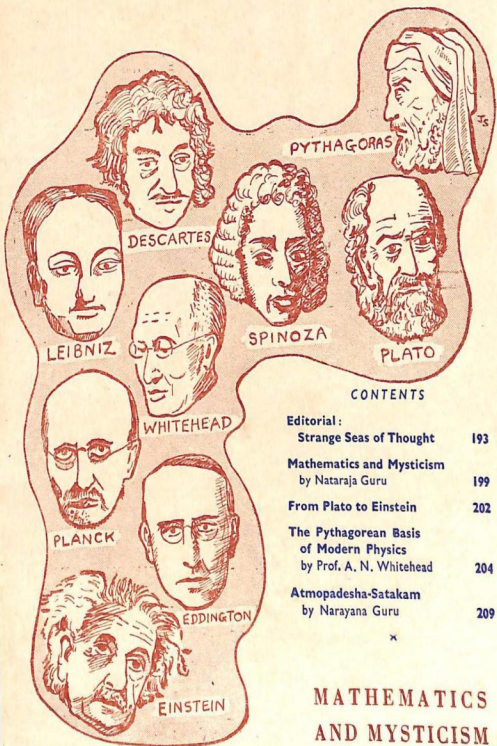


VALUES



PYTHAGORAS

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PLATO

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MATHEMATICS
AND MYSTICISM

*VALUES is devoted to integrating human understanding unitively,
impartially and globally in the interests of the general good.*

NEXT MONTH
EXISTENCE

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Editorial: STRANGE SEAS OF THOUGHT

Is human thought undergoing a transformation? From all over the world there is evidence of strange questionings in the mind, as old notions slip away. It is an intellectual and spiritual ferment which is mainly due to the new climate of scientific thought ushered in by the nuclear discoveries of the last few years, a ferment which has slowly spread over the remotest corners of the globe. In this ferment of wonder, fear and bewilderment at the "things-to-come" of an era of atomic power, and with the present sublime spectacle of extra-terrestrial exploration by moons and satellites, the old isolationist dogmas separating man from man are beginning to dissolve.

People are beginning to speak out about wisdom. Mr. Adlai Stevenson, for example, told four thousand people in Washington on Jan. 18: "We must find out who we are, and I would earnestly appeal, especially to the women of America, to organize an 'Operation Wisdom' and to lead the way to a new self-examination and self-discipline."

Former British Prime Minister Attlee addressing College students in Boston on Feb. 19, called for a World Government: "The time has come," he declared, "for the integration of World States. We must surrender to a world authority . . . The peoples of the world can have a World Government if they have the will to do it."

In India, in a carefully prepared speech in Delhi on Feb. 23, Mr. Nehru also spoke of the need for wisdom and a World State, and for a system of order in the world. "In the final analysis," he said, "what is required is the wisdom of how to live and make the most of life for oneself and for the community. Economic policy can no longer be considered as some interpretation of Nature's laws apart from human consideration or moral issues. We have to evolve a higher order involving not so much competition but much greater co-operation. Ultimately this should lead to a World State."

Wordsworth in *The Prelude* referred to Newton as "a mind forever voyaging through strange seas of thought alone."

Today we are all voyaging through these strange seas.

No Off-Beat: There is a reciprocity between the jet and nuclear discoveries and our own thinking. Mathematics is at present playing a curious role. Not only has it provided the devastating nuclear explosions and space voyagings, it has also given us the *mystique* of modern times. From the title of the topic in this month's VALUES, it would therefore be wrong to assume that we are in some escapist off-beat track. On the contrary we are probably in advance of the main stream of popular thinking which seems to be yet at the bewildered stage of mental revaluation, as the above quotations reveal.

The relevance of mathematics is that it is the instrument of pure reason, poised midway between the scientific and the philosophic pursuits of mankind. If our minds are now adventuring over these strange new seas, and if we are alarmed over the perils of the unknown, it is due to the new inventions. But these inventions owe their existence to the insight of mathematical contemplation. Whether at the extremity of the elementary quanta of energy, or whether at the counter extremity of the radiant immensities of the galactic systems, extremities exemplified on the one side by control of atomic energy and on the other side by the first explorations beyond the earth itself, daring mathematical precision has equated itself to the precision actually discovered in the physical universe following the period of unitive contemplation.

It is proof that the more orderly our contemplation and thinking is, the more orderliness it meets in nature, and subsequently the greater its fulfilment in actual scientific achievements.

Towards Unitive Reasoning: Wernher von Braun, the German-born scientist who built the Jupiter which hurled America's first moon, Explorer, into orbit, is quoted in the *New York Herald Tribune* as saying: "There is beauty in space, and it is orderly. There is no weather, and there is regularity. It is predictable. Just look at our little Explorer; you can set your clock by it — literally; it is more accurate than your clock. Everything in space obeys the laws of physics. If you know these laws, and obey them, space will treat you kindly."

What is being discovered is a new kind of thinking, at least new in our epoch. Nehru talks of a "higher order" and von Braun of space as "orderly." The *concept of order* is in the very word *cosmos* coined by Europe's first mathematician, Pythagoras. The search and discovery of orderliness is the mark of this new kind of thinking. The jump from calculation to mathematical thinking involves a new type of reasoning. This reasoning is "pure" in the sense that it has nothing at all to do with action in the physical sense, or indeed with any sort of external experimentation. Our atomic era began with Einstein's Theory of Relativity and Planck's Quantum Theory over fifty years ago. There were no Rutherford proofs let alone Explorers or Luniks at that time. Over and over again Einstein has said that *observation and experiment played no part whatsoever in the origin of the theory*. He also said: "I hold it true that pure thought can grasp reality."

Another example is that of James Clerk Maxwell, who by mathematical insight deduced the existence of electromagnetic radiation thirty years before Marconi's experiments in wireless telegraphy. So also it is only in

our own day that Einstein's *contemplative* reasoning was made the basis of *active* demonstration through experiment and invention.

This reasoning seeks unitive harmony and order, and establishes abstract precision within the depths of the mind, through the employment of the discipline of mathematics on the one side and through the direct awareness of the Absolute as the self-core on the other side. It is only later that the precision of invention and demonstration "out there" coincides with the precision achieved by the pure reason "within here." When this is so, is it too much to proceed further and say that we can expect that the reasoning here within can discover equal coincidence with the reasoning out there? Rational thought cannot tolerate duality. The apparent dualities in life are invariably sought to be abolished by the discovery of a series of fundamental common or generic unities, each of which manifests as an internal-external polarity, and each of which has a common centre of origin in an all-over prevailing wholeness or Absolute unity.

For it is Orderliness itself for which men are groping, and every step towards this supreme terminus is a victory for unitive reasoning and a victory for the human spirit.

Inherent Contradictions: It is in human relationships and in politics particularly, that the type of generic unity effectively applicable is being sought.

This search really requires the same discipline as the search in physics and cosmology which has proved so fruitful. In personal and social psychology and in global politics and world law, the same generic type of unity has to be discovered, mathematically determined and then — the main task before our puzzled public leaders who have sensed its consequences — followed by its rational adoption without fear, without prejudice and without any of the many extraneous, irrational dogmas or ideologies being permitted to intrude and vitiate its truly scientific nature.

When odd things happen in the world of the atomic physicist, such as the behaviour of *mesons*, the baffled men of experiment and action turn to the contemplative mathematician for a solution. When some planet such as Neptune behaves in a queer way, again they turn to the mathematician. In the former case the contemplative mathematicians Lee and Yang say it is due to left-handed and right handed twists in the elemental mesons. In the latter case Prof. Lowell by mathematics predicted a new planet Pluto (in 1914) which was only discovered in 1930 by Tombaugh, his assistant, fourteen years after Lowell's death.

The men of action in the political world when faced with their baffling problems can also hope for a solution from the contemplative experts, which is to say from those who have an understanding of the dialectical key which can unlock all their problems and bring out the bi-polar unity. Far from being useless, everything of a contemplative character which has orderliness or unity as its principle, is the *only* way to solve all human problems.

At present there are only a few really absolutist individuals who are able to see this clearly. The notion is still vague even with the intelligentsia and the leading personalities of the public world. That is due to the backwash of the past, to an obsolete education and a dualistic sociology. But the relativistic past is being disturbed as we have said —

thanks to the intervention of one discipline — mathematics — which to be effective, has got to be unitive and non-dualistic.

Human values and reason at any level can have no *isolated* existence. They must be bound up in accordant relevance with the rest of the universe. To be sceptical about this is to abandon the pursuit of science. Scepticism here finds itself defeated just where it claimed to be the sole victor. One cannot deny unity and order which are rational while proceeding to seek them out by mathematical orderly laws in the universe through mathematical reasoning. It is because mathematics is a form of reasoning *above the ordinary*, and above relativistic suppositions, that it has proved so fruitful. Therefore to remove reason here would be to deny the validity of mathematics, to deny all effective science and to unsettle the very foundations of modern civilization.

