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Indian Knowledge Tradition And The Development Of Physics

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Abstract: The intellectual tradition of the Indian Subcontinent is one of the most ancient and complex throughout history. Even before physics was established as a science in the Western sense, scholars from India researched questions surrounding materials, motion, luminal energy (Lamps), sound energy (musical instruments), and natural phenomena like earth, wind, sea, stars, sun, etc. This review examines the intellectual impact of prominent Indian philosophical schools and their scholars towards forming the theoretical basis of Physics, such as the contributions of the Vaisheshika system (atom), Aryabhata's (astronomy), and Brahmastava's (mechanics) works, and shows how each contributed to modern scientific theories. Furthermore, by examining how these were transmitted, transformed, and incorporated into International science, it can be clearly represented that the Indian knowledge system is valid and warrants consideration as the second great intellectual centre in the development of Physics history. The review will use both primary literature references and secondary literature sources to present an overall coherent story about the life of this intellectual tradition.

Keywords: Vaisheshika atomism, Indian knowledge tradition, history of physics, Aryabhata, Brahmagupta, natural philosophy, classical Indian science

1. Introduction

It is generally agreed that the history of physics is told through the lens of the European scientific revolution, starting with Galileo, then Newton, and later Faraday and Maxwell as the founders of physics. This is true; these men did help to establish the foundations of the discipline. However, to present physics in this way has the effect of marginalising other rich traditions of natural inquiry that developed outside of Europe. The case of Indian intellectual history is one that exemplifies both ends of this continuum: over three thousand years of continuous inquiry into physical reality, methods of mathematical description, and systems of cosmological order (Seal, 1915).

In the twentieth century, the study of Indian scientific history achieved serious scholarly status, with researchers like P.C. Ray, B.N. Seal, and later A.K. Bag and S.N. Sen, gathering documentation to verify the breadth and originality of classical Indian contributions (Bag & Sen, 1983, Ray, 1902). More recent scholarship continues to fill in and broaden the scope of this picture, emphasising that Indian natural philosophy is not simply an antecedent to modern science, but rather has its own sophisticated system of inquiry (Joseph, 2000; Plofker, 2009).

2. Ancient Foundations: Cosmology and the Concept of Matter

Vedic and Early Philosophical Approaches

The Physical World as a Systematic Reality in India: There first engaged with the physical world, systematic reality was the most developed ideas, and the only systematic physical philosophy developments we see in the Vedic literature (e.g., Rig Veda and Upanishads)as the ancient Indian texts are generally attributive to Hindus were primarily religious/philosophical; they are important to early physical science with seeds of physical idea science. The Nasadiya Sukta offers the Rig Veda will have offered the most fundamental philosophical questions related to the origin of the universe, future to a more systematic theoretical cosmic nature of the universe science (e.g., Basham, 1954). It was a way that the ancient Indian society perceived general systematic elements that would finally show a good idea of the universe, which we see as 5 elements: Earth, Water, Fire, Air & Space, the quantum nature.

The Samkhya school further elaborated a dualistic cosmology in which matter (prakriti) evolves through a series of transformations driven by three fundamental qualities (gunas), a framework that, while metaphysical in intent, reflects a sustained attempt to explain natural change in systematic terms (Larson, 1979).

The Vaisheshika Atomic Theory

The Atomic Theory developed by the Vaisheshika School of Thoughts in Ancient India is one of the most interesting examples of how Ancient Indian Philosophy has contributed to our understanding of Physics. The Vaisheshika School is traditionally associated with Kanada, and the main text, Vaisesika Sutra, is generally believed to have been written in the early centuries of the Current Era, though it is possible that the theories and ideas contained in it were based on earlier philosophical traditions (Gangopadhyaya, 1980). The Vaisheshika School believed that all of the physical world was made up of indivisible atoms or paramanu. These atoms have their own unique properties like colour, taste, smell, etc. When the atoms combine into groups of two, three, etc., they form what we see as all of the different types of physical matter. The Atomic Theory put forth by the Vaisheshika School of Thoughts can be viewed from the history of Physics perspective in the following ways:

1. Atoms (paramanu) are true ultimate particles and cannot be divided, and they continue to exist even when the world has ceased to exist due to disintegration (Universal Rebirth).

2. The Vaisheshika School used the properties and relationships between atoms to explain natural phenomena, and did not use the continual intervention of God to account for how things happen (Chattopadhyaya, 1986).

