



## Albert Einstein to Max Born<sup>1</sup>

Translated by Irene Born Newton-John

*In this letter to his old friend, now at Edinburgh University, Einstein first responds to Born's description of a local physician "who wouldn't hurt a fly, but [states] that no sacrifice is too great [for] the realization of Marxist ideals, not even the destruction of millions of human lives." And then it's back to the old quarrel about quantum mechanics. (See Born's comment below.)*

Princeton, 15 September 1950

Dear Born,

... People such as your Bolshevik doctor come by their fantastic attitude as a result of their objection to the harshness, injustice and absurdity of our own social order (escape from reality). If he happened to be living in Russia, no doubt he would be a rebel there as well, only in that case he would take care not to tell you about it. Nevertheless it seems to me that our own people here [in the US] make an even worse job of their foreign policy than the Russians. And the idiotic public can be talked into anything. And they really are very shortsighted, for technological superiority is transitory, and if it comes to an all-out conflict, the decisive factor is sheer numerical superiority.

There is nothing analogous in relativity to what I call incompleteness of description in the quantum theory. Briefly it is because the  $\psi$ -function is incapable of describing certain qualities of an individual system, whose "reality" none of us doubt (such as a microscopic parameter). Take a (macroscopic) body that can rotate freely about an axis. Its state is fully determined by an angle. Let the initial conditions (angle and angular momentum) be defined as precisely as the quantum theory allows. The Schrödinger equation then gives the  $\psi$ -function for any subsequent time interval. If this is sufficiently large, all angles become (in practice) equally probable. But if an observation is made (e.g. by flashing a torch), a definite angle is found (with sufficient accuracy). This does not prove that the angle had a definite value before it was observed—but we believe this to be the case, because we are committed to the requirements of reality on the macroscopic scale. Thus, the  $\psi$ -function does not express the real state of affairs perfectly in this case. This is what I call "incomplete description."

So far, you may not object. But you will probably take the position that a complete description would be useless because there is no mathematical relationship for such a case. I do not say that I am able to disprove this view. But my instinct tells me that a complete formulation of the relationships is tied up with complete description of its factual state. I am convinced of this although, up to now, success is against it. I also believe that the current formulation is true in the same sense as e.g. thermodynamics, i.e. as far as the concepts used are inadequate. I do not expect to convince you, or anybody else. I just want you to understand the way I think.

I see from ... your letter that you, too, take the quantum theoretical description as incomplete (referring to an ensemble). But you are, after all, convinced that no (complete) laws exist for a complete description, according to the positivistic maxim: *esse est percipi* [to be is to be perceived]. Well, this is a programmatic attitude, not knowledge. This is where our attitudes really differ. For the time being, I am alone in my views—as Leibniz was with respect to the absolute space of Newton's theory.

... I have not changed my attitude to the Germans, which, by the way, dates not just from the Nazi period. All human beings are more or less the same from birth. The Germans, however, have a far more dangerous tradition than any of the other so-called civilized nations.

Kind regards,

Yours,

A. E.

*Born's 1969 comment:<sup>1</sup> This is probably the clearest presentation of Einstein's philosophy of reality. ... He calls my way of describing the physical world "incomplete." In his eyes, that is a flaw which he hopes to see removed, while I am prepared to put up with it. I have in fact always regarded it as a step forward, because an exact description of the state of a physical system presupposes that one can make statements of infinite precision about it, and this seems absurd to me.*

### Reference

1. M. Born, *The Born-Einstein Letters 1916-1955: Friendship, Politics and Physics in Uncertain Times*, Macmillan, New York (2005), p. 184. Original letter © Hebrew University of Jerusalem.

In 1776, Euler, guided by his research on elasticity, came to regard the balance of angular momentum as an independent, second principle of mechanics,<sup>1</sup> the first principle being the balance of linear momentum. When Euler arrived at the rigid-body equations of motion in 1752 using the first principle, he had to invoke hypotheses about internal forces. However, once he saw the balance of the moments as an independent principle, he had no need of such hypotheses. In special cases such as that of a perfect fluid, the second principle follows from the first. In fact, the second principle leads to the symmetry of the stress tensor when all torques may be obtained as moments of forces.<sup>2</sup> The status of the third law has been clarified by the work of Walter Noll, who gives a precise mathematical interpretation of Newton's verbal statement of the law.<sup>3</sup>

Even in applications of quantum mechanics, Richard Feynman emphasized the importance of forces.<sup>4</sup> He commented that "many of the problems of molecular structure are concerned essentially with forces," that "forces are almost as easy to calculate as energies are," and that "the quantities are quite as easy to interpret." Another application of the concept of force is found in non-equilibrium statistical mechanics. Just as the contact force had to be found as the appropriate force to describe the dynamics of the continuum, the physically realistic short-time force derived from the mean instantaneous potential had to be discovered as the force that describes typical chemical dynamics in liquids,<sup>5</sup> in contrast to the traditional concept of the potential of mean force, which is more appropriate for slow or diffusion processes.

### References

1. C. Truesdell, in *Essays in the History of Mechanics*, Springer-Verlag, New York (1968).
2. R. Aris, *Vectors, Tensors and the Equations of Fluid Mechanics*, Dover, New York (1962).
3. W. Noll, in *The Axiomatic Method with Special Reference to Geometry and Physics*, North-Holland, Amsterdam (1959), p. 266.
4. R. P. Feynman, *Phys. Rev.* **56**, 340 (1939).
5. S. Adelman, R. Ravi, *Adv. Chem. Phys.* **115**, 181 (2000).

**Ramamurthy Ravi**

(rravi@iitm.ac.in)

Indian Institute of Technology, Madras  
Chennai, India