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Professor DS Kothari's Reflections on the Parallelism between Epistemological Foundations of Modern Physics and Indian Philosophical Thought—Part II: The Principle of Complementarity and Syādvāda

R.K. Jaggi
802, Ramada Drive, Houston, TX-77062, USA
Sameera Kothari
71, Vaishali, Pitampura, Delhi-110 034
and
A. Nagaratnam
Emeritus Scientist, Defence Metallurgical Research Laboratory, Hyderabad-500 258

A favourite theme in Prof Kothari's talks and writings during his later years was the close parallelism between Bohr's principle of complementarity and Indian philosophical thought, in particular, the *Syādvāda* of Jain philosophy[1-6]. In this part of the article, we have tried to summarize Prof Kothari's views on the subject.

The complementarity approach enables us to appreciate that seemingly irreconcilable points of view need not be contradictory, but parts of a 'totality' seen from different perspectives. Bohr fervently hoped that one day complementarity would be an integral part of everyone's education and provide guidance in the problems and challenges of life.

The complementarity principle has emerged, in the modern context, from the study of atomic phenomena. For example, let us consider the electron. It can behave as a particle as well as a wave. A particle is confined in space and time. It is characterized by its energy and momentum. All electrical devices, including TV tubes, work on the basis that electrons are charged particles. The same electron under a different set of conditions behaves like a wave. A wave exists everywhere in space and time at the same time. It is characterized by a frequency and wavelength, and has nothing in common with a particle.

The complementarity of the wave and particle aspects of matter can be illustrated by an idealized 'thought experiment'. There is an atom in a closed box. The box is divided by a partition into two equal compartments (Fig. 1). The partition has a small hole so that the atom can pass through it. According to the common sense view of reality, classical logic and classical physics, the atom (which is a particle) can be

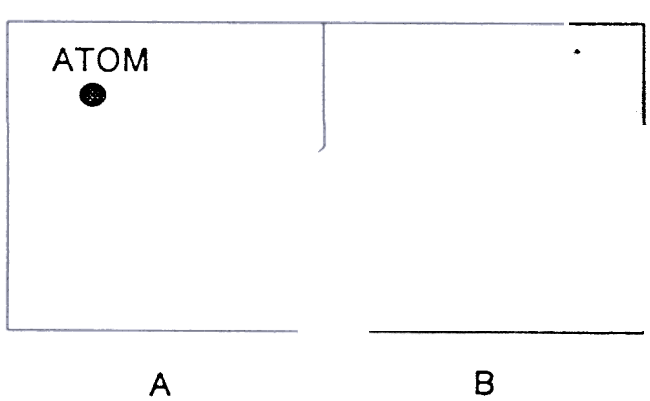

Figure A 'thought experiment' to illustrate the complementarity principle.

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either in the left or in the right compartment; there is no third alternative.

But to explain adequately the results of certain experiments (pattern of interference fringes), we have to admit that in some strange way, which defies description in words, the same atom is, at the same time, in both the compartments. This type of behaviour can be explained if we attribute wave-like behaviour to the atom. An experiment which demonstrates the wave aspect would automatically exclude demonstration of the particle aspect, and vice versa. It arises from an interaction, inherent in the nature of things between a system and the measuring instrument, between the observer (subject) and the observed object. The interaction cannot be eliminated even under ideal conditions, and cannot be reduced below a certain minimum limit, defined by Planck's constant. The interaction disturbs the state of the system under observation. The existence of this unavoidable 'disturbance' allows the *superposition* of contrary states, say state A (say, corresponding to particle being in compartment A) and state not-A (corresponding to particle being in compartment B), without generating contradiction. This happens because, when the superposed state of A and not-A is subjected to an act of observation to discover how the superposition comes about, the disturbance accompanying the observation projects the superposed state into either the state A or the state not-A. This makes contraries complementary, and not contradictory. As discussed a little later, it corresponds to the *avyakta* concept of *Syādvāda* in Jain philosophy. (In Aristotle's logic contraries are contradictory and cannot coexist.)

Similarly, we know that light, or more generally electromagnetic waves, behave as waves. We have radio and TV transmissions, all based on the wave nature of these radiations. One can perform interference, diffraction and polarization experiments to demonstrate their wave nature. Yet light is also known to exhibit particulate nature in certain circumstances. We have then to admit that we do not know what light is. Even Einstein said: "All these 50 years of conscious brooding have brought me no nearer to the answer to the great question 'What are light quanta?'. Now-a-days every Tom, Dick and Harry thinks he knows it, but he is mistaken".

