HEISENBERG'S UNCERTAINTY RELATION WITHOUT PARADOXES

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Heisenberg's uncertainty relation is considered as a regularity not susceptible to our concepts of reality. Incidentally, if the connection of the uncertainty relation with the wave function and their "probability interpretation" is abandoned then the justification of this relation becomes simple and compelling. We proceed from the assumption that: first, at all times when the uncertainty relation is used, an action is measured multiple to the Plank constant h and second, if the *action* is determined by mated parameters, for example by the product of impulse and the particles shift value, then the measurement of these parameters separately is impossible. In this case the measurement accuracy can not exceed in principle the value of h. The measurement accuracy of each parameter depends on the "graduation" of the measuring device. The measurement accuracy of mated parameters can be estimated only if the measurement is performed not simply simultaneous but as a *u n i q u e* measurement. In this case the "Einstein – Podolsky – Rosen paradox" loses its significance. The influence of the measuring device on the measurement results is not a peculiar feature of the micro-world and accordingly of Quantum mechanics.

Heisenberg's relation is considered to be one of the most important foundation of quantum mechanics.

Below is given a characteristic of this relation by L. D. Landau:

"The discovering of the uncertainty relation showed that men in the process of investigating nature is able to divert oneself from his imagination; is able to discover and realize even that. what is not in his abilities to understand" [1].

Landau's point of view reflects the wide-spread opinion concerning the uncertainty relation by Heisenberg. Let us consider opinions formulated by the authors of quantum mechanics, who had to explain and interpret this relation and so could justify the characteristic given above.

1. "Classical physics is terminating just there, where it is impossible to deny the influence of the observer on the studied process" [2]. "The impossibility to remove ones independent behaviour from its interaction with measuring devices, intended to study the conditions of the proceeding of an event, involves a non-uniqueness in ascribing the usual attributes to atomic events. This requires a revision of our attitude to the problem of physical explanation" [3].

This factor is present also in processes of usual measurements that are described by classic mechanics. But in this case the influence of the measuring devices is either taken into account and a correction is introduced, or the result of measurement is considered to be conventional and the methodic is stipulated. In any case, this factor is sufficiently obvious, and by no means resembles a paradox.

2. “A specific inexactness, determined by the uncertainty relation, is missing in classical physics“ [4].

“In quantum mechanics we meet with a paradox situation, the observed events obey the accident law… Presently the situation is reversed [as compared to “ preconceived ideas about reason”]: accident has become a primary concept”. [5,6]. “From the point of view of quantum mechanics just these nuclei (for example) have disintegrated without any reason, they disintegrated spontaneously. The quantum theory predicts only the probability of disintegration of nuclei” [7].

In this case the presence of *a r e a s o n* for the events taking place is denied. This is an often applied in quantum mechanics way to “solve scientific problems”: the problem is ”closed” by introduction of a corresponding “law” or “principle”. Born considered “determinism” as a label, characterizing in-acceptance of “contemporary” science [6]. He also could not accept the “compromising” theory of “hidden variables”.

The base of a mystic world outlook is a similar acceptance of some inexplicable: it is implied that a phenomenon that can not be understood by our mind, lies outward the possibility to be explained.

It should be noted that not all of the quantum mechanics classics adhered to this theory. Plank criticized it very determined: “if a similar step would be actually necessary, that would discard the aim of physical investigations causing a great damage, whose significance is not difficult to estimate.” [8]. Notwithstanding, this interpretation of the “ uncertainty relation” still remains in orthodox science.

3. Several authors regard the uncertainty relation as a reflection of the particles wave features — a consequence of the wave-corpuscular dualism. “ The uncertainty relation is following from the conception that the elements of the new world pattern are not material particles but simple periodic material waves” [9]. “Uncertainty relations follow from the methods by which the corpuscular and the wave part of unique objects of matter are linked with the aid of the constant h ” [9].

However, this point of view is not justified, what follows, particularly, from the derivation of Heisenberg’s uncertainty relation without “direct turning to the wave pattern, but with the help of the mathematical scheme of the quantum theory” [9].

4. Heisenberg’s uncertainty relation shows, that “between the precision with that the position of a particle can be simultaneously determined with the precision of its impulse exists a specific relation” [2].

$$\overline{\Delta}\, q\ \overline{\Delta}\, p \geq h\ , \qquad (1)$$

where $\overline{\Delta}$ is the mean-square deviation. The non-traditional expression in (1) is introduced to stress the difference of $\overline{\Delta}$ from the unit deviation that often is nominated as Δ, and in certain cases causes a wrong interpretation of this relation.

A not-acceptance of this relation in the starting period of quantum theory is demonstrated by a discussion between Einstein and Bohr, and also the so-called "Einstein – Podolsky – Rosen paradox", that assumes a "mental" simultaneous measurement of impulse and coordinates of two particles – "twins" [3,7,9,10].

It is a characteristic detail that the analysis of this relation is carried out in such a way, as if it is an empiric equation and not a relation obtained analytically. As a result, the interpretation of this relation turns out to be not connected with the assumptions and conventions that were implied by its derivations. This is one of the reasons of the paradoxes that are linked to the uncertainty relation. In details these contradictions will be discussed in the conclusions of this paper.