For if reason as the basis of mathematics is regarded as a by-product or superstructure arising out of an irrational, meaningless or "mindless" material universe — which is the position philosophically held by both the Pragmatists of America and the Marxists of Russia — a dogma believed in by the prevailing philosophers of democracy and communism, then these societies themselves become self-contradictory, without order and meaningless. But that they do have meaning is self-evident which only means the denial of their philosophical dogmas or beliefs in actual practice. This is proved also by the very character of *supposed* orderliness inherent in the mathematically based inventions of which these societies are quite properly proud. It is time that both the dogmatic Pragmatists and the Marxists were themselves hauled to order. They are both totally out of date.

An Ancient Problem: Having brought the argument thus far, the question arises as to what is to be done about the actual inherent contradictions in these giant rival states. How is this double-thinking, dualism and inherent contradiction to be ended?

The answer to this question is the application of that same unitive discipline so beautifully demonstrated in the mathematically based conquest of new regions of the universe, *to the understanding and conquest of relativistic thought in human nature itself.*

Specifically man seems disjunct from the universe, but generically under reason and unity he is not disjunct. What applies to the universe as reason and orderliness also applies to man. What has seemed as two separate irreconcilable disciplines, the discipline of understanding the nature of things and that of understanding the self-nature of man, must be brought together as one single unitive science, based where it should be, in the single principle of unity in man himself, which is the Self which is also the general Absolute.

The problem itself is very old. It may be that in each age it has need of periodic restatement and solution.

The disciplined rational investigation which contemplates the nature of life both analytically and mathematically, was known in India as the Samkhya (enumerative reasoning). Side by side with this discipline from antiquity there was the discipline known as Yoga, the way of the mystic who by various methods strove for solitary identity with God. Like the modern scientists the Samkhya investigators rejected the notion of God while the Yogis like modern religious mystics, turned their backs on society and

became escapist (as the saying is).

The mental climate of our time parallels this state of disengagement of Indian philosophic thought. Two sets of disciplines seem to be at cross-purposes. People do not deny (how can they?) the actual results of the way of science (Samkhya). At the same time they find it hopelessly and frigidly remote from the precious human values which make life worth while and with which the scientist and the mathematician profess they have nothing to do. On the other hand, while acknowledging the importance of an individual quest for spiritual union with God, mystical retreat or individual salvation, whether in the orthodox monasteries or in the heterodox schools, people do not find here any solution for the immediate problems facing them every moment, either in their homes or in the wide world of public relations and international (and interlocked) politics.

Vyasa's Solution: As for India, if you ask most pundits, they will offer you a version of Vedanta which is mainly Samkhya rationalism and a version of Yoga which is mainly Patanjali individualism, each discipline distinct from the other. And both will claim the Bhagavad Gita in support of their position! This is most extraordinary, since the Bhagavad Gita whose author was the great Guru Vyasa, contains the non-dualistic re-valuation, in the following words:

That (the way of) rational science (Samkhya) (together with) unitive self-discipline (Yoga) are distinct (different or separate), only children say, not the learned. One well-established in any one of them obtains the result of both.

That stance attained by the rational scientists is reached also by those of unitive self-discipline; Samkhya and Yoga as ONE — he who thus sees, he (alone) sees. — *Gita*, V. 4-5.

In other words, the quest of the scientist is fundamentally one of self-understanding, while that of the mystic or the yogi, in its turn is fundamentally scientific and rational. The childishness appears when the scientist or the mathematician denies personal human values, or when the mystic denies the importance of rational human thought. Each loses. Each produces a dualism. The case of both is spoiled.

Where Mathematics Comes in: In European philosophic thought it is only thus that we can answer a puzzling fact; why it was that the wise men of ancient Europe for one thousand years from the sixth century B. C. to the fourth century A. D. — i.e. until the advent of emotional dogmatic Christianity — insisted upon a course of studies which combined both the disciplines of science and philosophy. Anybody reading Plato must wonder at the "fuss" he makes about the importance of mathematics in philosophy. And the same with them all, from Thales to Proclus. *They were all mathematicians and yogis.* For a science of values to be established, for the power of dialectical solutions in human affairs to come to fruition, for the knowledge of the primal Unity or the Absolute to be understood, to lift the powers of reasoning from the relative, to give exactitude to the questing mind, these wise men insisted upon a preliminary course of studies in logic and mathematics. These were educators in the science of wisdom, and one which we hope will again prevail in the world.

But today in education we have this fundamental split, and we

have had it in Europe for the last 1500 years (and India has been no better), with all its concomitant results in the dichotomy seen in every aspect of human life, either under the dogmas of religion or under the dogmas of its recent rival, science. Even the philosophers from Descartes to Peirce, Russell, Sartre, have all had leanings either on the theistic or on the materialistic side. Not one has formulated properly the neutral non-dualistic stance. Even in India since the time of Sankara, the same can be said of all the philosophers, with the notable exception of Narayana Guru and his disciple Natarajan. His keen spiritual vision was able to by-pass the private and personal ecstasy of the *bhakta*, able to revalue it at a more sublime level of thoroughly neutral vision, while at the same time directing the intellectual powers of the scientist at the contemplative level.

It is not that science is *wrong* or religion *wrong*. As far as their disciplines go, each is correct. It would be as absurd to turn a laboratory into a temple of devotion as to provide church-goers with copies of the *Principia Mathematica* instead of Bibles.

Nirvana: No! But their boundaries have hitherto been determined by enclosing walls of dogma. These dogmas must depart, whether Christian, Hindu, Marxist, Pragmatist, Gandhian, Democratic, Socialist or Communist etc. etc. All dogmas are opposed to the genuine spirit of science and religion. This searching spirit of man of which these dogmas are the old discharges which inevitably become crystalline wastes, holds as equals both pure reason and pure faith as aspects of human value within the self. It is man's nature to reason and the highest reason (the pure *nous* of the European mystic-mathematicians, and the pure *buddhi* or enlightening principle of Indian sages) attains that wisdom which admits of no vagueness, indecision or error. Faith at this level is the same as confidence in the cosmic aspect of the Self. As a discipline of the mind mathematics is one of the most powerful devices leading to this light of wisdom. Indeed, mathematics, as the men who use it testify, induces a state of contemplative exaltation.

On the other hand, man is greater than any mathematics. When we say "man" here we are not thinking of man as five-and-a-half or six feet of body, nor even of man as the active abyss of mind. It is to the non-relativist core that we refer. This "man" is more important than all the external conquests of space and time, matter or energy, just as he is greater than all religions. And also, truth is more important than the private worlds of ecstatic visions. Both extremes lead to dogmas. Truth is central and man by attaining this comes to a new kind of nirvanic peace which men like Jesus and the Buddha knew. Bombs and dogmas are to the mind of man what focal matter is to the body and to be treated correspondingly. They are irrelevancies drawn from wrong key postulates. These will be forgotten as man voyages with full confidence in these new seas of thought, towards self-fulfilment, not merely as scientist, not merely as religionist, but as a contemplator of his own absolutist nature, at home in new seas, and under new stars, no longer made timid by the confusions of history. As a rational discipline and a master-compass in this greatest of explorations, mathematics raised to the final pitch of perfection in the Absolute, will bring him to many a shore of wonder and beauty.

[END]

Mathematics and Mysticism

by NATARAJA GURU

The Mystic is not generally a Mathematician. They differ yet agree in an interesting way. In both types the inner life is pronounced, yet in the matter of feeling or thinking there could be no two types so fundamentally different. They yet have the strange resemblance of twins. They present an enigma which could be explained partially at least by saying that they are subjectively disposed or verticalized personalities. Here is a study of these human types which has its relevance both to wisdom and to the world of atomic physics which plays so weighty a part in the life of humanity today.

WHILE the mathematician may be described as a vertical positive type, the mystic is generally more negatively adjusted. Anti-social traits could brand both types as peculiar out-of-the-way people. How the pure mathematician tends to be a mystic and how the active mystic often has a generalized and mathematical notion of the supreme reality of theology are interesting and intriguing matters to which it would be worthwhile here to direct our attention.

God as a Mathematician: It has lately become the fashion to speak of God as a mathematician. Whether Jeans or Eddington was first responsible for the idea behind this slogan, it seems to have caught on wonderfully. The implicit correspondence here referred to is as striking as it is attractive to the modern mind.

