field theory to Spirit of God or from omega point theory to eschatology — cf Tipler 1994 and Clifton 1990; also see Sharpe 1992:140 on scientific limitations). In an attempt to find a plausible epistemological model for this complex issue, we examine scientific claims to knowledge with regard to the bivalent and multi-valued logic models.

The value of bivalence lies in its simplicity and the fact that works. However, in the process it has to trade accuracy for simplicity. It is much easier to work with binary outcomes of A or not-A, yes or no, black or white, true or false, clearly defined propositions or terms, but bivalence requires some forced fitting and rounding-off. 'The Information Age rests on bivalence because it rests on the *digital revolution* in signal processing and microprocessor computer chips. We measure quantities ... that change smoothly with time. But we must sample and quantize, or round off, these signals to fit them into a computer's binary mind of 1's and 0's' (Kosko 1994:18). Information also enables us to form a picture of reality. Whether it is information gathered through our normal senses or through expanded senses (telescopes, microscopes et cetera), or through whatever specialised method of gaining information, it shapes our picture of reality. The irony, once again, is that the more information we gather, the clearer and more accurate our picture becomes. However, the more accuracy increases, the more fuzziness creeps into the picture as well.

> As the complexity of a system increases, our ability to make precise and significant statements about its behaviour diminishes until a threshold is reached beyond which precision and significance (or relevance) become almost mutually exclusive characteristics .... A corollary principle may be stated succinctly as, 'The closer one looks at a real-world problem, the fuzzier becomes its solution'.
>
> (Zadeh, in Kosko 1994:148)

Information seems to demarcate the grey areas. Hard lines can not be drawn. The more accurate one wants to draw the line, the more borders seem to blur and fade into each other (cf Pekala 1992 and Novák 1992 on the margin of uncertainty and vagueness accompanying knowledge). Bivalence, however, requires the drawing of hard lines, but nobody (except a few extremists) are prepared to do it. The result is a *floating hard boundary* (Kosko 1994:152), which is just as unacceptable to the prophets of bivalence and often the very reason for fighting among themselves. Philosopher of science Willard Van Orman Quine (in Kosko 1994:152) explains as follows: 'If the term table is to be reconciled with bivalence, we must posit an exact demarcation, exact to the last molecule, even though we cannot specify it. We must hold that there are physical objects, coincident except for one molecule, such that one is a table and the other is not'.

Bivalence is inconsistent in the way that it does not match reality. Bivalent theology would therefore be guilty of not living up to the call for relevance. Van Aarde (1995b:50) requests '... that there must be a certain mutual resemblance between everyday reality that confronts both church and theology, and the words and deeds preached by the church. In other words, the church must conduct itself in such a way that it is clearly evident to all people that it proclaims and acts in the light of, and with regard to the demands of everyday life' (own translation).

Multivalence, on the other hand, draws a fuzzy curve to show the smooth change from A into not-A. This interpretation claims to be more accurate (no artificial forced fitting or rounding-off was needed) than a hard line (floating or not), more true to reality and therefore more relevant (cf Van Aarde 1995b:50). Fuzzy curves can even be shaped to specific needs: in matters that appear to be not so multivalent, some regions can be kept 100% A and other regions can be kept 100% not-A. Instead of a hard line between A and not-A, a ramp can be drawn which will indicate that the change is not so smooth (the steeper the ramp, the less fuzzy the term).

In binary logic the answer to any problem is either A or not-A. In dialectic thought an alternative was found which proved to be of great success. Within the epistemic dialectic scheme, not only A *or* not-A, but also A *and* not-A could hold. Two supposedly contradicting terms could be placed next to each other, on top of each other, within each other (depending on your point of view), without the one being devoured by the other or without the one excluding the other. 'Dialectic thought ... is a way of practising theology whereby acknowledgement is given to the insight that no fundamental truth can be embraced or comprised in a single phrase' (own translation — Van Aarde 1995b:41). He further claims (Van Aarde 1995a:24, 26) that it was indeed dialectical theology that *introduced* us to the postmodern paradigm, and that it will be dialectical theology that can *lead us through* this paradigm. What is needed, however, is a broadening and expanding of our dialectical thought (Bosch 1991:353; Van Aarde 1995:26). It is in this sense that a multivalued understanding of reality can be perceived as a broadening and an exploration of dialectic epistemology. The dialectic tension between A and not-A is not removed, but divided into an infinite spectrum of options. In almost the same way that multivalence moved beyond probability[10], it has moved beyond dialectics — a position that is holistic in approach, vindicatory, upholding, but also enlarging and reconciliatory and one that gives new meaning to the object-subject scheme[11] (cf Bosch 1991:355). According to Martin, holistic hermeneutics will reveal at least the following three characteristics:

