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COMMENT

Comments on Robinson's thought experiment testing Heisenberg's principle

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Abstract. In this comment we point out the unphysical assumptions which led Robinson to conclude the violation of Heisenberg's uncertainty principle.

In a recent paper Robinson (1980) (see also Robinson 1969) has proposed a thought experiment which, he claims, could show the violation of the uncertainty principle. In this comment we show that Robinson has implicitly assumed, in his thought experiment, unphysical conditions resulting in the desired result. Before we do that let us describe the following thought experiment, which may help in understanding the catch point in Robinson's thought experiment.

Let us have two detectors D_1 and D_2 at x_1 and x_2 respectively. Let a particle (from a weak source of identical particles) travelling in the x direction be detected by D_1 and D_2 at times t_1 and t_2 respectively. So the particle was at x_1 at time t_1 and at x_2 at time t_2; the particle travelled in between x_1 and x_2 with velocity $v_x = (x_2 - x_1)/(t_2 - t_1)$. Let us pose a question at this stage. Now that the position (x_1) of the particle at time t_1 (and x_2 at t_2) are definitely known and at the same time the momentum ($p_x = m(x_2 - x_1)/(t_2 - t_1)$) is also definitely known, could one conclude that the uncertainty principle is violated? That the answer is definitely negative would become clear if we analyse the situation critically. In this thought experiment we have nowhere mentioned the physical process of the measurement. We have simply assumed that (somehow) the apparatus would give us position of the particle x_1 at $t = t_1$. It was only during the description of the physical process of measurement (by the apparatus) that we could realise that some sort of interaction between the particle and the apparatus (and between apparatus and observer) was necessary (see, for example, Bohm 1951, Maxwell 1972). And then we could easily realise that with such an interaction (between particle and apparatus) which could give us the particle position x_1 at time t_1, its momentum could be changed to an uncertain amount in the x direction. In fact the quantity $m(x_2 - x_1)/(t_2 - t_1)$ is the momentum of the particle after the measurement (at x_1 at time t_1) and not the momentum at time t_1. One does not know the momentum at time t_1. So the claim that position (x_1) and momentum (p_x) have been measured accurately at the same time is not true. What happened simply was that we imagined the apparatus to work in an unphysical way according to our will and obtained incorrect results.

Let us turn now to Robinson's experiment which consists of two detectors D_1 and D_2 at x_1 and x_2 separated by a velocity selector. The detector D_1 at x_1, coupled with a

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velocity selector, selects an ensemble of particles with velocity along the x axis in the range $v_s - \delta v_s$ to $v_s + \delta v_s$. The detector D_2 will register the presence of the particle at any instant (t_2) of time during which its wavepacket passes the point x_2. Thus in general the time of flight velocity would be $v_t = (x_2 - x_1)/(t_2 - t_1) \neq v_s$, but the average value (in an ensemble of experiments) $\langle v_t \rangle = v_s$.

Robinson *assumes* his experiment fulfils the following conditions:

(i) $v_t = v_s$ for every repetition of the experiment and

(ii) $\Delta x_1 \ll \delta v_s (t - t_1)$ and $\Delta x_2 \ll \delta v_s (t_2 - t)$ (and as a result $\Delta x < \delta v_s (t_2 - t_1)$).

Now condition (i) could be experienced only if $\delta v_s = 0$ and in that case $\Delta x = 0$ (from (ii)) and $\Delta p = m \delta v_s = 0$ and therefore obviously $\Delta x \Delta p < \hbar/2$. But Robinson's experiment under the conditions (i) and (ii) is exactly the thought experiment we described at the beginning, and the same arguments apply here as well.

We conclude, therefore, that because Robinson does not consider all possible physical processes taking place during the measurement process, he made certain unphysical assumptions and as a result obtained the condition $\Delta x \Delta p < \hbar/2$.

Recently Home and Sengupta (1981) have also refuted Robinson's conclusions. But we do not agree with them when they see a logical fallacy *petitio principii* in Robinson's analysis. In fact any (thought) experiment which, when analysed with all possible physical processes (interactions) taken into account, gives the result $\Delta x \Delta p < \hbar/2$ should be accepted as a proof of the violation of the uncertainty principle. For example, if Robinson describes the measurement process in his experiment which (under certain conditions) satisfies the conditions (i) and (ii), it should be taken as a proof. But according to their (Home and Sengupta 1981) logic, it would still suffer from logical fallacy *petitio principii.* In fact according to them any analysis which may show violation of the uncertainty principle should be thought to be suffering from logical fallacy, as (they say) it (i.e. the analysis) had already used, at some stage, ideas contrary to the uncertainty principle. We think this logic is itself suffering from fallacy. Because according to this as soon as one starts thinking of an analysis which goes against the uncertainty principle, one is suffering from logical fallacy *petitio principii* (as at least at some stage of the logical process one will include some process (or conditions) not obeying the uncertainty principle).

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