3. The Vaisheshika School of Thoughts created an advanced ontology of the categories of 'padarthas', which included the padarthas of substance, quality, and the padartha of motion, meaning that they were aware that for a complete physical theory, one must account for change as well as for a complete structure.

Commentators such as Prasastapada in his Padarthadharmasangraha continued to clarify and expand on the concepts within the framework of Vaisheshika by elaborating on the ways of contact and separation through which aggregates of atoms are created and destroyed. These expansions suggest that there was some form of continuous growth through philosophical development associated with the atomic tradition of thought, and these concepts were not simply fixed.

3. The Classical Mathematical-Astronomical Tradition

Aryabhata and the Aryabhatiya

One of the most well-known personalities in the classical Indian sciences is Aryabhata (b. 476 CE), who authored the Aryabhatiya in 499 CE. The Aryabhatiya is a significant text that describes both the mathematics and astronomy of the time, and is only 121 verses long but contains an enormous amount of material (Clark 1930; Shukla & Sarma 1976)

Some of the most interesting aspects of Aryabhata's work, given his contribution to physics, are as follows: Aryabhata provides an explanation of how the stars appear to move across the sky by the rotation of the earth('s axis), which was a revolutionary idea given that most people of that time believed that the earth was stationary (Pingree, 1978), and he made use of sine functions in calculating astronomical distances, which set the groundwork for the later development of trigonometry and mathematical physics.

Brahmagupta and Later Astronomers

Brahmagupta can be credited with making significant contributions to the study of gravity through his writings in Brahmasphutasiddhanta (598–668 CE). Brahmagupta was the first known individual to state that heavy bodies will tend to fall toward the Earth because of attractive forces exerted by the gravity of the Earth on those bodies. In fact, he expressed ideas about gravitational attraction over one thousand years before Newton (Plofker, 2009; Colebrooke, 1817). While Brahmagupta did not create a mathematical law for universal gravitation, his insight into attraction as an inherent force is an important advancement in the study of gravitational physics.

The study of gravitational models in the Siddhanta astronomical tradition was improved by Bhaskara I and Bhaskara II, who both contributed to the development of mathematical and physical models of Indian astronomy. The Siddhantasiromani, written by Bhaskara II (1150 CE), had discussions about instantaneous velocities that might be viewed as precursors to what later became known as the differential calculus (Rajagopal & Rangachari, 1986). The Kerala School of Mathematics developed the infinite series expansion for trigonometric functions between the 14th and the 16th centuries independently of England, with their results being attributed to Newton and Leibniz in Europe (Nair, 2011).

4. Optics, Sound, and the Physical Sciences

Theories of Light and Vision

Philosophers in India took an in-depth look into the physics of light and how it was related to vision. As per the Nyaya-Vaisheshika system of philosophy, light is thought to be "fire" (tejas). Therefore, the process of seeing is made possible by means of a "visual ray" which comes from the eye to the object being viewed, with the visual ray being altered depending on the conditions around it, including ambient light (see Bhattacharyya, 1958). Dignaga, a philosopher in the Buddhist tradition, and his successors developed a different view, much like that which existed among European thinkers until around the end of the 12th century. Dignaga's school maintained that the means by which we see things is due to light being reflected into our eyes from surfaces.

Brahmagupta and other astronomers also wrote about light and sight in relation to astronomy, and focused on examining both: the effects of the Earth's atmosphere on the appearance of the Moon when it was close to the horizon due to atmospheric refraction; and how the apparent flattening of the Moon as a result of the Earth's rotation caused it to look shorter when visible. While these and other explanations are largely found in a predictive approach rather than an explanatory context, they do demonstrate a basic understanding that light, in general, does not travel within a vacuum as straight as we assume it may under certain atmospheric conditions (Plofker, 2009).

Sound and the Theory of Vibration

Indian culture has made extensive contributions to understanding vibrational theory as sound relates to physics; this can be attributed to many factors, such as how important the spoken word is when performing Vedic rituals and a rich tradition that exists about musical theory. An example of this would be Bharata Muni's (possibly early centuries CE) Natyashastra (Widdess 1995), which provides details related to musical acoustics, including how to divide an octave into parts and the characteristics of vibrating strings. Later texts relating to musicology used the Vaisheshika framework and explained how sound functions as a quality transmitted from one body to another through the impact of oscillations through the air (Raju 2007). This general description is quite similar to the current scientific model for representing waves.

