Metaphysical Review

Essays on the Foundations of Physics

Metaphysics: The study of the fundamental or primary causes and the underlying nature of things

Vol. 4 August 1, 1997 No.2

ISSN 1083-1908

J. J. Thomson and 100 years of the Electron Part II.

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The Theory of the Electron and the Relation Between Field and Particle in Classical Electrodynamics

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(received June 10, 1997)

I. HISTORICAL BACKGROUND

> Before Maxwell people thought of physical reality — insofar as it represented events in nature — as material points, whose changes consist only in motions which are subject to total [i.e. ordinary] differential equations. After Maxwell, they thought of physical reality as represented by continuous fields, not mechanically explicable, which are subject to partial differential equations
>
> Albert Einstein

The basic nature of Newtonian mechanics is a universe of particles, each of which interacts with the others either through direct collision (as was the view in mechanistic philosophies such as Descartes'), or by means of various forces acting at a distance, of which the most famous example is of course gravitation. Mathematically, this is made most evident in Newton's second law of motion, which is an *ordinary* differential equation:

$$m\ddot{\mathbf{x}} = \mathbf{F}(\dot{\mathbf{x}}(t), \mathbf{x}(t), t).$$

Newton remained all his life a passionate defender of the corpuscular, or particle-like, conception of light. Throughout the eighteenth century, the great prestige of Newton, as well as the observational evidence at hand, helped to ensure the dominance of this particle-like conception of physical reality — the universe was a giant pool table, on which a finite collection of massive particles interacted, the whole system smoothly evolving through time.

Beginning in the nineteenth century, though, the use of smooth quantites, with an uncountably infinite number of spatial degrees of freedom, became more prevalent, first as a calculational aid in such subjects as heat flow and fluid mechanics: no one really doubted the existence of many millions of tiny particles, but it was simply more convenient to work with *partial* differential equations for bulk macroscopic variables such as velocity or pressure than to try and formulate and solve many millions of ordinary differential equations. But with Faraday's proposed magnetic field, another occult force (albeit one that continued to obey an inverse square law, just like Newton's law of universal gravitation) seemed to have been introduced, a force for which, like gravitation, no corpuscular interpretation seemed ready at hand. Young's famous experiment exhibiting the interefence of light seemed to cast further doubt on the wisdom of Newton's corpuscular views, and by the late nineteenth century a minor revolution was underway in physics, as Maxwell proposed the world's first complete *field* theory, which sought to unite the magnetic and electric fields into one electromagnetic field, which existed even in the absence of sources of any kind, and seemed indeed to knock the corpuscular view of physics off its throne, to be replaced with a field-theoretic conception of the natural universe: space was inhabited by various fields, interacting with each other, and the "particles" we observe are really nothing other than local excitations of these fields.

Then, of course, came Thomson's discovery of the electron in 1897; the old Newtonian view had found a new lease on life, but how could this "particle" be reconciled with Maxwell's field conception of electromagnetism? What was the appropriate equation for the motion of this new particle in the presence of an electromagnetic field? How did the field, as carrier of charge, interact with a charged *particle*, rather than a smoothly varying charge density or current vector, particularly if the particle was undergoing accelerated (i. e. noninertial) motion? Over the next fifteen years, these questions were to result in much controversy and discussion within theoretical physics, involving some of the most well-known names of that period: Lorentz, Einstein, Poincaré and Dirac, to name only some of the most prominent.

II. THE LORENTZ FORCE AND EQUATION OF MOTION

The first main requirement for obtaining an equation of motion for a charged particle in the presence of an electromagnetic field is a force law, to whose value we may equate the product of the mass and the acceleration of the point charge. Such a force law was first proposed by Lorentz, and can be expressed as (in units where $c = e = 1$, which we employ throughout this section)

$$\mathbf{F} = q\left[\mathbf{E} + \mathbf{v}\times\mathbf{B}\right]$$

where $\mathbf{E}$ is the electric field vector, $\mathbf{B}$ that of the magnetic field, $\mathbf{v}$ and q are the velocity and charge of the particle. Lorentz had hoped to give a purely electromagnetic model of the electron (see [1], Note 18, p. 252), but as Poincaré later pointed out, such a purely electromagnetic charged particle was impossible because classically, a charge distribution by itself is unstable. The Newtonian equation can then be applied to give us the equation of motion

$$m\ddot{\mathbf{x}} = q\left[\mathbf{E} + \dot{\mathbf{x}}\times\mathbf{B}\right].$$

But in writing down this equation we have neglected a crucial new development that emerges from the duality of our conceptions of field and particle: the particle itself carries with it an electromagnetic field of its own, which will contribute to the expressions for $\mathbf{E}$ and $\mathbf{B}$, and the effects of these new electromagnetic fields, both external ones and the "self-field" of the particle, travel at a *finite* velocity c, rather than the infinitely quick action-at-a-distance theory of Newtonian gravitation. Among other things, we know that this maximum velocity forces us to include relativistic effects in our equations, specifically with the mass term, which is transformed from m to $m_0\gamma(\mathbf{v})$, where $\gamma(\mathbf{v})$ is the relativistic Lorentz factor.