Below we present a rather simple derivation of the uncertainty relation, putting more emphasis to the initial postulates and conventions.

1. The base of the uncertainty relation is Planck's equation reflecting *quantization of "action"*:

$$E = \nu h$$

(E is the energy of a photon, ν is the frequency of the electromagnetic wave)

or its consequences:

$$p = \frac{h}{\lambda}$$

(p is the impulse, λ is the wavelength).

The additional "action", corresponding to h, is:

$$\Delta S_h = p\,\Delta q$$

(Δq is the augmentation of the coordinate).

Or at a simultaneous variation of p and q [11]

$$\Delta S_h = \Delta p\,\Delta q\,. \tag{2}$$

2. Let us note, that *display of the impulse is not possible without transfer*, and *display of energy out of time*. Display means here a registration through interaction of the object with the observer, with a measuring device. This is also true for classical mechanics.

3. By applying the uncertainty relation, and possible also in the general case, *"action" is measured and not its components: impulse, coordinates, energy, time*.

It is significant, that in "action" are united three fundamental notions: force, length, and time. A measuring device is graduated to measure impulse, coordinates, energy and time.

4. *Uncertainty is a principal in-possibility to determine* the value of a parameter, and not the result of obstacles or measurements errors that are depending on probability laws, if their exact value is not known.

Uncertainty that can not be removed, appears also in classical mechanics. It is simply explained and easily understood. This is the case, when the resolving power of a specific measuring device is restricted: too large is the scale-point, e.g. the measurement is performed with a fixed pattern, but the required accuracy cannot be achieved with the dimensions of this pattern. No-one is surprised that the resolution of a microscope is restricted by the wavelength in the lightening beam. Such an uncertainty is not caused by our ignorance of the reason, the more that no reason exists. We have not a methodic or a device to determine the parameter with a better accuracy.

5.In this relation the uncertainty is regarded as a factor that causes the error. Hence, formally there is an intention to attain a better accuracy than that can provide the discreet value of the action quantum.

If a measurement of length R is taken with a ruler having a scale-point r, then the *assured* accuracy is $\pm\ r$ and the absolute measurement error will be $\Delta R = r$. But if we intend to estimate from this measurement result the *possible* value of R with a better accuracy then $\Delta R \leq r$. From examples given by Heisenberg of using the uncertainty relation [9], it follows that he himself preferred the first version, e.g. the uncertainty is the in-possibility to determine the value of a parameter *better* than the accuracy that is *provided by* the available methodic.

The mentioned above conception, proceeding from equation (2), allows to express in line with point 5 the measurement error of action:

$$\Delta S \geq \Delta p\ \Delta q \geq \Delta S_h = h \tag{3}$$

$$\Delta S \geq \Delta E\ \Delta t \geq \Delta S_h = h \tag{4}$$

If each real measurement satisfy the uncertainty relation, then the result of their statistical reduction will also satisfy it (1) and its variety, Bohr's uncertainty relation:

$$\overline{\Delta}\, E\ \overline{\Delta}\, t \geq h\ . \tag{5}$$

Expressions (1) and (5) include the averaged error and are not fundamental. They are given here in connection with the traditional presentation of the uncertainty relation. A more important theoretical and practical content consists in expressions (3) and (4).

The traditional expression of the uncertainty relation is linked to the deep-rooted point of view on wave features of particles, that is represented by a chain of particles, — a wave package, — a probability interpretation of the wave function, taking into account only the probability of the particles characteristic. Even Heisenberg, deriving the uncertainty relation "without the wave pattern" considers the mean-square deviation p and q , with attributing to them a Gauss distributed probability [9]. As has been already shown, the main factor influencing the error is not connected with arbitrary actions, they may even not exist. The use of the wave function [12, 13], even considering it an abstraction, darkens the physical essence of the uncertainty relation.

Conclusion

The derivation given above changed the notion of the uncertainty relation and the paradoxes related to it.

1. The influence of the measuring device on the measurement results of mating parameters is not a quantum mechanics specification of the considered relation. Specific is the phenomenon of the action quantization.

2. The uncertainty relation is not reflecting wave features of particles [14] (see also the booklet: Bernstein V. M. "Development of the Gauss – Weber electrodynamics. Quantum mechanics without wave theory ").

3. Specific uncertainty corresponds to *impossibility* of determining parameters of a *single* particle, and is not reflecting a probability approach to an ensemble of particles.

4. The specific uncertainty of each of the mated parameters is determined by the methodic of measurements.

The link between the accuracy of mated parameters measurements holds *not for simply simultaneous measuring of both parameters, but for a single measurement*, corresponding to determination of the number of action quanta with parallel estimate, depending on the applied methodic, of their components, — the mated parameters. The model of such a measurement is an indicator with three scales, graduated not only in action quanta, but also in measured mated parameters.

Hence, the Einstein – Podolsky – Rosen paradox concerning simultaneous measurements of "twin-particles" is disagreeing with the conditions on which the uncertainty relation is based. Consequently, this relation should not be considered to be that paradoxical.

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