> (1) Each system employs an interactive epistemology embracing both subjectivity and objectivity in the hermeneutical process. Subjectivity and objectivity operate dialectically and together comprise a mind-system. (2) They employ a systemic structural analysis of an interpretative complexity comprising text, interpreters, context; all in their social, political and psychological reality. (3) They operate with a participating consciousness. This consciousness is manifested in acknowledging and working with the social-political realities.
>
> (Martin 1987:379)

A multivalued epistemological system is an open system, but not to the extend that *everything goes*. Within a postmodern paradigm, multivalued epistemology also means a selective departure from the modern paradigm (cf Van Aarde 1995:28). This also implies that the dialectic frame of mind is not abandoned, but broadened to accommodate more possible views. Such a scheme will thus always function between the two extremes of A and not-A. To prevent this stance from arbitrary and despotic outcomes, Kosko developed the *Fuzzy Approximation Theorem*[12] (Kosko 1994:167), a theore that works with weighted averages and proposes principles instead of rules or laws. Janusz Kacprzyk also made the connection with his theory on *soft degrees of consensus*[13] (Kacprzyk et al 1992:274). The difference, therefore, between rules and principles can be said as the difference between the letter and the spirit of the law. Rules are precise, black or white, and they have no or little exceptions. Principles are vague and full of exceptions, and they change slowly with time as culture evolves (Kosko 1994:178). Volumes of rules can thus be substituted with only a few principles. This is also known as the principle of deregulation. Correspondingly the exploitational and misfeasant nature (cf Van Aarde 1995a:19, 21, 28, 32) of the modern era can be substituted with a non-domination, non-paternalistic nature and tempered through commiserational and communal service. This is also known as the principle of decentralisation.

A multivalued epistemology must accommodate the meta-theories of interaction, complementarity, non-duality, wholeness and probability that Van Arkel (1988:225-228) pleads for, guarding against the foundationalism that Van Huyssteen (1993:433-436) warns against. Furthermore, it must take serious note of Van Aarde's (1995a:28) call for a cognitive, affective and pragmatic theology in one. This is an honest attempt to carry theology over the threshold of the twenty-first century.

6. QUANTUM THEOLOGY

'Rationality has to be expanded. One way of expanding it is to recognise that language cannot be absolutely accurate, that it is impossible finally to *define* either scientific laws or theological truths .... This recognition has led to a revaluation of the role of metaphor, myth, analogy, and the like, and to the rediscovery of the sense of mystery and enchantment' (Bosch 1991:353).

Metaphor, myth and analogous speech play a vital role in creating both scientific and theological theory: 'In fact, science can no more dispense with metaphorical thinking than can religion. The very nature of science depends on the use of metaphor to reinterpret old theories and create new ones .... In attempting to describe the unknown, the scientist must find terms that are intelligible, yet point beyond themselves' (Norris 1991:274).

