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Mysteries of the quantum world

Quantum physics, which epitomises a radical departure from classical physics, continues to throw up surprises even now, a century after the initial quantum hypothesis was made. Earlier on, one had to contend with issues like 'a quantum of energy', 'uncertainty principle', 'probability' instead of certainty, etc. In recent times, several buzz words like 'quantum optics', 'quantum computing', 'quantum encryption', 'quantum entanglement' and so on have emerged. As a result, a number of new possibilities have been forecast; quantum teleportation, quantum information-processing, etc. are some of them.

The concepts of the quantum world are so different from our day-to-day common ones that one has to remember what Richard Feynmann said almost 40 years ago: 'Now we know how the electrons and light behave. But what can I call it? If I say they behave like particles I give the wrong impression; also, if I say they behave like waves. . . . They behave in a way that is like nothing that you have ever seen before. Your experience with things that you have seen before is incomplete. . . . But the difficulty really is psychological and exists in the perpetual torment that results from your saying to yourself, "But how can it be like that?", which is a reflection of uncontrolled but utterly vain desire to see it in terms of something familiar. . . . There was a time when the newspapers said that only twelve men understood the theory of relativity. I do not believe there ever was such a time. There might have been a time when only one man did, because he was the only guy who caught on, before he wrote his paper. But after people read the paper a lot of people understood the theory of relativity in some way or other, certainly more than twelve. On the other hand, I think I can safely say that nobody understands quantum mechanics. I am going to tell you what nature behaves like. If you will simply admit that maybe she does behave like this, you will find her a delightful, entrancing thing. Do not keep saying to yourself, if you can possibly avoid it, "But how can it be like that?" because you will get "down the drain", into a blind alley from which nobody has yet escaped. Nobody knows how it can be like that' (*The Character of Physical Law*, 1965, p. 129). Someone else has said that 'the quantum world really is different, and the only way to come to grips with it is to suspend disbelief'.

'A single atom, nearly at rest in an empty universe, for arbitrarily long periods of time is an ideal quantum system for experiments' thus begins, almost poetically, the article entitled 'Recent experiments in quantum optics and their implications' by Amitabh Joshi and Suresh V. Lawande (**page 816**). As a layman, having not dabbled in the theoretical world of the quantum, I feel somewhat inadequate introducing this article. The article is being published in two parts in successive issues of *Current Science* (10 April and 25 April 2002).

In the first part, the authors begin their review of some of the recent novel experiments in quantum optics by describing the non-classical features of light like antibunching and squeezed state of photons. Magneto-optic and other traps and laser cooling have enabled experimenters to 'observe' novel features of quantum jumps of a trapped ion. Realization of quantum computation may depend on the developments in this area of experimental physics. Understanding/interpretation of these quantum jumps has been the subject matter of several theoretical approaches. The authors have briefly summarized these efforts. 'Measurement' in quantum systems has been a subject matter of debates over several decades. One view is what is referred to as *Quantum Zeno effect*: 'A continuously observed state can never decay.' One remembers in this connection the famous paper by John Bell in *Physics World* (1995) entitled 'Against measurement'. Quantum Zeno effect – rather, the reverse effect namely *Quantum anti-Zeno effect* –, is said to be the 'cause for concern in connection with . . . quantum computers'. Quantum entanglement is said to be at the heart of quantum information processing.

In the second part of this article (to be published in the 25 April 2002 issue of *Current Science*) the thrust is mainly on what is referred to as 'cavity quantum electrodynamics'. Currently 'devices have been created in which spontaneous emission (of a photon by an isolated atom) can be halted, accelerated or even completely reversed'. 'Micromaser', 'quantum eraser' are some of the other recent developments. The authors discuss conditions under which Pancharatnam phase in cavity quantum electrodynamics can be observed. Finally, the authors dwell on the nature of particle–wave duality of non-classical light, in the light of recent experiments that address both the particle and wave attributes of light.

Many aspects of theory and experiments that are covered in these two publications like quantum teleportation, etc. touch frontiers of current research. The web-site http://www.newscientist.com/hottopics/quantum/ deals with a new book entitled 'New Scientist's guide to the quantum worlds' and lists several topics under the title 'Latest on the quantum world', a set of popular articles. The non-specialist reader would find several novel, and interesting as well as complimentary aspects in this web-based collection of articles.

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