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Ideas and Researches on Physical Concepts in India

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In an article of this kind with rather an ambitious title and spanning a long period, though a knowledgeable reader can understand some oversights and omissions of minor significance, it is essential that there should not be any factual errors, misinterpretations nor exaggerated claims. A historian of science needs to be truthful to the primary or original works both in their context and content. Viewed in this light, some comments on this article are as follows:

In the Abstract (p.361), the statement: *'The Buddhist, Jain, Sāmkhya and Nyāya- Vaiśeṣika schools gave central focus to Nature (prakṛti), in place of Gods*, *as a limitless entity which is self existent',* is a distorted view. For, it is well known that the main plank of Buddhism is its Doctrine of Impermanence or momentariness (Pali: *anicca*; Sans: *anitya*), considering existence as a flux or continuous *becoming*. A section of the Buddhists was also nihilist (*śūnyavāda*) in a way negating the idea of world and existence. The Jainas no doubt do not think of God as the creator, because they consider the Universe as uncreated and endless in time. But they do believe in the transformation of *ātman* into *paramātma*, and the worship of *tirthankaras,* their ideal of perfection and enlightenment. The *Sāmkhya* system expounds *prakṛti* as an intertwined equilibrium of three *guṇas*, evolving itself in a particular way as a result of its nearness to or interaction with *purūṣa*. The *Nyāya*-*Vaiśeṣika* school postulates reality in terms of seven categories, the first one being substance or *dravya* composed of nine substances. As regards the idea of god, there was also *Seśvara Sāmkhya* with a god- head, besides the *Niriśvara* one. The Nyāya- Vaiśeṣika projected the idea of *adṛṣṭa* or unseen (divine) force while explaining the cause of atomic motion. In any case, the *Sāmkhya*, the *Vaiśeṣika* and the Nyāya belong to the orthodox schools, accepting the Vedic thoughts.

The author's exposition of the *Sāmkhya* school (pp 361; 364-65), is far- fetched and echoes the views of a few old authors like B.N. Seal. If the original texts dealing with *Sāmkhya*, like the *Sāmkhyakārikā* of Iśvarakṛṣṇa and the *Sāmkhyapravacanabhāṣya* are studied, one can get a true picture of the expositions of the *Sāmkhya*. It may be noted that the word, *prakṛti*, in *Sāmkhya*, is also called *pradhāna or avyakta* or unmanifested. This needs to be understood in terms of the equilibrium of the three *guṇas* (*sattva, rajas and tamas*) and *prakṛti'*s evolution when this equilibrium becomes disturbed, as noted earlier, because of its nearness to, or interaction with *purūṣa* or sentient being. It is certainly not a cosmic evolution of 'both matter-stuff and mind-stuff' as the article tacitly asserts. In the Sāmkhya evolutionary scheme, the *tanmātras* or the subtle states are connected with the 'Ego' and not with the mind, the idea of *tanmātras* itself owing its origin to the upaniṣadic metaphysical approach to Brāhman. In any case the *Sāmkhya* school envisages multitude of *purūṣas* and a duality in a special way.

The formation of the five elements from the subtle *tanmātras* in a progressive, evolutionary manner is an integral part of the *Sāmkhya* evolutes. In the process, the five elements of upaniṣadic origin cast off their metaphysical garment and assumed special physical properties and associated with the five senses. The *Sāmkhya* does not subscribe to the notion of cause and effect, but only to an evolutionary model. Likewise, it does not think in terms of atomism as the *Vaiśeṣika* does. To project the *Sāmkhya* ideas in the frame of atoms, misinterpreting the *tanmātras* in terms of atoms is erroneous. The use of words like 'atomic *ākāśa'* and 'non-atomic *ākāśa'* (p.365) by the author is but fanciful and difficult to understand them. His statements: 'The concept of non-atomic *ākāśa* as a starting point of material creation reminds one of Fred Hoyle's of material creation' and '..the duality concept like *purūṣa* and *prakṛti*, *Śiva* and *Śakti,...*is comparable to Dirac's hypothesis of anti-matter..' (p.365), are examples of incompatible extrapolation.

