On Heisenberg's quantum mechanical reinterpretation of kinematic relations and the wave-particle duality.

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Hundred years ago Werner Heisenberg published the very first paper of modern quantum theory [1], formulating the basics of "matrix mechanics" [2]. In the present talk we attempt to follow the development of quantum theory around the time of this discovery. First we illustrate that in quantum mechanics even the kinematics of the motion of a microparticle is reinterpreted, so that its position and momentum are described by non-commuting matrices. This is in sharp contrast to our picture of the classical motion of a particle, which takes place along some trajectory. We shall also highlight the "Drei Männer Arbeit" (three men's work) of Born, Heisenberg and Jordan [2], submitted also in the year 1925. This work - besides giving solutions to several fundamental problems constituting today basic parts of any standard texts on quantum mechanics - contains a first version of field quantization, namely, the quantization of the normal modes of an oscillating string. As an application of this new formalism, the authors derived [2] an analogue of Einstein's fluctuation formula (1909) expressing the "wave-particle duality" of black-body radiation [5]. According to this result, both the wave-like and the particle-like fluctuations are simultaneously showing up, which is characteristic e.g. in the Hanbury Brown and Twiss type intensity correlations, or in the fluctuation of the number of particles in a gas satisfying the Bose-Einstein statistics (1924). We shall also deal with Heisenberg's "uncertainty relation" [3] coming from an analysis of physical observations, by using Born's probability interpretation [2a]. Finally, we present a brief comparison of wave mechanics and matrix mechanics with the help of two examples: the harmonic oscillator coherent wave packets derived by Schrödinger [4], and the squeezed state amplitudes constructed by Kennard [3a], who used the transformation theory of Jordan [3b] and Dirac [3c].

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