The very nature of the metaphor makes it an indispensable conceptual tool in the shaping of rationality in science and theology:

> Metaphors are unique in their ability to shock and suggest by the juxtaposition of dissimilar entities, structures, or ideas. A metaphor is characterised by the surprise or *tension* it causes in the hearer. Metaphors suggest new meanings that may at first seem absurd; but upon further reflection they suggest a perception or an experience similar to one's own. One critical difference between symbolic and metaphorical statements is that the latter always contain the whisper, *it is and it is not.*
>
> (Norris 1991:274)

6.1 Metaphors as fuzzy sets

The epistemological status and nature of explanations and explanatory claims in science and theology as uncertain, tentative, suggestive and probable, reflect their metaphorical character. It is therefore expedient for metaphors to play a leading role in a postmodern *quantum theology* (cf Van Aarde 1995b). A multivalued theology, one that can accommodate an infinite number of options between A and not-A, will in turn also rely heavily on metaphors for expression. Metaphors can therefore be seen as fuzzy sets, a view that not only corresponds with their respective features, but also gives expanded possibilities for the use of metaphors. (Van Aarde 1995b illustrated the relation between metaphor, myth and analogy, and therefore I only refer to *metaphors* when indeed this interrelation is supposed.) Parables that function as extended metaphors can be seen as fuzzy systems (fuzzy systems relate fuzzy sets in the same way that sentences relate words, therefore a group of sentences containing fuzzy sets, provides a fuzzy system). This can also be seen as an expansion of rationality, opening new and exciting possibilities for the essence of being as searching for truth in our life *coram Deo*.

6.2 Ecumenical theology

A multivalued *quantum theology* has to regard ecumenical theology as a high priority. The very nature of its epistemology as provisional, propagates and proclaims to accommodate diversity, to *tolerate* diversity, to *overcome* diversity and to overcome the domination of one conviction over the other. Van Aarde (1995b:53) describes the goal of ecumenical theology as communion, *despite the* diversity, with the living God. In this sense, unity and communion will prevail regardless of diversity. It is not nestled in the structure of a *super church*, but rather in a faith that has the structure to accommodate, and the conduct of learning instead of condemning.

The multicultural diversity of the *global village* we inhabit calls for new momentum in the struggle for peace among world religions. The same principles mentioned above will naturally be of value in contemplating this issue. Therefore, dialogue between world religions does not aim at condoning religious blending (under which all religions would apostate their faith), but at finding mutual consent on common issues such as global responsibility for world peace, religious peace, ethics, interreligious dialogue, mutual respect, human well-being, social upliftment etcetera (cf Kung 1988, 1991). In this regard it is meaningful to look at the parameters proposed by Van Aarde (1995b: 54). Within the interreligious dialogue he perceives a theology that 1) attests to a reformational-dialectic perspective; 2) accepts the challenge of the global and plural postmodern culture; 3) maintains that God is the wholly-other and therefore works with a metaphorical Biblical theology; 4) does not take the value of the historical-Jesus research for granted, and 5) does not apostate the unique tenets of the Christian faith.

6.3 Ethics

In *quantum theology* the principle holds that no hard lines can be drawn. This relates to ethical issues as well. Again it does not mean that morals and ethics are disposed of, but simply calls for a revaluation and restructuring of the matters at hand. Each act of man is to some extent intentional *and* determined, ethical *and* non-ethical. People are to some degree right *and* to some degree not-right. Once again more information can be added, but the lines will blur into curves and black and white will shade into grey. This happens when ethical issues like abortion, euthanasia and extramarital relations are disputed. The line between life and non-life, for example, is not hard but a smooth fuzzy curve, just as the lines between life and death, adultery and non-adultery, et cetera. Everybody who objects, wishes to draw hard lines. Few however are prepared to take the step and fight for it, because bivalent logic does not match fact and it gets absurd in its consistency.

Between al this uncertainty, quantum theology still provides an answer. The dialectic principle holds that the answer is contained within the problem. Multivalued logic is a system developed to deal with uncertainty. It is therefore also a system capable of accommodating uncertainty. When dealing with ethical issues, among many others, principles will hold above rules. The principle of weighted averages, for example, and the principle of soft degrees of consensus, the principle of fuzzy approximation, and the Biblical principles of the love and remission of Jesus Christ, will all be found in perfect harmony as guidelines when contemplating ethical issues.