God has been called the Great Architect or the Master Designer or the Creative Artist. We have ourselves reduced Him into terms of a vertical dimension. The anthropomorphic Zeus idea of a God has long been outmoded even as an idiom in the West. Even in the more sentimental climate of Eastern thought the Bhagavad Gita refers to God both as the correlating thread of values and the machine behind the visible phenomenal world of necessary happenings (see Gita, VII. 7 and XV. 61). Krishna, the Guru of the Gita, refers to the latter God concept 'in the third person, suggesting its inferiority as a philosophical notion.

As humanity reads, hears or thinks for itself, the idea of God also changes to adapt itself to the prevailing idiom. The Guru Narayana referred to God as the Great Captain of a steamship, while philosophically comparing him to the dimension of depth implied in phenomenal life (see VALUES Dec. 1957).

The following paragraph from Sir James Jeans suffices for us here to point out that the role of God as a master mathematician is the latest of the similes applied to the concept of the Maker of all things :

If, however, the more intricate concepts of pure mathematics have been transplanted from the workings of nature, they must have been buried very deep indeed in our subconscious minds. This very controversial possibility is one which cannot be entirely dismissed, but it is exceedingly hard to believe that such intricate concepts of a finite curved space and an expanding space can have entered into pure mathematics through any sort of unconscious or subconscious experience of the workings of the actual universe. In any event, it can hardly be disputed that nature and our conscious mathematical minds work according to the same laws. She does not model her behaviour, so to speak, on that forced on us by our whims and passions, or on that of our muscles and joints, but on that of our thinking minds. This remains true whether our minds impress their laws on nature, or she impresses her laws on us, and provides a sufficient justification for thinking of the universe as being of mathematical design. Lapsing back again into the crudely anthropomorphic language we have already used, we may say that we have already considered with disfavour the possibility of the universe having been planned by a biologist or an engineer ; from the intrinsic evidence of His creation, the Great Architect of the Universe now begins to appear as a pure mathematician. (pp. 166-167, *The Mysterious Universe*, London 1937)

Mathematics could thus be thought of as having a place in the mind of God and we could think conversely likewise that mysticism consists of knowing the same God through feelings rather than through thoughts.

The Content of Mysticism : The mystic is essentially a contemplative. Although it is usual to speak of an active and a contemplative mystic, just as we might speak of a pure or an applied mathematician, the true mystic is always one who lives in a world of imagination rather than of reality. An active mystic might engage himself in pious works for God or cultivate "the presence of God" in ways that reveal themselves in his outer behaviour, while the true mystic might resemble more the quietist who lives in silence and retirement.

The world referred to as the world of "whims and passions" as also that belonging to the "muscles and joints" in the above quotation from Jeans, is one that is equally outside the life of both the mystic and the

mathematician. The introversion implied in contemplative mysticism has been generally recognized. The world of the mystic resembles that of the subjective and selected world of a mathematician where only certain kinds of values or interests enter, while a great number of common human interests and connected activities are carefully excluded.

The mystic lives in a world of his own which, as we shall see presently is in all essential respects the same as the one in which the spirit of the mathematician lives and moves. They are "of imagination all compact" as Shakespeare generalized inclusively in the cases of the lover, the madman and the poet. The resemblance of the pure mathematician to the poet or the mystic, however, needs some more explanation to be fully evident. The mystic feels a strange kinship with the life that is external to him, while the mathematical structure of reality or nature that the mathematician is capable of intuiting within himself establishes a similar be-polar relation between himself and the Maker of all things here. Both become tuned to the same Absolute whether outside or inside, whether emotionally or intellectually, or both. Thus it is that mystics and mathematicians become strange bedfellows.

How Do Mathematicians Think? From the day of the Pythagorean notion of the "mystery of numbers" down to the day Eddington spoke of a "sedenion" algebra the nature and content of mathematics has been the subject of much speculation.

Are mathematical judgements analytic or synthetic, *a priori* or *a posteriori*, subjective or objective, "selective" or "creative," positive or negative? These are open questions, answered differently by different people. That mathematicians are "queer folk" has been pointed out by both the parties concerned in such discussions. Whether experiments confirm the findings of mathematicians or whether mathematics deserves primacy of treatment in respect of scientific certitude seem matters not yet decided one way or the other.

The suggestion we make is that both could be equally true without scientific validity being affected one way or the other. Reality or truth as the Absolute has two sides which come together into a central unity without contradiction. How this way of thinking could be valid has been the subject of our inquiry in the pages of VALUES during the last few years. Unitive or dialectical thinking reveals the possibilities of such a notion of a neutral Absolute both transcendent and immanent at once.

We could therefore say that if God could be thought of as a mathematician, the mathematician may also be expected, in his thought at least, to resemble God. If we could think of this dual proposition without the anthropomorphic flourish which rhetoric might introduce, and imagine man's mathematics and God's creative thinking to be counterparts of the same unitive situation, belonging as they do both, to what we have tried to distinguish as the vertical aspect of reality, life or the Absolute, in the

(Continued on page 215)

From Plato to Einstein

THE PHILOSOPHER, because he has to rise above the changing and lay hold of true Being, must learn the art of number—not with a view of buying and selling, but for the sake of the soul itself and because this will be the easiest way for it to pass from becoming to truth and Being. This knowledge may truly be called necessary, since it obviously obliges the mind to make use of pure intelligence in the attainment of pure truth. The knowledge at which geometry aims is knowledge of the eternal, and not of aught perishing or transient. Then geometry will draw the soul towards truth, and create the spirit of philosophy and raise up that which is now unhappily fallen. In every man there is an eye of the soul which, when by other pursuits lost and dimmed, is by these studies purified and reilluminated, and is more worthy of preservation than ten thousand bodily eyes, for by it alone is Truth seen. — PLATO, *Republic*, 525B – 527E.

WHEN I think, it is the spirit of the world which is striving to express its thought; it is nature which is trying to know and fathom itself. It is not the thoughts of some other mind, which I am endeavouring to trace; but it is I who transform that which exists into something which is known and thought, and would otherwise neither come into being nor continue in it. — SCHOPENHAUER.

FARADAY told Tyndall, "You are young, I am old, but then our subjects are so glorious, that to work at them rejoices and encourages the feeblest; delights and enchants the strongest."

I cannot stop abruptly where our microscopes cease to be of use. Here the vision of the mind authoratively supplements the vision of the eye. — JOHN TYNDALL.

THE mathematician has reached the highest rung on the ladder of human thought. — HAVELOCK ELLIS.

It cannot be said that Physics explains away the secrets of Nature, but rather that it traces them back to deeper secrets. — VON WEIZSÄCKER.

IN the work of mathematicians the aesthetic motive is very apparent. Many mathematicians have written about their work in a sort of prose poetry, and the satisfactions they get from it seem indistinguishable from those of an artist. — J. W. N. SULLIVAN.

MATHEMATICS, rightly viewed, possesses not only truth but supreme beauty—a beauty cold and austere, like that of sculpture, without appeal to any part of our weaker nature, without the gorgeous trappings of painting or music, yet sublimely pure, and capable of a stern perfection such as only the greatest art can show. — BERTRAND RUSSELL.

THE stuff of the world is mind-stuff. The mind-stuff is not spread in

space and time ; these are part of the cyclic scheme ultimately derived out of it. But we must presume that in some other way or aspect it can be differentiated into parts. Only here and there does it rise to the level of consciousness, but from such islands proceeds all knowledge. Besides the direct knowledge contained in each self-knowing unit, there is inferential knowledge. The latter includes our knowledge of the physical world.

— EDDINGTON.

THE curse of philosophy has been the supposition that language is an exact medium. Philosophers verbalize and then suppose the idea is stated for all time. Even if it were stated, it would need to be restated for every century, perhaps every generation. Plato is the only one who knew better and did not fall into this trap. When ordinary methods failed him, he gave us a myth, which does not challenge exactitude but excites reverie. Mathematics is more nearly precise, and comes nearer to the truth. In a thousand years it may be as commonly used a language as is speech today. — A. N. WHITEHEAD.

THE longing to see this pre-established harmony is the source of the inexhaustible patience and persistence which we see in Planck's devotion to the most general problems of our science, undeflected by easier or more thankful tasks. I have often heard that colleagues sought to trace this characteristic to an extraordinary will-power; but I believe this to be wholly wrong. The emotional condition which renders possible such achievements is like that of the religious devotee or the lover; the daily striving is dictated by no principle or programme, but arises from an immediate personal need. — EINSTEIN. [END]

A Happy Portent

(In a letter to John Spiers, "Dharmu," an Indian disciple of Nataraja Guru, writes as follows.)

THE succession-Naming announced in VALUES (Feb. issue) is doubtless a great event. The unity of mankind under a formless and nameless Absolute is emphasized once again in the event. The total identification of an European under an Indian environment in the unitive aspect of the Absolute and the absolute trust of an Indian Guru in a Scottish disciple are happy portents of the great things to come. Devoid of creeds and religions based upon narrow and parochial relativism, the philosophy of the Absolute is bound in this very character of universality of approach to appeal to all thinking mankind.