5. Transmission, Dialogue, and Integration with Global Science

The Indian knowledge tradition's contributions were not isolated. Mathematical and astronomical knowledge from India during the Medieval period was shared with the Muslim world, translated, integrated with Greek thought and enhanced (Gupta, 1980). The most important transmission was the use of the "Hindu-Arabic numerals," including the concept of zero and the notation for place-value, which greatly enhanced calculation in both the Muslim world and later across Europe. Due to this numerical structure, it is inconceivable how the physical sciences of the scientific revolution could have emerged without it.

In the ninth and tenth centuries CE, Indian and Islamic scholars communicated directly with one another, and as a result, several significant texts on Indian astronomy, including various versions of the Brahmasputha Siddhanta, were translated into Arabic (Saliba, 2007). Knowledge was exchanged between the two cultures in two directions: Indian astronomers also received large portions of Greek astronomy knowledge through the Persians, and combined these traditions into their own evolving structures. This reciprocal exchange illustrates the complexity of the historical record on science and supports a pluralistic view of the relationship between Indian and Islamic science (Needham, 1969).

There has been an ongoing tradition of rational inquiry into physical phenomena in India; however, it has been ruptured at times throughout history. The colonisation of India resulted in the partial displacement of local scientific traditions by the introduction of European science education, as well as challenges to the validity of classical Indian philosophy of science (Arnold, 2000). The recovery and reevaluation of this scientific legacy in India has been an active agenda for historians of science in India, with major contributions from the Indian National Science Academy and from individuals like D.M. Bose, S.N. Sen, and B.V. Subbarayappa (Bose, Sen & Subbarayappa, 1971).

6. Discussion

This review sums up the evidence on the Indian system of knowledge and its development of physics, making several general conclusions. First, independent of one another, Indian thinkers created many conceptual systems of physics—atomic theory, gravity, the properties of light and sound and the mathematical concepts of motion—all of which have European similarities in the Scientific Revolution and post-Revolutionary period. This is not a coincidence but rather demonstrates the existence of some common questions about physics that can be answered by a rigidly constructed systematic search for answers by creating answers to physics questions through various manners of methodology.

Second, the primary characteristic of the Indian system of knowledge is that it has a fundamentally productive relationship with mathematics and physics. The Indian astronomical system, in particular, provides an example of this relationship as it shows how mathematical principles and physical modelling have co-evolved in Indian astronomy, predating the current-day scientifically established mathematical study of physics. The Indian developments of infinite series, trigonometric functions and the concepts of instantaneous change were all substantial mathematical concepts that could be used to develop modern physical concepts long before modern European science reached the same level of development as the Indian scientific community.

Furthermore, the monetary exchange of various Indian philosophies and ideas—including the mathematical system, as well as various methods associated with it—were crucially important to the advancement of science across Europe and beyond. Any complete history of physics cannot deny the contribution made by the transmission of these philosophies to scientific advancement.

At the same time, there are significant caveats attached to this statement. Their natural philosophy also had a larger context of larger conceptual systems, such as Theological and/or Cosmogonical, and it would be grossly anachronistic to attempt to apply contemporary concepts of physical reality to texts from thousands of years ago. Much of the similarity in physical concepts between modern Western physics and those found in ancient India can be attributed to the architecture of the conceptual framework. For example, the Vaisheshika Atom is very different from the atom in Dalton's or Bohr's Theory, and Brahmagupta's concept of Gravity is not equivalent to Newtonian Law of Universal Gravitation. In my view, the objective of this study will not be to claim that ancient Indian science was in a stage of advancement equal to or greater than modern-day science, but rather to illustrate how to give ancient India's science an authentic place within the larger and truly global context of physical inquiry.

7. Conclusion

The evolution of physical thought in Indian knowledge descriptions has been traced in this review, covering Indian sources (the Vedic and early philosophical period), the heights of the classical mathematical-astronomical period, and the period of interaction with Islamic and, eventually, European science. What emerges is a physically rich and technically advanced system that made significant and novel contributions across almost all parts of what are now included in the category of physics (e., the structure of matter, non-linear motion, light and sound, the description of the universe).

To give adequate credit to these contributions through their full integration into the standard narrative of the history of physics would be important for scholars. This would not only be an issue of historical justice but would help clarify many aspects about how the discipline perceives its own conceptual repertoire as well as offer many ways in which humanity attempts to understand the physical world. Current investigations should be done with attention to the primary texts using strict philological methods along with a keen engagement with more general epistemological and philosophical issues/items of science through cross-cultural comparison.

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