The Reaction Force Does no Work?:

a Comment on *Physica Scripta* **84** (2011) 055004

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Abstract

Newton's third law will not produce correct results as long as the work of the reacting force is not considered. We have always only focused on the work of the acting force. We have never considered the work of the reacting force, but to obtain correct results at the microscopic level we have no choice but to admit that the reacting force performs work.

The author of the *Physica Scripta* article reports several supposed violations of Newton's third law. It is we however who violate the law by not allowing it to calculate the effect of the reacting force on the acting force. There most assuredly is work performed by the reaction force, but we customarily neglect it.

All of us begin the analysis of the action-reaction law incorrectly. We consider a force F is applied to a mass object M. The mass M is provided a kinetic energy $\frac{1}{2}Mv^2$.

Right away we have a problem. What is the nature of the applied force? Does the force come from another mass object? Does it come from a field? We have to know the nature of force. The reason is because the mass M that is acted upon will do work on the applied force. Here's why.

The applied force *F* and the mass M will move together as a system for a short interval *ds*, where *s* is the distance of the interaction. During that interval there will be an exchange of energies in this closed system. Let's assume mass M is initially at rest. The only energy it has at the moment is internal energy. When mass M is provided kinetic energy, it has to lose internal energy. The impacting object loses kinetic energy but gains internal energy.

The following example is for illustrative purposes only. It is presented only to help the reader see the energy exchanges. We will use two electrons in the illustration. The electron at rest has internal energy 0.511 *MeV*. When it is moved from rest, it will acquire kinetic energy. It can do so only by surrendering some of its internal energy. The acting electron on the other hand has lost kinetic energy, but gained internal energy. In this example, the internal energy gained is in the form of a photon. The photon was emitted by the accelerated electron. In the Bohr model of hydrogen atom, we might recall, an electron that speeded up in the lower orbits lost internal energy by radiating a photon. When the electron jumped up to higher orbits where it had less speed, it absorbed a photon. The photon in our two-body example does not escape from the system.

The mathematics to support our position is rather simple. The author of the *Physica Scripta* writes $F_{12} = -F_{21}$, but we prefer to write it as

$$F_{12} + F_{21} = 0 \tag{1}$$

Why the difference? Because we want the reader to focus on the fact that F_{21} has to be negative. When we perform the work integral, we have

$$\int_0^s (F_{12} + F_{21})ds = 0 \tag{2}$$

Distribution and separation provides

$$\int_0^s F_{12}ds = -\int_0^s F_{21}ds \tag{3}$$

and, since a negative sign in front of the integral on the right-hand side yields positive work, we have

$$W_{12} = W_{21} \tag{4}$$

In other words, the force of reaction does as much work as the acting force.

Why has the analysis of Newton's third law been wrong for so long? It is because at the macroscopic level we ignore what happens within the distance interval *ds*. At the macroscopic level the energy exchange in the interval *ds* is of very little import. At the microscopic level, however, the energy exchange cannot be overlooked.

We make the observation that our analysis here does not support special relativity's rest-mass increase with velocity. Our analysis shows that the rest-mass in fact decreases with velocity.

Does what we have said apply also to an electron in a static field? Yes it does. The field works on the electron, and the electron works on the field, a fact which is neglected with grave consequences in special relativity. The supposed mass increase of the electron in the field does not occur.

What about Newton's third law in open systems? The problem with open systems is that outside influences are difficult to control, which is what the *Physica Scripta* author finds. Those types of problems, however, are not third-law problems in the strictest sense. The third law requires us to focus on closed two-body systems.

Bibliography

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