VEDĀNTA AND QUANTUM PHYSICS

Vedāntic thinkers like Patañjali, Śankara and Madhva had grappled with the same metaphysical questions as modern physicists. They relate in particular to the dual nature of reality and the domain of scientific theories.

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Background: common ground

First I want to thank Prasara Bharati and the All India Radio for inviting me to give this talk on subjects close to my heart— science and philosophy, and philosophy of science. For my talk today I have chosen a subject of great interest to both scientists and philosophers— Vedānta and quantum physics. I just returned from a conference on the subject in the U.S. and have given several talks on the topic in the U.S., India and U.K. which have allowed me to see its relevance at first hand. The interest ranges from particle physics to frontier technologies like quantum information and computing, but in this talk I'll stick to the basics.

I'll begin my talk by posing the question: what do Vedānta and quantum physics have in common? A good deal it turns out, especially if we want to understand the reality of the world described by modern physics. Quantum physics is the physics of the micro-cosmic world— the world of atoms, protons, electrons and others that we cannot see. This forces us to try to understand the unseen world on the basis of what we can see and measure in our laboratories.

This means we don't really know what goes on in the quantum world of light (photons), atoms, electrons and other elementary particles because we cannot see them. We know only how they interact with our apparatus in the laboratory. When we say light is both wave and particle we only mean that we see wave like patterns when light acts on our laboratory equipment. From that interaction between invisible things like light waves and the visible lab equipment we try to draw conclusions about what the quantum world is really like.

This produces a gap in our knowledge of the world between what we can see and what we are trying to describe. This means there are two worlds— the physical world which is nature's creation and the world described by mathematical theories created by scientists based on experiments and observations in the laboratory. Vedanta also recognized this duality in our knowledge of what we perceive and the world as it really is. This is a much deeper form of duality than that of wave-particle duality.

Direct and derived knowledge

Patañjali in his Yogasūtra described knowledge as pratyakṣha (direct), anumāna (inferred or derived), and āgama (compiled). In classical physics, which includes relativity, knowledge was more or less direct. What you saw was what you got. So scientists could create theories based on observations and expect them to apply to the physical world and the universe. These theories, in Patañjali's words were anumāna or derived not direct, but still a real description of nature. The duality between pratyakṣha and anumāna was there but not apparent.

As a result, until about a century ago scientists didn't need to worry too much about the reality of the physical world they were trying to understand and describe. They could assume that the things they were observing and measuring were real. When doubts arose about the reality of some ideas used in their theories, like light waves in the eighteenth century, they assumed that the question would be settled by some clever experiment. This did happen in 1801 when Thomas Young in a famous experiment demonstrated the wave nature of light.

But the situation began to change when scientists started introducing into their theories things like atoms that could not directly be observed. Even in the twentieth century there were scientists who refused to believe that atoms were real.

What convinced scientists was not any experiment but Einstein's explanation of the irregular movement of particles suspended in a liquid known as Brownian motion. Jean Perrin's 1909 experiment verified one of Einstein's predictions based on the atomic theory of Brownian motion without actually observing atoms. This was the beginning of atomic physics that soon became entangled with quantum theory and all that came with it.

Quantum revolution

The big shift was the coming of the quantum. In 1900 the German physicist Max Planck said that energy doesn't flow in a continuous stream but in discrete units which he called quanta. No one today doubts the reality of the quantum any more than the reality of the atom, but to Planck it was purely a mathematical trick needed to resolve some anomalies observed in heat radiation; he never believed that quanta were real. Five years later, Einstein extended the quantum idea to light to explain the photoelectric effect which wave theory could not. As he saw it, light flowed not in a continuous stream like water but in discrete lumps like ice cubes coming out of a vending machine.

Unlike Planck, Einstein had no doubt that his light quanta, now called photons were real. He also realized that he had brought about a fundamental change in physics. Writing to a friend in 1905, the 'miracle year' in which he created the special theory of relativity, explained Brownian motion and introduced the light quantum, he described only the quantum theory of light as being 'truly revolutionary'. At a conference in Salzburg in 1909 Einstein proclaimed: "The next phase of the development of theoretical physics will bring us a theory of light that can be interpreted as a kind of fusion of the wave and particle theories."

Neither Einstein nor anyone else at the time could have known where this wave-particle duality of light would take physics. At first, things seemed natural enough with the Bohr-Sommerfeld model of the atom explaining light emission and spectral lines, though Niels Bohr, soon to be recognized as the second seminal figure of twentieth century physics (after Einstein) professed that he didn't care for Einstein's light quantum idea.

In his famous equation E = mc2 Einstein had already shown that matter and energy are one and the same. Now he was saying that light, which is a form of energy, is both waves and particles. Louis de Broglie connected the two and proposed that matter also had to be waves. This too received experimental support. Next, if matter can be a wave, there must be a wave equation describing it. This was supplied by Erwin Schrödinger, though no one at first seemed to understand what it was wave of. Then Max Born offered the explanation that it was not really a wave like a water wave or a sound wave, but an abstract mathematical function that allowed one to calculate the probability of finding a particle like electron at a particular place.