I herein send you my congratulations on your being the next in succession and my deep respects to Nataraja Guru on his translation of absolutism into concrete shape in one aspect of human relations. I fervently hope that the future of the Narayana Fellowship will be bright and big. *Vanakkam!*

[We would like here to thank the many friends who have also written-in giving their approval of Nataraja Guru's decision. — JOHN SPIERS.]

The Pythagorean Basis of Modern Physics

By Prof. A. N. WHITEHEAD

This brilliant philosopher-mathematician gives evidence here to show how great is the debt of modern science to the discoveries of Pythagoras, in solving the many paradoxes involved in atomic physics, and in the quantum theory in particular.

THE Science of Pure Mathematics, in its modern development, may claim to be the most original creation of the human spirit. . . a divine madness. . . a refuge from the goading urgency of contingent happenings.

THE full universe, disclosed for every variety of experience, is a universe in which every detail enters into its proper relationship with the immediate occasion. The generality of mathematics is the most complete generality consistent with the community of occasions which constitutes our metaphysical situation.

Unitive Key-Patterns: The exercise of logical reason is always concerned with these absolutely general conditions. In its broadest sense, the discovery of mathematics is the discovery that the totality of these general abstract conditions, which are concurrently applicable to the relationships among the entities of any one concrete occasion, are themselves inter-connected in the manner of a pattern with a key to it.

The key to the patterns means this fact: that from a select set of those general conditions, exemplified in any one and the same occasion, a pattern involving an infinite variety of other such conditions, also exemplified in the same occasion, can be developed by the pure exercise of abstract logic. Any such select set is called the set of postulates, or premises, from which the reasoning proceeds. The reasoning is nothing else than the exhibition of the whole pattern of general conditions involved in the pattern derived from the selected postulates.

This reasonable harmony of being, which is required for the unity of a complex occasion, together with the completeness of the realization (in that occasion) of all that is involved in its logical harmony, is the primary article of metaphysical doctrine. It means that for things to be together involves that they are reasonably together. This means that thought can penetrate into every occasion of fact, so that by comprehending its key conditions, the whole complex of its pattern of conditions lies open before it.

Einstein's Debt to Pythagoras : It comes to this: provided we know something which is perfectly general about the elements in any occasion, we can then know an indefinite number of other equally general concepts which must also be exemplified in that same occasion. The logical harmony involved in the unity of an occasion is both exclusive and inclusive. The occasion must exclude the inharmonious, and it must include the harmonious.

Pythagoras was the first man who had any grasp of the full sweep of this general principle... He insisted on the importance of the utmost generality in reasoning, and he divined the importance of number as an aid to the construction of any representation of the conditions involved in the order of nature.

Pythagoras is said to have taught that the mathematical entities, such as numbers and shapes, were the ultimate stuff out of which the real entities of our perceptual experience are constructed... About a thousand years separate the Athanasian Creed from Pythagoras, and about two thousand four hundred years separate Pythagoras from Hegel. Yet for all these distances in time, the importance of definite number in the construction of the Divine Nature, and the concept of the real world as exhibiting the evolution of an idea, can both be traced back to the train of thought set going by Pythagoras.

Pythagoras was fortunate. His philosophical speculations reach us through the mind of Plato. The Platonic world of ideas is the refined, revised form of the Pythagorean doctrine that number lies at the base of the real world. So today, when Einstein and his followers proclaim that physical facts, such as gravitation, are to be construed as exhibitions of local peculiarities of spatio-temporal properties they are following the pure Pythagorean tradition.

From Actual Entities to Abstract Formulae : In the seventeenth century the influence of Aristotle was at its lowest, and mathematics recovered the importance of its earlier period. It was the age of great physicists and great philosophers; and the physicists and philosophers were alike mathematicians. The exception of John Locke should be made, although he was greatly influenced by the Newtonian circle of the Royal Society. In the age of Galileo, Descartes, Spinoza, Newton, and Leibniz, mathematics was an influence of the first magnitude in the formation of philosophic ideas. But the mathematics which now emerged into prominence, was a very different science from the mathematics of the earlier epoch. It had gained in generality, and had started upon its almost incredible modern career of piling subtlety of generalization upon subtlety of generalization; and of finding, with each growth of complexity, some new application, either to physical science, or to philosophic thought.

The Arabic notation had equipped the science with almost perfect technical efficiency in the manipulation of numbers . . . Algebra now came upon the scene, and algebra is a generalization of arithmetic. In the same way as the notion of number is abstracted from reference to any one particular set of entities, so in algebra abstraction is made from the notion of any particular numbers. Algebra thus develops into the general science of analysis in which we consider the properties of various functions of undetermined arguments.

Finally the particular functions, such as the trigonometrical functions, and the logarithmic functions, and the algebraic functions are generalized into the idea of 'any function.' Too large a generalization leads to mere barrenness. It is the large generalization, limited by a happy particularity, which is the fruitful conception. For instance the idea of any *continuous* function, whereby the limitation of continuity is introduced, is the fruitful idea which has led to most of the important applications. The rise of algebraic analysis was concurrent with Descartes' discovery of analytical geometry, and then with the invention of the infinitesimal calculus by Newton and Leibniz. Truly, Pythagoras, if he could have foreseen the issue of the train of thought which he set going, would have felt himself fully justified in his brotherhood with its excitement of mysterious rites.

Mathematics supplied the background of imaginative thought with which the men of science approached the observation of nature. Galileo produced formulae, Descartes produced formulae, Huyghens produced formulae, Newton produced formulae.

A Vivid Pythagorean Dream: As a particular example of the effect of the abstract development of mathematics upon the science of those times, consider the notion of periodicity. The general recurrences of things are very obvious in our ordinary experience. Days recur, lunar phases recur, the seasons of the year recur, rotating bodies recur to their old positions, beats of the heart recur, breathing recurs. On every side we are met by recurrence. Apart from recurrence, knowledge would be impossible. In our experience as we gain the idea of exactness, recurrence is fundamental.

In the sixteenth and seventeenth centuries, the theory of periodicity took a fundamental place in science. Kepler divined a law connecting the major axes of the planetary orbits with the periods in which the planets respectively described their orbits; Galileo observed the periodic vibrations of pendulums; Newton explained sound as being due to the disturbance of air by the passage through it of periodic waves of condensation and rarefaction; Huyghens explained light as being due to the transverse waves of vibration of a subtle ether; Mersenne connected the period of the vibration of a violin string with its density, tension and length.

Nothing is more impressive than the fact that as mathematics withdrew increasingly into the upper regions of ever greater extremes of abstract thought, it returned back to earth with a corresponding growth of importance for the analysis of concrete fact. The history of the seventeenth century science reads as though it were some vivid dream of Plato or Pythagoras.

The paradox is now fully established that the utmost abstractions are

the true weapons with which to control our thought of concrete fact.

Mathematics is the science of the most complete abstractions to which the human mind can attain. We are entering upon an age of reconstruction, in religion, in science, and in political thought. Such ages, if they are to avoid mere ignorant oscillation between extremes, must seek truth in its ultimate depths. There can be no vision of this depth of truth apart from a philosophy which takes full account of these ultimate abstractions, whose inter-connections it is the business of mathematics to explore.

Clue to Quantum Theory Paradox : At present physics is troubled by the quantum theory. There is no difficulty in explaining the paradox (of the discontinuous existence in space of the electron) if we consent to apply to the apparently steady undifferentiated endurance of matter the same principles as those now accepted for sound and light. A steadily sounding note is explained as the outcome of vibrations in the air : a steady colour is explained as the outcome of vibrations in ether. If we explain the steady endurance of matter on the same principle, we shall conceive each primordial element as a vibratory ebb and flow of an underlying energy, or activity. Suppose we keep to the physical idea of energy; then each primordial element will be an organized system of vibratory streaming of energy. Accordingly there will be a definite period associated with each element; and within that period the stream-system will sway from one stationary maximum to another stationary maximum —, or, taking a metaphor from the ocean tides, the system will sway from one high tide to another high tide. This system, forming the primordial element, is nothing at any instant. It requires its whole period in which to manifest itself. In an analogous way, a note of music is nothing at an instant, but it also requires its whole period in which to manifest itself.

Accordingly, in asking where the primordial element is, we must settle on its average position at the centre of each period. If we divide time into smaller elements, the vibratory system as one electronic entity has no existence. The path in space of such a vibratory entity — where the entity is *constituted* by the vibrations — must be represented by a series of detached positions in space, analogously to the automobile which is found at successive milestones and at nowhere between.

