# On a proposal to base wave mechanics on Nernst's Theorem

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(20. II. 1962)

The following considerations are founded on the conviction that Nernst's Theorem is a fundamental law of nature and is really the third law of thermodynamics (3. L.). Wave mechanics is not only compatible with the 3. L. but I believe that it should be possible, under quite general assumptions, to derive the content and formalism of wave mechanics with the help of the 3. L. One of the general assumptions would certainly be that classical mechanics is a limiting case of wave mechanics. I am not able to prove my conjecture but in the following present some arguments for the validity of the proposal in the hope that a proof will be forthcoming.

Usually the 3. law is derived from wave mechanics, however I propose to reverse this procedure. It might be necessary for this purpose to generalize the 3. L. An evident generalization is the assumption that the entropy $S \rightarrow 0$ not only for the temperature $T \rightarrow 0$ but for any process diminishing the entropy of a system, e.g. the isothermal compression of gas in a temperature bath.

To apply the 3. L. to a mechanical system we have to use statistical mechanics. There the entropy is determined by the volume $\Phi$ of the phase space $\Phi = \int dV$ or in the case of one mass point $\Phi = \int dp\, dq$ ($p$ momentum, $q$ coordinate). Than the 3. L. means that $\Phi$ has a finite lower limit experimentally determined to be essentially $h$ (Planck's constant). We cannot measure simultaneously $p$ and $q$ with arbitrary accuracy but we have to assume that we have only a probability of measuring certain values. This probability cannot be arbitrary but has to have the following property. If we measure $q$ very accurately and find a value between $q$ and $q + dq$ and then measure $p$ with greater accuracy than $dp = h/dq$ we destroy the result of the measurement of $q$. This consequence of the 3. L. requires – so it seems to me – an interference effect. That means that the probability of a certain value of $q$ is determined by the superposition of wave functions with $p$'s as parameters and in the right phases and that the measurement of $p$ destroys this phaseconnection. It puts in its place the corresponding superposition of wavefunctions with $q$'s as parameters and the right phases. In other words, I conjecture that the 3. L. applied to a mechanical system already requires the dependence of the probability on wavefunctions, i.e. the existence of a probability amplitude $\psi$. That the probability is simply the absolute square of $\psi$ should follow from Ehrenfest's theorem which I propose to assume as a premise rather than a conclusion.

The connection between energy and frequency follows from the theorem and the 3. L. using $\Phi = \int dE\ dt$ (Energy, $t$ time), e.g. for the mass point by equating the group velocity to the macroscopic velocity.

Finally I would like to mention how the idea of the 'pure case' follows directly from an idealized experiment. We make a molecular ray experiment by splitting the beam into different energy states and collecting every state in a different vessel. With some idealization the separation can be considered as reversible*). The 3. L. requires that it should be impossible to further split a definite energy state. If we try to make this splitting using some property of the atom completely determined by the energy, e.g. the total angular momentum, then of course we do not get any further splitting. (The property is 'exchangeable' with the energy.) If however we use any other property, e.g. a component of angular momentum, the law requires that it is impossible to obtain any splitting without disturbing the energy measurement. Again we have to assume interference which is destroyed by the measuring apparatus.

If one could succeed in working out the theory along the lines of the proposal it would not only constitute a more satisfactory foundation for wave mechanics but might also be of help in giving a new approach to unsolved problems.

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*) By providing the oven and the receivers each with a parabolic mirror we can attain equilibrium. Each reveicer works finally as oven and the oven as receiver. By providing pistons we get the usual arrangement as with semipermeable walls.