The Geek theory of elements, as presented by the author (p.367), needs factual correction and refinements. The pre-Socratic thinkers like Thales (c.624-565 BC), Anaximenes (born c. 570 BC), and Heracleitus (c. 540-475 BC) respectively postulated that the primordial or basic essence of the Universe was, *Water, Air or Fire*. Empedocles (c.500-435 BC) added *Earth* as the fourth element and called them the 'Roots of the World'. It was Empedocles, not Aristotle as presented in the article (p.367), who thought of two pairs of opposing qualities— hot and cold, dry and moist— and the transformations of the elements into one another in relation to these qualities. Further, it was Aristotle who included *Aether* as the *fifth* element and postulated that it was the constituent of all celestial luminaries. Thus he divided the celestial and the terrestrial, also in terms of motions—celestial motions are perfect, circular and with uniform velocity, while the terrestrial ones are imperfect. These ideas held sway over men's minds for nearly 1700 years, till they were set aside by the works of Kepler and Newton. The idea of *aether* lingered on in some other form even in the middle of the nineteenth century as a medium of propagation of electromagnetic waves including light. It was the negative result of Michelson-Morley experiment (1887) that eventually led to the rejection of the assumption of *aether* through the Special Theory of Relativity of Einstein.

The Greek theory of five elements was, however, different in conception from the Indian, the latter being associated with the five senses, the gateways of human knowledge, unlike the Greek, or the Chinese.

The statement that the atomic concept of the Greeks was not so clear as that of the Indians (p.407) cannot be justified on facts. The Greek atomism was conceptually strong unlike Indian atomism which had different nuances. The *Nyāya-Vaiśeṣika* atomism was only a part of its idea of *substance* comprising the five elements (earth, water, fire, air and *ākāśa*), space, time, self and mind. Even then, it was only the first four elements which were regarded as atomic, each having its own attributes. The combination between like atoms was thought of in terms of *adṛṣṭa* or an unseen (divine) entity, and the combinations were conceived in relation to two atoms- a dyad; three dyads-a triad; four triads-a tetrad and so on—all in a speculative manner. The Jainas conceived of their atomism (four elements only) as part of their concept of *pudgala* and it needs to be understood in the context of the Jaina's *Syadvāda*, and their view of time also being atomic. As for Buddhism, it was not the entire Buddhist thought-structure that envisaged atomism, but It was only the *Vaibhāśika* and the *Sautrantika* branches (of *Hīnāyana*) that postulated an atomism of the four elements including their qualities, even so as *forces* or energy and in the context of their doctrine of impermanence and flux.

On the other hand, in Greece, the pre-Socratic thinker, Leucippus (fl. 475 BC) and Democritus (c.470-400 BC), a contemporary of Socrates, as well as Epicurus (c. 342-270 BC) and his followers including Lucretius (95-55 BC) till about the beginning of the Christian era, expounded that atoms were the primordial stuff of the world (in contrast with the four elements as in India) and all things were made of solid indivisible atoms together with space or *void.* This pristine or foundational concept appealed to Gassendi (1592-1655) in France, Newton (1642-1727) and Robert Boyle (1627-91) in England, who revived in their own manner the Greek atomism in the 17th century. While calculating the planetary motions, Newton had assumed the inter-stellar space as a vacuum; but when he thought of the motion on the earth, the Greek idea of atoms and void appealed to him. Even Christian Huygens (1629-95) who did not subscribe to Newton's corpuscular theory of light propagation, lent support to Greek atomism. The Greek atomism was clear in its postulation, coupled with its concept of void, and universal in its approach, unlike the circumscribed, metaphysical Indian atomism. Hence Greek atomism, but not Indian atomism that became a part of history of modern science.