The wave-particle complementarity in quantum physics lies entirely within the domain of objective science. But it can serve as a launching pad, as it were, to gain insight into higher complementarities which lie beyond science.

Both science and religion have their origins in man's basic urges and his deepest convictions. Scientific truths and moral truths are not contradictory, but complementary. It is the exploration and practice of the complementarity of scientific and moral truths that gives to life richness, dignity, beauty and happiness. Fortunately, science is now slowly and steadfastly moving towards a unified world view which includes both knowledge and values as complementary and mutually reinforcing.

In the *Gita*, as well as in the *Upanishads*, one often encounters statements which appear to contradict each other. They appear nonsensical to normal logic and even 19th century science. For example, *Isha Upanishad* (verses 4 and 5) states[7]:

Verse 4

One unmoving that is swifter than Mind
That the Gods reach not
For It progresses even in front. That, Standing
Passes beyond others as they run
In That the master of Life establishes the Waters.

Verse 5

That moves and That moves not
That is far and the same is near
That is within all this
And That is also outside all this.

In Verse 61 of Chapter XVIII of the *Gita*, Lord Krishna says: 'The Lord dwells in the hearts of all beings, O Arjuna, and by His *Maya* causes all beings to revolve as though mounted on a machine', while Verse 83 states: 'Thus has wisdom more profound than all the profundities been declared to you by Me. Reflect upon it fully and act as you choose'.

What is the point in asking Arjun to do what he wants, when the Lord has said that He drives everything like a machine!

Prof Kothari was very fond of these two verses. On many occasions when a 'scientist' or an 'engineer' came to him and talked about logic and 'science' and superstitions in India, he would quote these and leave the person to ponder. Serious individuals, by deeply thinking on these two, were led to an in-depth study of

the *Gita*. Even Aurobindo says: "The principle the *Upanishads* follows throughout is of uncompromising reconciliation of uncompromising extremes".

The profoundest and most fundamental of all complementarities is that of matter and consciousness (mind), of *phusis* and *psyche*, of the 'external' and the 'internal' worlds, that is to say, the 'atom' and 'self'.

Prof Kothari elaborates on this point by recapitulating Schroedinger's line of argument[8]: Let us assume, as undisputed, the two facts of experience: (a) my body is a machine, totally governed by the laws of nature, and (b) its motions are under my control (free will). While (a) is a scientific and objective fact of experience, (b) is a subjective fact of experience. From these two facts the only possible inference, as Schroedinger has stressed, is that every mind that has ever said or felt 'I' is the *One* who controls the 'motions of the atoms' to control the universe, according to the laws of nature. Says Schroedinger[8]: "From the early great *Upanishads* the recognition *ATHMAN-BRAHMAN* (the personal self equals the omnipresent, all-comprehending eternal self) in Indian thought is considered, far from being blasphemous, to represent the quintessence of deepest insight into the happenings of the world." Prof Kothari similarly concludes that the seeming contradictions discussed by Schroedinger are ultimately expressions of the *Vedantic* identities 'That Thou Art' [तत्वमसि] and 'I am the Brahman' [अहं ब्रह्मेस्मि]. The Jain *Sutra Samana Suttam* (*Sutra* 19) similarly says[5]: "He who knows his self (*atma*), knows the outer world; and he who knows the external world, knows his self".

The logic of complementarity has a special place in Jain philosophy[2]. *Syādvāda* (*Syād* means 'may be') asserts that the knowledge of reality is possible only by denying the absolutistic attitude. (Prof Kothari points out that Mahalanobis[9] and Haldane[10] have discussed the significance of *Syādvāda* for the foundations of modern statistics.) Every facet of reality can be described in 7 ways, which are combinations of affirmation and negation, viz., existence, non-existence, occurrence of existence and non-existence, inexpressibility or indeterminateness (*avyakta*), inexpressibility as qualified by existence, inexpressibility as qualified by non-existence, and inexpressibility as qualified by both existence and non-existence. The key element of *Syādvāda* dialectic, viz., the fourth mode of inexpressibility (*avyakta*) is particularly applicable in the discussion of the wave-particle duality and the principle of complementarity in modern physics.

Prof Kothari points out that the validity of the concept of complementarity is implicitly recognized in most philosophical systems of the east[3]. For example, when the Nobel Laureate in physics, Hideka Yukawa was asked whether he had difficulty in comprehending the idea of complementarity as do physicists in the west, he replied that the concept appeared to him to be self-evident. "You see, we in Japan have not been corrupted by Aristotle's logic".

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