6.4 Social applications

Van Aarde (1995b:52) emphasised the social dimension of the Christian faith. In social and political matters the church has to proclaim and remind both itself and the world of the gospel of Jesus Christ. Theology, when venturing into the social and political dimensions of society, would therefore proclaim an assiduous and subservient attitude. Within the multicultural diversity of our *global village*, the appeal would be for tolerance and acceptance. Society will also be summoned to greater responsibility. Multi-valued *quantum theology* presupposes the decentralisation and deregulation principles — principles calling for a greater social responsibility awareness. In turn, the principle of soft degrees of consensus was developed for group decision making under fuzzy preferences with a fuzzy majority represented by linguistic quantifiers (Kacprzyk et al 1992:268), and will therefore have profound implications on our view of democracy. Could it be possible that quantum theology has taken the next step in reaching a common moral language in South-Africa? Not in the sense that everyone talks *the same,* but *within* a system that accommodates diversity (cf Smit 1995a; 1995b).

7. CONCLUSION

The basic assumption of fuzzy logic is the *mismatch* between binary/bivalent logic and reality. Binary logic depicts a world of true or false values with a hard line drawn in between, while quantum reality shows a world of jagged edges and quantities that vary smoothly. 'So far as the laws of mathematics refer to reality, they are not certain. And so far as they are certain, they do not refer to reality' (Albert Einstein quoted in Kosko 1994:3). Fuzzy logic is the product of the *mismatch problem.* During the last few years this underlying multivalued epistemology has been used with great success in engineering, computer science, electronic devices (from vacuum cleaners to rocket launchers), signal processing, neural networks and many others (cf Kosko 1994; Zadeh 1992; Yager 1992). The success of fuzzy logic can largely be ascribed to the simple fact that it works.

Multivalued epistemology has also proved to be applicable in the social sciences. With the dawning of postmodern culture on society our future appears uncertain, diverse and fuzzy, but multivalued logic provides a solution, a product that works — if only for the moment. Thus, for so long as the postmodern moment lasts in space-time, we have a product to work with, one that can turn uncertainty, diversity and probability into opportunity. At the same time, however, we have a product that has to face new encounters of a new age, build new bridges, accept new responsibilities and also new challenges. Among these is the challenge to assess the theological relevance of the interface between quantum physics and human consciousness (cf Basti 1992; Penrose 1994). With the reintroduction of the categories of contingency and unpredictability (cf Russell 1988; Hedman 1989; Pannenberg 1991), the notion of change — the belief that things can be different, that it doesn't have to be this way — are again recognised as both scientific, theological and sociological categories. This has, in the words of the late David Bosch (1991:356) '... creat[ed] almost boundless hope in the hearts of millions, particularly among the less privileged ... and at the same time giv[en] a new relevance to the Christian mission'.

End Notes

[1] With a specific law of force (such as the inverse square law of gravitation), the Newtonian scheme translates to a precise and determinate system of dynamical equations. If the positions, velocities, and masses of the various particles are specified at one time, then the positions and velocities (and their masses — these being taken to be *constant*) are mathematically determined for all later times. This form of *determinism*, as satisfied by the world of Newtonian mechanics, had (and still has) a profound influence on philosophical thought (the question of free will, human consciousness etc).

(Penrose 1989:167)

[2] The big difference between the ideas of Aristotle and those of Galileo and Newton is that Aristotle believed in a preferred state of rest, which any body would take up if it were not driven by some force or impulse ... [B]ut it follows from Newton's laws that there is no unique standard of rest ... [T]he lack of absolute standard of rest meant that one could not determine whether two events that took place at different times occurred in the same position in space ... one could not give an event an absolute position in space ... and there would be no reason to prefer one person's position to the other's.

(Hawking 1988:17)

[3] In 1905 Einstein postulated his special theory of relativity and explained that the speed of light appears the same to all observers and that nothing can travel faster than the speed of light. This theory, however, was inconsistent with the Newtonian theory of gravity: objects attracted each other with a force that depended on the distance between them. This meant that if one object is moved, the force would change instantaneously, instead of at a velocity below the speed of light.

In 1915, Einstein proposed his general theory of relativity. According to this theory gravity is not a force like other forces, but is a consequence of the fact that space-time is not flat (as had been previously assumed) but curved by the distribution of mass and energy in it. In general relativity bodies always follow straight lines in four-dimensional space-time, although they appear to us to move along curved paths in three-dimensional space. Light rays also follow geodesics (straight lines in curved space) in space-time and are bent by gravitational fields (Hawking 1988:28-31).