The Section on European science (pp. 369-70) in colonial India makes a disjointed reading, and even a confused one, in view of such statement by the author that '*no concrete effort was being made to introduce British science in its curriculum*'(p.369). There was neither British nor French science, then as now. The colonized people sometimes referred to it as western or European science, a region from which it came. The two-paged sub-section titled: '*Urge for European science by Indians'* (pp. 369-70) is sketchy and leaves much to be desired.

In the history of modern science, that of physics which is indeed an enchanting story, has been well documented and delineated as a glorious and triumphant human adventure in scientific ideas. This saga has been ably presented and clearly expounded in several scholarly books on history of modern science *chronologically* from the time of Renaissance in Science (from the 15th cent.) till the end of the twentieth century. There are also scholarly works which deal with the evolutionary and revolutionary ideas on the physical world of matter, motion, space and time, heat and light, magnetism and electricity, transformation of forces, doctrine of energy and the law of conservation of energy, mass and energy relationships, radiation, particle physics and related explorations. Some of the books also discuss the scientific methodology, the nature and structure of scientific knowledge and the criteria of verifiability, reproducibility and even 'falsibiability', besides the scientific determinism and its limitations.

The bibliography appended to this article does not confirm that the author has read authentic books of this kind and appears to be a summary of what the three authors, namely, Brennan's *Heisenberg probably slept here;* C.N.R. Rao's *Understanding chemistry*; and M.K. Pal's *Old Wisdom and New Horizon* have given. Nevertheless, in this survey, there is a glaring omission of one of the most important scientific ideas of the history of science as a whole and of history of physics in particular—a seminal one-namely, the historical aspects of the doctrine of energy and the associated law of conservation of energy, in the origin and evolution of which J.P. Joule (1818-89), Hermann Helmholtz (1821-94) and William Thomson (later Lord Kelvin; 1824-1907) played a key role. This doctrine became foundational one in the emergence of new physics in the twentieth century.

There are, in addition, several inaccurate ideas or incomplete expositions. For Example: (i) the account of H.C. Oersted's experiment concerning the connection between electricity and magnetism(p.376) should have been as follows: 'If a wire carrying an electric current was placed near and parallel to a magnetic needle, it deflected it, but not if the wire carrying the current was at right angles to the needle. The direction in which the needle turns depends on whether the wire carrying the current is above or below the needle, and on the direction of the current'; (ii) The work of Lother Meyer (1830-95) and Newlands law of octaves relating to Periodic Table should have been included to appreciate the historical development of the Periodic Table; (iii) As regards J. J. Thomson's discovery of electron, the article puts the date as 1904 (p.379). But, it is well known that it was in 1897 that Thomson showed that the cathode rays were a stream of negatively charged particles and called them the corpuscles. The word, electron, was coined by an Irish physicist, J. Stoney and by 1900, Thomson's corpuscles had been identified with electrons; (iv) A perplexing statement (p.379) of the author is: 'By 1900 Max Planck believed that atoms were the building blocks of nature, and energy is continuous, radiated in waves irrespective of heat, sound and light waves.' There are other statements which appear to be in the nature of name-droppings and incoherent writing (like the one in the beginning of second column on p.371; second column of p.405 etc); (v) It is rather hard to understand the last five lines of the *Abstract* (p.361); (vi) The dates of Newton's paper and Huygens' book (p.374) need rechecking. The foregoing list is not exhaustive.

In this context an observation may not be out of place. In India, studies in the history of modern science since the time of Renaissance are conspicuous by their absence, possibly because the University system is lukewarm about them. It is strange but true that, though India, as a nation, is committed to the progress of modern science and technology in diverse ways for national development, their history and social dimensions as well as Science as a knowledge system, have not received any serious attention. Even scientists and science-teachers do not seem to have any knowledge of history of modern science. It is time that prestigious institutions like INSA, UGC, ICHR and ICSSR initiate steps to promote education/ studies/researches in these fields. For, they are not only intimately concerned with the progress of science and technology, the greatest enterprise of mankind today as Nehru emphasized, but also enable us to appreciate the rationality of science as a knowledge system and its role in societal transformation.

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