

Although such energies may not be reachable in laboratory experiments, much can be learned from forthcoming experiments in physics and astronomy (cf. Box 2) which will probe distances deeper than what has been studied so far and of course Planck's guiding spirit, that tells us that there are absolute laws in Nature that must be simple and logically consistent.

1. Kuhn, T. S., *Black Body Theory and the Quantum Discontinuing: 1894–1912*, Oxford Univ. Press, 1978; Planck, M., *Scientific Autobiography and Other Papers*, Philosophical Library Inc., NY, 1949; Pais, A., *Rev. Mod. Phys.*, 1979, **51**, 863; Kangro, H., *History of Planck's Radiation Law*, Taylor and Francis, London, 1976; Klein, M., in *History of Twentieth Century Physics*, Academic Press, New York, 1977. There is no unanimity among historians about how

Planck arrived at his formula. My account here is based on Planck, Kuhn and Pais.

2. Heilbron, J. L., *The Dilemmas of an upright man – Max Planck as spokesman for German Science*, University of California Press, 1986.

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## Random selections

### Quantum physics

'One hundred years of quantum physics'  
Daniel Kleppner and Roman Jackiew  
*Science*, 2000, **289**, 893–898

An essay in the series 'Pathways of Discovery', the article under selection is unique inasmuch as the subject matter of the essay itself, namely Quantum Physics. Kleppner and Jackiew, both professors at Massachusetts Institute of Technology, USA have put together in a very readable fashion their perspective of a vast subject that has 'been responsible for advances in essentially every other science' in the twentieth century. Its influence has been so much, as the authors point out, that 'there would be no global economy and Information Age, to speak of without quantum mechanics'.

The year 2000 marks the Centenary of Max Planck's 'Quantum Concept'. Thousands of pages of spectral data of elements and compendiums of many thermo-

dynamic properties of materials could all be understood on the basis of a 'quantitative theory', based on quantum mechanics, during the early part of the twentieth century. This essay provides a bird's eye view of all important landmarks dotting the achievements of Quantum Physics within the confines of mere six pages. The span of the subject is captured in the quote: 'Quantum Physics actually encompasses two entities. The first is the theory of matter at atomic level: quantum mechanics. It is the quantum mechanics that allows us to understand and manipulate the material world. The second is the quantum theory of fields. Quantum theory of fields plays a slightly different role in science.'

The article covers a vast canvass starting from Planck's quantum hypothesis and moves through concepts dealing with dual nature of light, Bohr's atomic structure hypothesis, de Broglie's hypothesis about duality of matter, Bose–Einstein statistics, matrix and wave mechanics,

Fermi–Dirac statistics, interpretation and validity of quantum mechanics and finally touching on aspects like quantum entanglement, quantum communication and quantum computation.

In the second part of the essay, the authors have dealt with quantum field theory ('the predictions of quantum field theory are the most precise in all of physics'), covering Dirac's theory, quantum electrodynamics, quantum chromodynamics, the latter two being 'the cornerstones for a grand synthesis known as the Standard Model', ending finally with string theory.

The Timeline of Quantum Physics, a part of the essay, is a catalogue of important landmarks in the saga of interplay between theory and experiment that has been sustaining the continuous growth of 'fundamental concepts and essential tools for all of the sciences'. A variety of materials (and phenomena) such as superconductors, lasers, Bose–Einstein condensates, quark–gluon plasma, etc. have taken shape thanks to this scenario.