We must first ask whether there is any evidence to associate the quantum theory with vibration. This question is immediately answered in the affirmative. The whole theory centres round the radiant energy from an atom, and is intimately associated with the periods of the radiant wave-systems. It seems, therefore, that the hypothesis of essentially vibratory existence is the most hopeful way of explaining the paradox of the discontinuous orbit.

Lucky Guess or Insight? In the second place, a new problem is now placed before philosophers and physicists, if we entertain the hypothesis that the ultimate elements of matter are in their essence vibratory. By this I mean that apart from being a periodic system, such an element would have no existence. With this hypothesis we have to ask, what are the ingredients which form the vibratory organism. We have already got rid of the matter with its appearance of undifferentiated endurance.

Apart from some metaphysical compulsion there is no reason to provide another more subtle stuff to take the place of the matter which

has just been explained away. The field is now open for the introduction of some new doctrine of organism which may take the place of the materialism with which, since the seventeenth century, science had saddled philosophy.

It must be remembered that the physicists' energy is obviously an abstraction. The concrete fact, which is the organism, must be a complete expression of the character of a real occurrence. Such a displacement of scientific materialism, if it ever takes place, cannot fail to have important consequences in every field of thought.

Finally, our last reflection must be, that we have in the end come back to a version of the doctrine of old Pythagoras, from whom mathematics and mathematical physics, took their rise. He discovered the importance of dealing with abstractions; and in particular directed attention to number as characterising the periodicities of notes of music. The importance of the abstract idea of periodicity was thus present at the very beginning both of mathematics and of European philosophy.

In the seventeenth century, the birth of modern science required a new mathematics, more fully equipped for the purpose of analysing the characteristics of vibratory existence. And now in the twentieth century we find physicists largely engaged in analysing the periodicities of atoms. Truly, Pythagoras in founding European philosophy and European mathematics, endowed them with the luckiest of lucky guesses—or, was it a flash of divine genius, penetrating to the inmost nature of things?

(condensed from Chapter 2 of "Science and the Modern World.")

[END]

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3.

These phenomenal aspects five such as the sky
Which as emergent from outside here seem to be,
By contemplation one should bring to non-difference.
As the sea is to the waves that rise in rows thereon.

AFTER making out the two poles involved in contemplation, one at the core of one's own being, and one in the void beyond, in the previous verses, the accent now shifts to the subject, who is here treated as a passive onlooker witnessing the given phenomenal physical world.

This world is what is known to physics and as in the pre-Socratic hylozoism of ancient Europe, it is even now habitual in India to refer to the sky, air, fire, water and earth as graded realities of the phenomenal aspect of the Absolute. The elements thus contemplatively understood should not be confused, however, with elements as understood in modern physics or chemistry. It is not merely the material basis of phenomena which have to be thought of under the symbols of the elemental names, but rather as stable nodes in a vertical series of graded entities which, when more closely scrutinized, would reveal themselves to be of the same substance as the Absolute itself as understood in the first verse.

Waves on the sea are water under specific name and form but otherwise homogeneous with the ocean. This classical Vedantic example is resorted to by the Guru here to refer to the differenceless between the cause and the effect in the phenomenal world. The cause when viewed contemplatively yields this answer, while when viewed horizontally or non-contemplatively, the waves will have to be given a status in reality of their own.

Indian logic makes the distinction between the material cause such as the clay that makes the pot and the occasional or incidental cause, which is the potter's work. The former is the vertical cause, while the latter would refer to a horizontal sequence of causes and effects. Each wave might have an individuality horizontally viewed, but contemplatively or vertically viewed, the material cause and effect, namely, water, leads to a differenceless unitive vision. The text here being of a contemplative order

and especially as there is reference to contemplation in the verse itself, the vertical unitive view of cause and effect is what is intended here by the Guru.

"Emergent from outside here seem to be": That Vedanta especially as stated by Sankara refers to the visible world of phenomena as a mere appearance or a passing show is proverbially known. *Maya-vada* (the doctrine of illusion), *a-jata-vada* (doctrine of non-creation) and *vivarta-vada* (doctrine of emergent appearance) are all different names by which the negative principle of nescience is supposed to dim the transparency of the human mind, making for all sorts of conditioned states of consciousness, by which representations of apparent realities become supposed or super-imposed on the pure being which is the subjective-objective Absolute.

Other favourite examples of nescience are the snake imagined in a piece of rope or the silver imagined in the mother-of-pearl. The colourless glass crystal conditioned or "coloured" by its being placed on a piece of red silk is another favourite example of the fallacy, optical or logical illusion possible in respect of reality. What seems to exist, as it were, "over there" in our common experience of the visible world, is not in reality there substantially at all. The blue of the sky, to start with, is a mere optical effect known to science. It is due as much to the weakness of the optical nerves as to the effects in the dispersal of light.

As we come down from the subtlest of the elements, the sky, through the intermediate nodes marked out symbolically by the elemental principles known by the respective names, understood subjectively and objectively at once, we seem to appreciate degrees of differentiation as between the successive items taken in order. Even here the difference, as between say, fire and water for example, is due to the interpenetration of factors in an ascending as well as a descending order at once.

The process of such neutralization by opposites is known in Vedantic literature as *panchikarana* and the elements themselves, thought of as principles rather than things, are called *tan-matras* (things-in-themselves). The story of the process of *panchikarana* or equalization of the five factors is described by Prof. Lacombe as follows:

The great elements do not enter as such into the composition of individual realities, but undergo first a sort of shaking-up which is called quintipartition — *panchikarana*. Each of them is divided by the Creator into two parts and each of these halves again into four parts. Each of these quarters is afterwards mixed with the half that remains intact of each of the four elements. This takes place in such a way that each element becomes already composed as follows $\frac{1}{2}$ element pure plus $\frac{1}{8}$ of each of the other four elements. And these are the composite elements which serve the constitution of the individual things. The dominating proportion of the primitive element safeguards its authenticity. But the addition of bits of the other elements gives account of the participation of all things with all things and explains certain anomalies of the perception. (p. 325, *L'Absolu selon le Vedanta*, Paris 1937 — translated).

Although the above process of how actualization of elemental principles as individual entities is graphic enough, the reference to the

Creator therein gives it a theological flavour which is due to the fact that this version of *panchikarana* is taken from the writings of Ramanuja and his followers such as Sri Nivasa Dipika, rather than from the more strictly philosophical Sankara school. In the *Vivekachudamani* (verse 88), Sankara attributes *panchikarana* to action in previous births.

The same process of *panchikarana* is accepted in the other Vedantic schools.

In the Guru's verse here, this elaborate story of the process of *panchikarana* does not have to be drawn into the discussion especially at the present stage. Simpler theories of concretion and individuation are found elsewhere in this same work, which we shall discuss at their proper place. Meanwhile it would be good for the student to be informed about the prevailing theories on the subject.

"As the sea is to the waves that rise in rows thereon.": The analogy of the sea invoked here is not the sea of *samsara* (phenomenal existence) but the sea of consciousness. *Samvit sagara*, (the sea of consciousness) has to be distinguished from *samsara sagara* (the sea of phenomenal becoming in nature).

The world of appearance is only the specific aspect of the basic consciousness in which all things have being. Name and form are the factors giving specificity to the general consciousness. The electromagnetic field and the gravitational line in modern physics are comparable to the twin factors which may be said to give rise to the mechanism of radiating waves in the context of the quantum theory.

The picture presented here is not without similarity to wave mechanics. Mass and velocity or energy and many other pairs come into the picture of the physical world as understood at present through mathematical constants such as that of Max Planck's "*h*" which is the unitive principle between the twin rival or complementary factors involved in the particular mechanics. Just as the trained scientist can understand wave mechanics in terms of the constant "*h*" so the philosopher is asked here to look at the successive grades of phenomenal manifestation of the visible world through elemental principles understood as substantially the same as the stuff of consciousness itself.

Consciousness has its radiating or horizontal wave aspect and the aspect of depth in which contemplative operations can move. When contemplation is established the difference vanishes, but in a more passive state, the waves appear as such in consciousness. Appearance has to be overcome and appreciation of reality established by the effort of contemplation. The effort alluded to in the previous verse is here too suggested as desirable for contemplative vision. The reference to the rows is to mark out the subtle gradation which will still persist in the vertical scale of reality between two elemental principles. Thales and Heracleitus gave primacy to water and fire respectively in their hylozoic systems of pre-Socratic philosophy. The flux of phenomenal life was, to Heracleitus, like a river which one could not enter twice. The vertical process of becoming was distinguished from the horizontal aspect of being. The latter was mere appearance. What is implied here in the Guru's verse is a similar idea in terms of pure consciousness which for him remains the central reality understood through the notion of a neutral Absolute.