Because of this, our naïve attempt at writing down an equation of motion cannot be complete; to take account of this duality between field and particle, we will have to couple this Lorentz force equation to the Maxwell equations describing the evolution of the electromagnetic field itself. The resulting system has the form

$$\begin{aligned}
\frac{\partial\mathbf{E}}{\partial t} &= \nabla\times\mathbf{B} - 4\pi(\mathbf{J}_{\text{ext}} + \mathbf{J}_{\text{self}}) \\
\frac{\partial\mathbf{B}}{\partial t} &= -\nabla\times\mathbf{E} \\
\nabla\cdot\mathbf{E} &= 4\pi(\rho_{\text{ext}} + \rho_{\text{self}}) \\
\nabla\cdot\mathbf{B} &= 0 \\
\frac{d}{dt}(\gamma(\dot{\mathbf{z}})\dot{\mathbf{z}}) &= \frac{q}{m}(\mathbf{E} + \dot{\mathbf{z}}\times\mathbf{B}).
\end{aligned}$$

Here, ρ_{ext} and J_{ext} are the charge density and current vector arising from the external fields, while the charge density and current vector for the self-field take the form of scalar-valued and vector-valued distributions

Given expressions for $\rho_{\text{ext}}(\mathbf{x})$, $\mathbf{J}_{\text{ext}}(\mathbf{x})$ and appropriate initial and boundary data, we should then be in a position to solve the coupled Lorentz-Maxwell equations. The direct solution of these equations, though, is extremely difficult, so we will exploit a knowledge of the retarded field of a point charge to find what we hope will be the correct equation of motion of a point charge in classical electrodynamics. This retarded field, the Liénard-Wiechert field, can be written as (in a frame in which the particle is at rest at the origin at the retarded time)

$$\mathbf{E}_{\text{ret}} = q\frac{\mathbf{n}}{r^2} - q\frac{\mathbf{w}}{r}$$

and

$$\mathbf{B}_{\text{ret}} = q\frac{\mathbf{w}\times\mathbf{n}}{r}$$

where $\mathbf{n}$ is a unit vector in the direction of the field point, $\mathbf{w}$ is the component of the acceleration vector orthogonal to $\mathbf{n}$ (and $\mathbf{v}$) and r is the distance from the origin to the field point. The Poynting vector (Jackson [2] equ 6.109) for this field can be easily calculated to be just

$$\mathbf{P} = \frac{q^2}{4\pi r^2}|\mathbf{w}|^2\mathbf{n} + \mathrm{O}\left(\frac{1}{r^3}\right),$$

giving a total energy outflow through a retarded sphere of

$$E_{\mathrm{out}} = -\frac{2}{3}q^2|\dot{\mathbf{v}}|^2$$

the Larmor radiation law. Now that we understand how much energy is being radiated by the electron as it moves, we can (hopefully) correct our original Lorentz equation to take account of this energy loss.

So, starting with

$$m\dot{\mathbf{v}} = \mathbf{F}_{\mathrm{ext}} + \mathbf{F}_{\mathrm{rad}}.$$

and following the presentation in Jackson [2], pp. 783-4, we can show that the equation of motion of the electron assumes the unusual form

$$m\left(\dot{\mathbf{v}} - \frac{2}{3m}q^2\ddot{\mathbf{v}}\right) = q\mathbf{F}_{\mathrm{ext}}. \tag{1}$$

This purely classical equation is called the Abraham-Lorentz equation, after the two men who were largely responsible for its derivation. The first, striking, fact about this equation is that it is *third* order, and so requires the specification of not only the initial position and velocity of our hypothetical point particle, but also of its initial acceleration. There are other problems: let us suppose that $\mathbf{F}_{\mathrm{ext}} = 0$, then there exist two solutions to this equation, the obvious one $\dot{\mathbf{v}} = 0$ *and* $\dot{\mathbf{v}} = \mathbf{a}\exp(3mt/2q^2)$, where $\mathbf{a}$ is the initial acceleration, a solution which diverges as $t \to \infty$! We can avoid these unwelcome "runaway" solutions by replacing this equation with an integro-differential equation by means of an integrating factor: let $\epsilon = 2q^2/(3m)$ and multiply both sides of (1) by $\exp(-t/\epsilon)/(\epsilon m)$, yielding

$$\frac{d}{dt}(\dot{\mathbf{v}}e^{-t/\epsilon}) = -\frac{3}{2q}\mathbf{F}_{\mathrm{ext}}.$$