> Another prediction of general relativity is that time should appear to run slower near a massive body like the earth. This is because there is a relation between the energy of light and its frequency: the greater the energy, the higher the frequency. As light travels upward in the earth's gravitational field, it loses energy, and so its frequency goes down. (This means that the length of time between one wave crest and the next goes up). To someone high up, it would appear that everything down below was taking longer to happen .... In the theory of relativity there is no unique absolute time, but instead each individual has his own personal measure of time that depends on where he is and how he is moving.
>
> (Hawking 1988:33)

[4] In 1900, German scientist Max Planck suggested that electromagnetic waves (such as radio waves, light rays, X-rays etcetera) could not be emitted at an arbitrary rate from a hot body (such as a star), but only in certain packets he called quanta. 'Moreover, each quantum had a certain amount of energy that was greater the higher the frequency of the waves, so at a high enough frequency the emission of a single quantum would require more energy than was available. Thus the radiation at high frequencies would be reduced, and so the rate at which the body lost energy would be finite' (Hawking 1988:54).

[5] In order to predict the future position and velocity of a particle, one has to be able to measure its present position and velocity accurately. The obvious way to do this is to shine light on the particle. Some of the waves of light will be scattered by the particle and this will indicate its position. However, one will not be able to determine the position of the particle more accurately than the distance between the wave crests of light, so one needs to use light of a short wavelength in order to measure the position of the particle precisely. Now, by Planck's quantum hypothesis, one cannot use an arbitrary small amount of light; one has to use at least one quantum. This quantum will disturb the particle and change its velocity in a way that cannot be predicted. Moreover, the more accurately one measures the position, the shorter the wavelength of the light that one needs and hence the higher the energy of a single quantum. So the velocity of the particle will be disturbed by a larger amount. In other words, the more accurately you try

to measure the position of the particle, the less accurately you can measure it speed, and *vice versa* .... Heisenberg's uncertainty principle is a fundamental, inescapable property of the world.

(Hawking 1988:54)

6 Although light is made up of waves, Planck's quantum hypothesis tells us that in some ways it behaves as if it were composed of particles: it can be emitted or absorbed only in packets, or quanta. Equally, Heisenberg's uncertainty principle implies that particles behave in some respects like waves: they do not have a definite position but are 'smeared out' with a certain probability distribution .... [T]here is thus a duality between waves and particles in quantum mechanics: for some purposes it is helpful to think of particles as waves and for other purposes it is better to think of waves as particles. An important consequence of this is that one can observe what is called *interference* between two sets of waves or particles .... The phenomenon of interference has been crucial to our understanding of the structure of atoms.

(Hawking 1988: 56)

7 The collapse of the wave-packet in the Schrödinger equation (the fundamental differential equation governing the evolution of a physical system in wave mechanics) is explained by the famous thought experiment introduced by Erwin Schrödinger (1935), *the paradox of Schrödinger's cat*: Imagine a sealed container (so that no physical influence can pass either inwards or outwards) with a cat inside. There is also a device that can be triggered by some quantum event (like the decay of a radioactive atom or the triggering of a photo-cell by a photon). If that event takes place, then the device smashes a phial containing cyanide and the cat is killed — if the event doesn't take place, the cat lives on. Both alternatives, however, are equally weighted as part of a quantum linear superposition: according to an outside observer, the cat is in a linear superposition of being dead *and* being alive. It is only when the container is opened that the 'wave-packet' collapses and the cat is either dead *or* alive. (See Polkinghorne 1989:62-69 and Penrose 1989:293-301 for various attitudes in existing quantum theory on this experiment).