(An interesting sidelight: Max Born may be a major figure in modern physics but the public probably knows his granddaughter better. She is the famous actress Olivia Newton-John.)

Werner Heisenberg threw a bombshell into this mix with what is called the uncertainty principle. He claimed that it is impossible to know both the position and the velocity (or momentum) of a particle exactly. Just as Einstein's relativity theory placed a limit on velocity, Heisenberg's uncertainty principle placed a limit on knowledge. All one can calculate is the probability of a particle like the electron going from one place to another, say from the earth to the moon, and not the path by which it gets there. Worse, the electron doesn't even exist until we observe it on the moon. So it is the observer that defines its existence.

(I use the term 'electron' generically, to mean any subatomic particle including the light photon.)

So here was the new reality: a wave equation without a wave that is needed to find a particle that becomes real only when we observe it. As Heisenberg saw it, "Reality has evaporated into mathematics." His colleague Pascual Jordan, who might have won a Nobel Prize but for his unsavory politics (he became a Nazi storm trooper) said, "There is no reality; we ourselves create things with our experiments." Bohr, the high priest of this new physics proclaimed: "Physics is not about reality but about our knowledge of reality." This is like saying nature is what our physics theories say it is. This means it has no independent existence.

Einstein was unhappy with the turn of events in the revolution that he had done so much to launch. To him the physical world was reality, not something that evaporated into its mathematical dual created by physicists. They were now saying reality is only what we observe; what we don't observe doesn't exist. But Einstein asked: "Do you really believe that the moon exists only when I am looking at it?"

Vedānta: orders of reality

The curious thing is that this philosophical muddle grew out of experiments, not just metaphysical speculation. To make sense of this mass of contradictions, some of the pioneers of quantum physics like Schrödinger, Heisenberg, Robert Oppenheimer and David Bohm turned to eastern philosophy. There they found that some of the problems lying at the center of new physics like duality, reality, and existence had received the attention of Hindu philosophers of the school known as Vedānta (of which yoga is probably the best known).

Of these Schrödinger was a committed Vedāntin. He wrote: "It is quite easy to express the solution in words, thus: the plurality [of interpretations] that we perceive is only an appearance; it is not real. Vedāntic philosophy, in which this is a fundamental dogma, has sought to clarify it by a number of analogies, one of the most attractive being the many-faceted crystal which, while showing hundreds of little pictures of what is in reality a single existent object, does not really multiply the object."

In this he had been anticipated by Acharya Madhva (1238 – 1317) who gave the most penetrating insights into the question. In his work on reality called Tattva-Viveka Madhva observed: "There are two orders of Reality— independent and the dependent." And in what amounts to an anticipation of Heisenberg and Hugh Everett's many worlds interpretation of quantum physics, Madhva asserted: "The knowledge of the many through knowledge of the One, is to be understood in terms of the preeminence of the One."

Now scientists including me and my colleagues are finding Madhva's way of looking at duality and reality can simplify the reality question in quantum physics. (What is encouraging is that Madhva's Order Principle, as it may be called, is amenable to mathematical treatment. I have done it myself, but it is not appropriate for a talk like the present. And for the same reason, I have also not said anything about important results like Bell's theorem and its experimental results.)

Madhva's predecessor Śankara (788 – 821) saw the world as conceived in latent form in pure consciousness like the tree in a seed. "The relation between the world of multiplicity and the Absolute is an inconceivable one." Madhva on the other hand wanted to understand it.

Śankara also said: "Scripture is not any word of God, but consists entirely of perceived truths. This perception can be from karma (actions or empirical facts) and jñāna (gnosis or thought) through reflection or deduction." And most significantly for our purpose, he also claimed: "Any attempt to connect the Absolute with its manifestations in the shape of the world must end in failure, for no relation can be imagined beyond the sphere of duality."

Where does all this leave us? Reality and our conception of it, can the twain never meet?

I see the question of Reality as a possible meeting ground between Vedānata and modern physics, especially quantum mechanics. Reality is the Holy Grail of quantum physics; it is an area in which Vedānta has already made a significant contribution; it can do still more and thereby come to occupy the center stage in modern metaphysics. The real question is the relationship between the Vedāntic approach and that of modern physics. To understand this, let us try to see where we stand.

Among physicists Heisenberg, Bohr and their followers held that there was no reality beyond our observations and theories. Schrödinger on the other hand believed that the many manifestations that we observe with different people represent a single entity in a single reality. In effect he was invoking a version of advaita philosophy. But we cannot wish away duality. We have the wave-particle duality of both light and matter. We have the more profound duality of the real world (the unmanifest) and the world described by our theories and experiments (the manifest).

This means we need to understand natural phenomena based on how they manifest themselves in our laboratories but recognize that the two are not the same. Part of the problem is that results in quantum physics violate what we take to be fundamental laws of physics like the limit set by velocity of light (non-locality) and occupying multiple states (superposition).

This brings us back to what Madhva said in his Tattva-Viveka: there exist two orders of reality, the manifest and the unmanifest. It is the goal of both Vedānta and quantum physics to understand the relationship between these two manifestations of reality. It is a central problem in physics today as it has always been in Vedānta. The two can and should work together.

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