Word Notes: The Vedantic term *vivarta* in this verse has been translated as "emergent" and by "seem to be" understood together. A mental projection of supposition of a reality not there is what is implied. *Vibhuti* has been translated "phenomenal aspect" because the root *bhav* suggests "becoming."

Bhutas are those entities that *have come to be*: the *mahabhutas*, the great elements, is the term applied to those elements in their universal aspect as fundamental principles in the creation or phenomenal emergence of the visible world.

4.

Knowledge, its meaning known, and the personal
knowledge

Subjective, together make but one primal glory;

Within the unrarified radiance of this great know-
ledge

One should merge and become that alone.

THERE is a subtle tri-basic factor called *triputi* which is responsible for our wrong appraisal of reality. The lazy mind left to itself without the attitude of contemplation has a tendency to view reality sectionally or horizontally, as it were, from an angle which takes for granted the knower, the knowledge as a concept, and the objective side of knowledge as three distinct disparate entities. One has to counteract this tri-basic prejudice to which the human mind is naturally disposed. We take a cross-sectional rather than a lengthwise view of reality.

Bergson has referred to this tendency as "the cinematographic function of thought" by which it appraises "stills" of a moving picture rather than the motions as such. Pure motion eludes appraisal by the mind because of its incapacity by its very structure to take in events other than mechanistically. The horizontalization of our relation with the visible world produces a similar tri-partite cleavage in our thought-process, which, instead of being the continuous process that it really is, shows itself under split or separated aspects by which the unitive nature of thought is marred.

The paradoxes of Zeno are well-known classical examples of the kind of contradiction or error implied in all thought referring to the phenomenal world related to space. Even with reference to the vertical time axis, pure time can be thought of without such divisions into disjunct events by a little training in meditation; but it is merely the time as known by the tickings of the clock that is more naturally cognized.

When the vertical view is established a sense of wonder of contemplative vision goes with it. As such knowledge refers to the Absolute, it is called here the "great knowledge" which, once established, shines inclusively without intermission.

"But one primal glory": When the tri-partite split has been transcended by another way of approach to reality which is more in keeping with contemplation, an inclusive and universal value of great interest and intellectual content takes its place in the centre of consciousness.

The elements when conceived as belonging to the grand elements of the vertically graded series that we have seen as implied in the last verse, is

here referred to as the *mahas*. The Guru does not want straightaway at this initial stage of the development of the subject, to refer to any definite finalized concept such as the Absolute. The notion of the Absolute Self will be developed methodically stage by stage. The relation thus correctly established between the subject and the object of contemplation does not admit of any duality at all, and the bi-polarity is bound to be perfect. The unitive compact character of the relationship is underlined by the words "but" and "one" which, read together with the last word of the verse where the word "alone" occurs, contains something of the same idea as that of Plotinus where he refers to contemplation as the "flight of the alone to the Alone."

"Unrarified radiance": Light is the favourite analogy for wisdom. Direct awareness which true wisdom demands, is not of the nature of a merely syllogistic ratiocination, but approximates to an intuitive vision which is immediate rather than mediate. Ratiocinative thought is normal as between things and is a dull mechanistic movement in consciousness compared to the compact or intensive thought which contemplation can establish.

Henri Poincare refers to a state of mind in which he was led to a great mathematical discovery when he one night lost his sleep after drinking black coffee. This is a recent instance where the mind shows itself in special states to be capable of functioning differently at a higher scale than usual. Mystical states referred to in religious books become probable in the light of such possibilities. When such a white heat is established in thought, the methodology applicable becomes changed. The logical rules of double negation and inclusive conjunction become applicable to the style of thinking which has nothing to do with ordinary logic. Light when it becomes intense denies darkness and establishes itself as a reality without rival. Relativistic thought thus changes into absolutist thought which becomes unitive and positive.

"Become that alone": The identity of subject and object in contemplative life has been recognized both in the East and the West. The reference of Plotinus to the flight of the alone to the Alone is a direct paraphrase of the state of *kaivalya* (aloneness) which is the goal of contemplative life even according to dualistic schools such as that of Patanjali. With the *maha-vakyas* (great dicta) derived from the Upanishads, such as *Tat tvam asi* (That thou art) etc., this identity of subject and object may be said to be the central doctrine of wisdom generally.

When we say that the kingdom of God is within or that I and my Father are one, in the biblical context, the same verity is implicit. The imitation of Christ would be sacrilege if there was not this idea implicit in the suggestion made. That the *brahman* (Absolute) knower attains the Absolute and becomes one with it is clearly stated in the *Taittiriya Upanishad* (II. i) "He who knows Brahman attains to the highest." That the present work follows the lines of Vedanta in general is indicated here.

Word Notes: *mahas* and *mahat* are terms originally known in the context of Samkhya *tattvas* (principles) later incorporated into the Gita and other Vedantic works. It has to be understood in the light of the revaluation it has undergone in the course of its use, with all vestiges

of duality being progressively abolished. In his book *Yoga as Philosophy and Religion* (New York, 1924), Surendranath Das Gupta refers to the "two parallel lines of evolution" starting from *mahat*, one by which it passes through intermediate *tattvas* such as "ego, manas, the five cognate and the five connative senses" while in another line of evolution "it develops into the five grosser elements through the five *tan-matras* which are directly produced from *mahat* through the medium of *ahamkara*. *Vyasa Bhashya* II. 19, has a revised version in which the duality of yoga texts is better reconciled." (pp. 59—60)

(To be continued)

Correction : On page 199, 3rd line from bottom
 "XV" should read "XVIII"

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Mathematics and Mysticism

(Continued from page 201)

abstract as both transcendent and immanent, we shall have succeeded in equating the mystic and the mathematician with human and divine powers at one and the same time.

God as the designer of man thinks mathematically and man meditating on God as the mathematician is doing the same thing from another pole of the vertical axis which unites them both in a single dialectical situation. The best mathematicians when they are engaged with the fundamental problems of the universe are obliged to think like the Maker of all things, and the mystics on their part who contemplate God are another variety of subjectivists who are capable of fitting the notion of a unitive God into a picture of the universe which they can feel around them.

The kind of subjective selectivism represented by the modern physicist when he employs the symbolic language proper to his subject is a form of delving into the negative recesses of the self not different from the introspection of contemplative mystics. Only the style differs.

Mystery of the Language of Physics: Prof. George Temple put his finger correctly on the two extreme limiting points of the role of modern mathematical thought when he made the following statements:

My answer to the question 'What is mathematics?' can be given in six words. I maintain that mathematics is the language of physics and that this conception of mathematics is the key to the contemporary organization of physical science. (p. 555, *The Listener*, March 10, 1950).

In his next broadcast published in *The Listener*, April 6, 1950, he amplified the above statement so drastically that he might be said to have, in effect, negated its import. He said:

It would, however, be a profound mistake to think that the pure mathematician regards his work solely as conferring a certain formal polish and orderliness on physical mathematics. He does indeed recognize how much the applied mathematician has to learn from the pure mathematician, but the improvement of mathematics as the language of physics is by no means his main work. That work may be tentatively described as the creation of new languages unrestricted by any expectation that they may one day embody physical truth. Modern algebra may be broadly described as the systematic examination of all possible mathematical structures and linguistic situations... As for modern geometry, that is such an untrammelled flight of the imagination as to pass over the frontier of language into pure poetry.

Further the professor refers to mathematics as "this strangely esoteric

science" and when we read such remarks from the lips of those who have full authority to speak on the subject, side by side with statements such as "There is no place in mathematics for passion or prejudice" and that "Mathematicians are queer folk" and that they live in "intellectual isolation" and that "no doubt these principles (of mathematical formulae embodying the basic principles of theoretical physics) have been *cogitated by induction* from a vast assembly of empirical facts"—all these remarks put together must give us now a clearer insight into the nature of mathematics than ever before. The professor also refers to a certain "*dynamism in mathematical thought*" which "carried on the mathematician from putting the question to devising the reply." (*ibid.*)

Mathematics could therefore be thought of as qualitative operations in time which can predict what could be true by a kind of inductive cogitation from one set of abstract facts to another. It is a form of pure reason or intuition of a certain *thing-in-itself* without reference to anything that is outside the mind or itself. It refers to movements in consciousness lying along the vertical axis of the world of perceptual, not actual, values.