8 A simplified version of the experiment, modified after (philosopher of science David) Bohm's suggestions, is as follows. A particle enters the experimental device. It has the properties that it is not spinning and can be split in half. It is split with each half heading of in different directions. One half is spinning one way and the other half has the opposite spin. The total spin of the two halves must be zero by the conservation of spin at the point at which the parent split — the parent particle had zero spin, and the equal but opposite spins of the two halves cancel each other out. When the two halves are some distance apart, one has its spin changed. The question concerns what happens to the spin of the other half. It would instantaneously change, so the conservation of spin holds. What tells it that the other half particle has changed its spin?

(Sharpe 1992:138)

[9] In 1965 Lofti Zadeh, then chair of UC Berkeley's electrical engineering department, published a paper Fuzzy Sets, in the journal 'Information and Control' (338-353). 'The paper applied Lukasiewicz's multivalued logic to sets or groups of objects. Zadeh put the label "fuzzy" on these vague or multivalued sets — sets whose elements belong to it to different degrees ...' (Kosko 1994:9)

[10] According to probability theory, the probability that an event *will* happen is determined. It is also called the theory of *randomness* or chance. Information seems to *decrease* probability or chance. Whenever we are uncertain, we often use probability talk: 'She will probably buy that dress'. Probability can never be caught in the act — we find only the *after-the-fact* outcomes of random experiments. The probability of success devided by the total amount of trails is called the *relative frequency* or *success ratio*.

Multivalued logic also works with probabilities, but has moved beyond probability theory in an expanded model of description. Information increases fuzziness. Fuzzy logic not only describes the degree to which a future event *will* happen, but also the degree to which an event *is* happening and *has* happened. Probability is contained within the expanded model of fuzzy logic: Relative frequency or success ratio is the degree to which the subset A (set of successes) contains the whole X (set of trails), also known as the fuzzy principle of *the whole in the part* (Kosko 1994:44-64).

11

> The dominance over and objectification of nature and the subjecting of the physical world to the human mind and will — as championed by the Enlightenment — had disastrous consequences. It resulted in a world that was closed, essentially completed and unchanging ... a rigidly programmed machine. At the same time, and paradoxically, instead of liberating humans it has enslaved them .... Production became the highest goal of being human, resulting in humans having to worship at the altar of the autonomy of technology. A further disastrous consequence ... is found in what we today refer to as the ecological crisis. We have degraded the earth by treating it as an insensitive object; now it is dying under our very hands .... Enlightenment culture ... has misinterpreted both humanity and nature, not only in some respects, but fundamentally and totally. A basic reorientation is thus called for .... One should think holistically, rather than analytically, emphasise togetherness rather than distance, break through the dualism of mind and body, subject and object, and emphasise *symbiosis* .... It implies that nature and especially people may not be viewed as mere objects, manipulable and exploitable by others.
>
> (Bosch 1991:355)

[12] The Fuzzy Approximation Theorem (FAT) was originally developed to model processes and to raise machine IQs, but can be used for the purpose of this paper as well. The FAT idea has a simple geometry: A curve is covered by a finite number of fuzzy patches.

> Each piece of human knowledge, each (fuzzy) rule of the form 'if this then that', defines a patch. All the (fuzzy) rules define patches that try to cover some wiggly

curve. The better the patches cover (and overlap) the curve, the smarter the system. More knowledge means more (fuzzy) rules. More (fuzzy) rules means more patches and a better covering. The more uncertain the rules, the bigger the patches. The less fuzzy the rules, the smaller the patches. If the rules are so precise they are not fuzzy, then the patches collapse to points ....

(Kosko 1994:158)

FAT works with the concept of 'fire all (fuzzy) rules *parallel and partially*' (depending on your specific goal), thus creating a fuzzy weighted average. In making or defending a decision, each reason is a fuzzy patch, a matter of degree, with a fuzzy weight. No one reason throws the decision, but they all add up to approximate your choice with a fuzzy weighted average. Fuzzy weighted averages proposes principles instead of precise rules.

13 According to this principle, fuzzy logic with linguistic quantifiers (exemplified by *most, almost, all, some* ...), can be used in group decision making. The quantifiers are employed to represent a fuzzy majority, a *soft* majority assuming individual and social preference relations. This is then used to redefine concepts in group decision making, presenting new soft degrees of consensus (Kacprzyk et al 1992:263).

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