PASQUALE TUCCI*

Remarks on Fox's paper

I would to make some remarks on Fox's paper.

It deals with the so called 'crucial' experiments that ought to allow us to decide about the correctness between two competing theories.

Fox's view is that 'crucial' experiments have lost something of the central place that they once held in the interpretations of the scientific change. And he gives some reasons for his approach:

1) the transition from a theory to another is not an *event* but a *process*. The new theory is not an Athena who springs from the head of Zeus. (these are my words).

2) Some experiments seem crucial only in retrospective. They were not at all crucial for the eyes of contemporaries.

3) *The* theory doesn't exist. What we call *The* theory is a cluster of theories each founded on different premises and each able to explain some but not all phenomena. They coexist and are used indifferently according to the phenomena that have to be explained.

As example Fox discusses a group of experiments of Benjamin Thompson, Count Rumford, which demonstrates that the friction that occurred in the boring of a brass cannon produced unlimited quantities of heat. According to Thompson these experiments ought to overthrow the 'caloric' theory in favour of the heat as a form of motion.

I would quote two other examples which support Fox's view and allow me to stress another aspect of the crucial experiments.

The first example is Foucault's experiment on the velocity of light in water and in air.

The second one is the Michelson-Morley second order experiment for detecting of the movement of the Earth across a fixed ether.

* Istituto di Fisica Generale Applicata, Università degli Studi di Milano, Via Brera, 28 - 20121 Milano.

Foucault's experiment

At the beginning of the 19th century, two rival hypotheses concerning the nature of light existed in physics: the corpuscular theory, which is usually ascribed to Newton, and the wave theory, which originated with Descartes and Huygens, and was revived by Young and Fresnel.

These two theories could account for many experimental phenomena. But there was an important point of difference between them: the corpuscular theory assumed for its explanation of refraction that the speed of light in a transparent medium (such as glass or water) is greater than the speed of light in empty space.

The wave theory, on the other hand, assumed exactly the opposite.

On the basis of this difference, François Arago proposed a "crucial experiment" which would compare the two speeds.

The experiment was carried out in 1850, with clear results: light travels more slowly in water than in air.

Therefore one could deduce from the experiment that light is a wave, and the corpuscular hypothesis can be discarded.

But Duhem disagreed with this conclusion.

First, he pointed out that Foucault's experiment did not decide between two isolated hypotheses, but between two complete theoretical systems.

Moreover it's possible that a future theory might be built upon the corpuscular hypothesis, with the aid of some new auxiliary hypotheses which would be different from those entering the Newtonian system.

And, it is not at all certain that the current concepts "wave" and "particle" are the only possible ones; perhaps a new concept might be formulated, which would go beyond this dichotomy, possibly by combining some aspects of both concepts.

So even though an experiment could be crucial in a certain time it could be not at all crucial in a future inside a new theoretical and experimental context.

In fact, shortly afterwards, Einstein re-introduced into physics the idea of a corpuscular nature of light, starting with his 1905 paper on light quanta.

But in this new context "particle" and "waves" were destined to acquire new meanings.

The Michelson-Morley experiment

In 1881 and 1887 Michelson and Morley performed a series of experiments aimed at measuring the earth's velocity relative to an hypothetical all-pervading ether.

The results was nil in contrast with Lorentz's theory.

After the publication of the Special Relativity Theory the Michelson-Morley experiment was considered an experimental proof for the theory of relativity and as a disproof of the theory of electromagnetic ether.

And this point of view is still present in several textbooks of physics.

But we know that the ether was not abandoned.

In the 1925, 20 years after the Special Relativity, another experimenter (D.C. Miller) had claimed to have detected an ether wind.

The results are still controversial but is striking to note that the issue of ether was still alive – despite Einstein's theories.

In the 1951 Dirac wrote: "Physical knowledge has advanced much since 1905, notably by the arrival of quantum mechanics, and the situation [about the scientific plausibility of aether] has again changed.

If one examines the question in the light of present-day knowledge, one finds that the aether is no longer ruled out by relativity, and good reasons can now be advanced for postulating an aether….

We can now see that we may very well have an aether, subject to quantum mechanics and conformable to relativity, provided we are willing to consider a perfect vacuum as an idealized state, not attainable in practice. From the experimental point of view there does not seem to be any objection to this. We must make some profound alterations to the theoretical idea of the vacuum…. Thus, with the new theory of electrodynamics we are rather forced to have an aether."

Which moral from these examples?

An experiment is never "crucial" because

a) it is confronted with a cluster of a theories and not with *The* theory (Thompson);

b) what can be considered "crucial" in a given time can be reinterpreted afterwards within a new theoretical and experimental context (Foucault);

c) physical concepts (ether, particle, wave, electron, current) owe their meaning within a theoretical and experimental context. (Dirac's aether is different from Lorentz's aether.)

To conclude a question:

Why is't very common to find in scientific papers and textbooks quotations of "crucial experiments" against an impressive historical evidence?