The Axis of Mathematical Dynamism: That there are two different levels in our consciousness where mathematical notions cluster themselves in the form of logical coherences or natural laws is an interesting feature which is coming more and more in evidence in modern thought. There is a subconscious or subliminal stratum in consciousness where mathematics resides in terms of feeling rather than as relations or entities of intelligent thinking. The latter has a level of its own and might give us useful notions in applied science holding the interest of the inventor. These two strata of mathematical thought react and combine under favourable conditions of the psyche. The following two paragraphs extracted from the writings of Henri Poincaré enable us to distinguish the emotional and logical poles in which mathematical operations could take place in the psyche:

For fifteen days I strove to prove that there could not be any functions like those I have since called Fuchsian functions. I was then very ignorant; every day I seated myself at my work-table, stayed an hour or two, tried a great number of combinations and reached no results. One evening, contrary to my custom, I drank black coffee and could not sleep. Ideas rose in crowds, I felt them collide until pairs interlocked, so to speak, making stable combination. By the next morning I had established the existence of a class of Fuchsian functions, those which come from the hypergeometric series; I had only to write out the results, which took but a few hours. (*The Foundations of Science Relating to Mathematical Creation*, quoted p. 36 in *The Creative Process*, Mentor, New York).

The pairs that interlocked to give rise to the understanding of the functions in the above story of their discovery reveals the structure of mathematical thought which forms at two levels. The dynamism

be comes more explicit in the following further explanation of Poincare :

Now what are the mathematic entities to which we attribute the character of beauty and elegance and which are capable of developing in us a sort of aesthetic emotion? They are those whose elements are harmoniously disposed so that the mind without effort can embrace their totality while realising the details. This harmony is at once a satisfaction of our aesthetic needs and an aid to the mind, sustaining and guiding. And at the same time in putting under our eyes a well ordered whole, it makes us foresee a mathematical law. Now, as we have said above, the only mathematical facts worthy of fixing our attention and capable of being useful are those which can teach us a mathematical law . . . So that we reach the following conclusion. The useful combinations are precisely the most beautiful, I mean those best able to charm this special sensibility that all mathematicians know but of which the profane are so ignorant as often to be tempted to smile at it. (*ibid.* p.40)

Mathematics thus moves between two poles, one which appeals to the sentiments and the other which refers to formal logic. The purer the mathematics the more mystically aware of the global aesthetic pole of mathematics the mathematician will be. Invention or prediction implied in all discovery through mathematics is in the form of an interaction between the two poles, both of which belong to the order of abstractions of the mind. Interest is the vertical axis along which the two sets of mathematical entities whether known as emotions or facts, can interact. The mystical mood and the mood of the positive scientist have thus to co-exist and interact in any valuable human discovery, whether *a priori* or *a posteriori* or both, worth the name.

Quantitative and Qualitative Abstractions : When we count and pass from one-two-three to infinity there is something strange happening within us which we generally do not notice. Till three we really think quantitatively, but at the mention of infinity we stand face to face with something of quite another order. The quantitative infinities of numbers could be many, depending on the serial, cardinal or ordinal, which might be thought of. The Russell Paradox which he himself describes as follows could be overcome when we separate these two aspects of number, quantitative and qualitative, more correctly :

Take the series of whole numbers from 1 onwards ; how many of them are there? Clearly the number is not finite. Up to a thousand there are a thousand numbers ; up to a million a million. Whatever finite number you mention, there are evidently more numbers than that, because from one to the number in question there are just that number of numbers, and then there are others that are greater. The number of finite whole numbers must, therefore, be an infinite number. But now comes a curious fact. The number of even numbers must be the same as the

number of all whole numbers. Consider the two rows :

1, 2, 3, 4, 5, 6 . . .

2, 4, 6, 8, 10, 12 . . .

There is one entry in the lower row for every one in the top row ; therefore the number of terms in the two rows must be the same, although the lower row consists of only half the terms in the top row. Leibniz who noticed this thought it a contradiction, and concluded that though there are infinite collections there are no infinite numbers. Georg Cantor, on the contrary boldly denied that it is a contradiction. He was right. It was only an oddity. (*History of Western Philosophy*, 1946)

The Russell paradox as stated above is only a particular instance of subtler paradoxes mentioned by Zeno and Prof. McTaggart where pure or qualitative time is brought into contrast with space or motion. If we think of pure time as qualitative, space would be quantitative. The primacy of time over space as an abstraction, could be brought out by the following laws regulating the incidence of ordinary physical bodies :

- (1) A given body could not be at two different places at the same time.
- (2) Two different bodies cannot be at the same place at the same time.
- (3) One body can be at the same place at two different times.*

The body and its location are horizontal aspects of reality, and only when the vertical aspect of time is introduced do we understand its reality more fundamentally. The paradox implied here has been analysed in a verse of the Guru Narayana :

*The body and the like, one in another no being have;
The converse therefore untrue becomes : as from day to day
Unextinguished they prevail ; assuming again their
Existent form they keep ever becoming.†*

The Primacy Due to Time Abstraction: In other words qualitative existence in time is of a different order from quantitative existence in space. Things cannot occupy the same space horizontally but could continue to exist in time as a vertical reality. Mathematical entities could be thus thought of vertically or horizontally. The horizontal admits of contradiction but the vertical does not. The Zeno and McTaggart paradoxes and that of Russell could attain to an intelligible status if this distinction of vertical and horizontal abstraction that mathematics is capable of, became better recognized. We could then see how to understand the Leibnizian view as also those of Kant, Bergson or Descartes more unitively and intelligently.

* cf. *The Listener*, April 10, 1956, broadcast by G. J. Whitrow on *The Mathematicians' Idea of Time*.

† *Atmo-padesha Satakam*, verse 86.

The mystery of number which has persisted from Pythagoras to Eddington would be well on the way to being settled as understandable, non-understandable, or both, when our epistemological approach to abstract notions is better clarified. The vertical aspects should not be mixed up with the horizontal aspects with mathematical entities representing various values in consciousness. What Bertrand Russell dismisses as a mere *oddity* above is a deeper mystery to the truer philosopher like Leibniz who sees in the oddity a contradiction which has to do with the enigma of life itself. His monadology in his answer where the vertical is given primacy over the horizontal realities of life. Russell prefers to remain a sceptic for its own sake and gives primacy to horizontal values, while Leibniz as a truer philosopher tends to give primacy to the vertical. Reality can be viewed with equal validity, giving primacy to the one or the other of these axes of correlation.

It is up to each philosopher to say what he wants. Mathematical entities could be quantitative or qualitative abstractions and under each of these broad divisions there is a further possibility of degrees of abstraction. The difference between arithmetic and algebra already represents this possibility of abstraction; algebra being more general than the world of arithmetic which suits the quantitative aspect of reality better. The sedenion algebra of Eddington and the Fuchsian geometry of Poincare are more generalized forms of mathematics which can accommodate more particular cases than ever before. Topological geometry and projective geometry similarly represent the abstraction of flat Euclidean geometry which started with earth measurements. A football-like spherical space is going out of fashion in favour of something like the inside of a half-inflated tyre tube in cosmological imagery at present.

Mysticism Enters by the Back Door: Logic depends on abstract operations of the mind. Language is needed for these operations. When logic has to deal with a large number of instances under a generalized heading it has to enter into the semantic and syntactical implications of propositions. Mathematics helps to reveal the structure of pure or practical thought in the generalized or much abstracted form of logistic or propositional calculi. Although at one time scientific empiricists thought that they had nothing to do with abstractions, they have admitted the need for logic recently in the revised logico-empirical world of reality they have come to accept.

The Vienna circle of "Logical Positivists" although they rely on abstract statements largely, are limited to the empirical method of determining what is "meaningful" to them against what they consider absurd or meaningless. The meaningless is what cannot *work* and prove its use in the progress of science. The tradition of Peirce is continued here. The working of the mind of those who stood for mathematics or logic as strictly limited to the domain of the experimental sciences can be gathered from the following extract:

This marriage of the empirical and logical traditions was first

solemnized by the name 'Logical Positivism' in order to indicate the two families united, but this was changed later to 'Logical Empiricism' when it was realized how bad the odor of the word 'positivism' was for those who associated it with the narrowness of Auguste Comte. (p. 204, *The Age of Analysis*, Morton White, Mentor, 1955).

Logical Empiricists like Rudolph Carnap and Bertrand Russell insist on pinning their faith on the *a posteriori* world of demonstrable events or facts of life. They take pride in their scepticism which saves them from all that is 'according to them' meaningless," which latter is often the domain of the *a priori*.

To put the contrast in one sentence, if you ask the Logical Empiricist if the sun will rise the next day he would content himself by saying "It is *very probable*," instead of saying "sure" as common sense might dictate. Perhaps the common sense position in the matter could be slightly improved and made more scientific if we should say, "It is *very unlikely* that the sun will *not* rise tomorrow." The former way gives primacy to the *a posteriori* while the latter gives primacy to the *a priori*. A science could make use of both these ways and still have the validity of equal certitude or meaningfulness.

When thus the *a priori* is admitted into science on its own right, we have a new approach to wisdom, which at first resembles mysticism although, as we have tried to say, mathematics and mysticism are only two poles of abstract subjective, yet dynamic, thought processes. Through the admission of logic into empiricism, mysticism may be said to have already entered the domain of science as it were, by the back door.

Non-Experimental Mathematics: When we say that the proof of the Pythagorean theorem of a right-angled triangle does not depend on actual measurement, we have made a statement most damaging to experimental science.

From the idea of pre-established harmony and the mystery of numbers through the *Mathesis Universalis* of Leibniz to the *Principia Mathematica* of Russell and Whitehead and the Fundamental Theory of Eddington, we have a long history of subjectivism in mathematical speculation by which the problem and its solution could be arrived at with eyes shut.

In the meanwhile Euclidean geometry has been superseded by what is called projective geometry and algebra has its new version in sedenion algebra, both of which latter treat the corresponding prior form of mathematics as merely particular cases. In fact the scope of mathematical inquiry has extended. Likewise, Newtonian space has had to be discarded in favour of a time-space continuum which refers to a frame of reference which can speak of a hundred and fifty light years with space attracting or repelling bodies from any point in a universe that expands or contracts or both.

The sense of wonder and consequent vagueness of the import of these great discoveries are not yet over and the language of science has to rid itself of much confusing rhetoric before we can see clearly through the maze of new facts which have to be fitted into a coherent whole. Einstein has been responsible for tempering with mathematics which he sometimes justified and sometimes himself criticized. As Eddington explained: "Einstein has been as severe a critic of his own suggestion as any one, and he has not invariably adhered to it." (p. 31, *The Expanding Universe*). The suggestion that Einstein made is referred to by Eddington in the following simple terms:

Einstein almost inadvertently added a repulsive scattering force to the Newtonian attraction of bodies. (*ibid.* p. 30)

Earlier, in the same work, Eddington describes what Einstein did:

The central result of Einstein's theory was his law of gravitation . . . A year or so later Einstein made a slight amendment to his law, to meet certain difficulties that he encountered in his theory. There was just one place where the theory did not seem to work properly, and that was infinity. I think Einstein showed his greatness in the simple and drastic way in which he disposed of difficulties at infinity. He abolished infinity. He slightly altered his equations so as to make space at great distances bend round until it closed up. So that if in Einstein's space you keep going right on in one direction you do not get to infinity; you find yourself back at your starting point again. Since there was no longer any infinity, there could be no difficulties at infinity. Q.E.D. (pp. 28—29, *ibid.*)

In the above paragraph we have a close-up of what takes place in the philosophy of science where some "Absolutist" notions are replaced by "relativist" ones for the sake of avoiding difficulties in the actual working out of theories. It is a trial-and-error process of revision. A careful study of the modified theories would be seen, however, to have included certain other absolutist notions themselves. The cosmical constant *lamda*, is one such. Many other constants have now been added. The velocity of light is often used as an absolute norm of reference, thus coming back to a form of absolutism. All this tampering with classical notions in mathematics is ushering in a new era of modern mathematics which might serve as the language of physics and metaphysics at one and the same time.

That mathematical thinking, though exact and logical need not necessarily, by itself, lead to the same or similar conclusions is sufficiently evidenced by the fact that Russell and Whitehead, who were joint authors of the work on the principles of mathematics, differed diametrically, in their own philosophical findings. The same mathematical method produced the greatest of modern sceptics as well as perhaps the greatest of modern believers.

Sir Edmund Whittaker, delivering his memorial address on Eddington on Aug. 9, 1951, rightly applauds the philosophical system of the century based on the latest notions of mathematics and science when he says:

The philosophical system of my old friend and teacher Alfred North Whitehead is justly regarded as the most metaphysical achievement of the present century. (p. 31, *Eddington's Principle in the Philosophy of Science*, Camb. Univ. Press, 1951)

Eddington as understood by Whitehead leads us back through mathematics to a revised form of belief in God which is not without its striking kinship with mysticism of a pure and revised form.

"Subjective Selectivism" and Sheer Mysticism: Eddington has described himself as a selective subjectivist and as being against mere "crude experimentalists." His various mathematical constants are meant to reveal a world based on fundamental theory referring to a "principle of science" of his own as stated in his posthumously published volume bearing the title *Fundamental Theory*. Although there seems, just at the present moment, a tendency among scientists to put Eddington's ideas back into a sort of cold storage, especially by the school calling itself "Logical Empiricist," about which we have already made some remarks, Eddingtonianism constitutes in itself one of the major challenges to be met by the modern thinker.

It is related backwards to the theorem of Pythagoras which could question the length of the hypotenuse of a right-angled triangle and answer it without recourse to measurement. Both the question and its answer belong to the domain of subjective thought-dynamics. Leibnizian Universal Mathematics also stressed the qualitative side of reality as against the quantitative side. As Sir Edmund Whittaker has said:

Leibniz, however, initiated a new philosophical outlook; he advocated in his own words (Vol. VI, *Mathesis Universalis*) a subordination of a science of quantity to the science of quality — of the science that deals with numerical relations to that which treats of order and similarity. This is Eddingtonianism pure and simple. (p. 5, *ibid.*)

The same writer makes the subjectivism implicit in Eddington's mathematical methods very clear when he continues:

Eddington's Principle depends on the distinction between what we have called quantitative and qualitative assertions; it may be stated thus: *All the quantitative propositions of physics that are the exact value of the pure numbers that are constants of science may be deduced by logical reasoning from qualitative assertions, without making any use of quantitative data derived from observation.* (pp. 2-3, *ibid.*)

Mysticism is sometimes defined as the cultivation of the presence of God. It refers to the way of life of the believer. Eddingtonianism which

is the latest expression of mathematically understood science, in the light of the above authoritative quotations, refers not only to a form of inner life like that of the mystic, but involves a reference to an entity equivalent to the concept of God or the Absolute Principle. This entity is sometimes referred to as the Eternal as in the following passage from Sir Edmund's analysis of Eddingtonianism :

We stand in awe before the thought that the intellectual framework of nature is prior to nature herself—that it existed before the material universe began its history—that the cosmos revealed to us by science is only one fragment of the plan of the Eternal. (p. 31, *ibid.*)

Mysticism cannot come any nearer that what is implied in the above quotation to join hands with the language of physics which is mathematics. Much as we should not like to see the language of mathematical physics lapsing into one of complacent solipsism, and keen as we are to see mysticism rid of its sentimental vagueness about the notion of the Absolute, which is the central subject matter of both these forms of activity in human consciousness, it would still be an important day in the history of modern thought to see that mathematics and mysticism though two of the strangest of possible bedfellows, could come together as complementary aspects of the same wisdom that concerns both these approaches to the Absolute.

By a dynamism taking place within consciousness as between two poles of the human personality and joined theoretically by a vertical axis of correlation, mysticism and mathematics represent activities of the psyche that always belong together as expressions of the Absolute which each of us represents within. This Absolute could be referred to as being immanent or transcendent, as psychologically within or cosmologically without. There is a pre-established correspondence between the two aspects thus united. Whether called God, Nature or the Eternal in theological or contemplative language, the subject-matter and object-matter of human thought or emotion must refer to the same central Absolute.

Finally, in order to make it sufficiently evident that scientific mathematics and mysticism could refer to the same high value whether in the Vedanta of the East or in the Fundamental Theory of a leading scientist of the West, we shall not in vain conclude here with one more quotation from Sir Edmund Whittaker which must suffice to put the seal, as it were, on the final rapprochement of the two ways of life we have discussed, irrespective of the time or clime of the thought involved :

In the laws of nature, known and unknown, we recognize a system of truth, which has been revealed to us by the study of nature, but which is unlike material nature in its purely intellectual and universal character, and which if the conclusions we have reached are correct, is timeless in contrast to the transitory universe of matter: Material nature has made manifest to our

understanding realities greater than itself, realities which point to a God who is not bound up with the world and who is transcendent and subject to no limitation. The principle that matter exists not for its own sake but in order to help us in bridging the gulf that separates us from the divine, may be expressed in theological language by saying that nature has a sacramental quality, a principle that has long been recognized in religion, and can now be admitted to be not alien to the philosophy of science. (p. 34, *ibid.*)

Except for the part we have italicised in the above quotation, which points to the same Platonic tendency which we have noted in the philosophy of Whitehead (see *VALUES*, Feb. 1959) — a tendency to transcendentalism at the expense of Aristotelian reality — the whole paragraph quoted could pass for the essence of Eastern Vedantic thought as in the Bhagavad Gita (VII. 8-9) which refers to earth and water as sacred side by side with the more abstract idea of the Absolute which is adorable elsewhere in the text. When an epistemology and methodology could be evolved common to the "sciences" and the "humanities" and a theory of values formulated, mathematical and mystical abstractions could be made to refer to one and the same central human norm conceived as that neutral Absolute which is the World Spirit both immanent and transcendent at once.

[END.]

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