Integrating both sides gives us

$$\ddot{\mathbf{x}}(t) = \frac{3}{2q}e^{t/\epsilon}\int_t^\infty \mathbf{F}_{\mathrm{ext}}(\mathbf{x}(s))e^{-s/\epsilon}\,ds \tag{2}$$

which is equivalent to the original Abraham-Lorentz equation under the condition that $\lim_{t\to\infty}\dot{\mathbf{v}}(t)\exp(-t/\epsilon) = 0$. We note here that nothing in this reduction of (equ 1) to (equ 2) assures us that $\lim_{t\to-\infty}\dot{\mathbf{v}}(t)$ will be well-behaved, though we assumed this to vanish in order to derive (1) in the first place. Another problem with our integro-differential equation is that *pre-acceleration*: the acceleration of the particle at time t in 2 seems to depend on the value of the external force at times $s > t$, i. e. at *later* times — the particle can begin to accelerate before the external field is applied! An *ad hoc* dismissal of this problem can be made by arguing that these violations of causality should occur over time intervals of approximate duration ϵ, due to the damping factor $\exp(-s/\epsilon)$ in the integrand, and for such obvious examples of point particles as the electron, ϵ is of the order of magnitude of 10^{-23} seconds, ruling out any hope of experimental observation. Moreover, when dealing with external forces turned on over an interval of length ϵ, there will be an energy uncertainty of $\Delta E \approx \hbar/\epsilon$ according to the Heisenberg Uncertainty Principle; if this energy uncertainty is of the order of the particle's rest mass mc^2, then the motion of the particle will in fact be far from the domain of validity of classical mechanics. Thus many authors argue that the whole issue of the electron's motion can only be properly dealt with in quantum electrodynamics (QED), but the logical and philosophical foundations of QED are, if anything, even murkier and less well understood than those of classical electrodynamics.

It might be objected that had we done this calculation in a fully relativistic manner, the equation thus obtained would not suffer from the defects of the Abraham-Lorentz equation. In fact, such is not the case as the relativistic calculation (see [3], pp. 136-43) adds only one additional term and leads to the Lorentz-Dirac equation,

$$a_\mu(\tau) = e^{\tau/\epsilon}\int_\tau^\infty \left[\frac{3}{2q}F_\mu^{\mathrm{ext}}(u(s)) + a_\nu(s)a^\nu(s)u_\mu(s)\right]e^{-s/\epsilon}\,ds$$

where τ is the proper time for the particle, u_μ is its four-velocity, a_μ the four-acceleration and indices are raised and lowered using the standard Minkowski metric $\mathrm{diag}(1,-1,-1,-1)$. This equation too suffers from the violation of micro-causality, and despite having been the object of much study over the past fifty-nine years since Dirac derived it (see [4]), very little of a definitive nature is known about its solutions. All that is known for certain is that some solutions can behave in ways that seem very counter-intuitive: for instance, let us suppose we have two particles in symmetric straight-line motion, that is

$$u_1^{\mathrm{in}} = \gamma(\mathbf{v})(1,\mathbf{v}) \qquad \textit{and} \qquad u_2^{\mathrm{in}} = \gamma(\mathbf{v})(1,-\mathbf{v})$$

with the only fields present being those of the retarded fields of the two particles themselves. If the two particles have equal but opposite charges and $\mathbf{v}_{\mathrm{in}} = 0$, it can be proved that they never collide and that they end up travelling in opposite directions with velocities asymptotic to that of light (see [5]).

It can also be shown that this same problem of point electrodynamics also leads to strange behaviour in the context of curved spacetime, where the usual Lorentz-Dirac equation seems to lead to violations of the strong equivalence principle. The equation of motion for free fall of a charged test particle in a curved spacetime assumes the form

$$ma^\mu = \Gamma^\mu - \frac{1}{3}v^\alpha \left(R^\mu_\alpha + \frac{1}{c^2} R_{\alpha\beta} v^\beta v^\mu \right) + \phi^\mu$$

This equation clearly depends on the mass of the particle, and so the strong principle of equivalence* is *not* valid for charged particles in true gravitational fields (by true, we mean gravitational fields caused by genuine spacetime curvature, so that $\phi^\mu \neq 0$ and $R_{\mu\nu} \neq 0$). It is, however, true for charged particles in apparent gravitational fields since then the only solution of the equation consistent with the boundary condition at infinity is $\ddot{z}^\mu = 0$. Rohrlich observes:

> One can speculate about the consequence of this result. [...] Now we are faced with the fact that charged particles satisfy Einstein's principle (i.e. the weak equivalence principle) but not the principle (E) (i.e. the strong principle). Does this imply that a geometrization of electromagnetic interactions is not possible? This conclusion is certainly suggested. The consistent lack of success of the many attempts at a fully unified field theory seems to point in the same direction. It may well be that electromagnetic interactions have much more in common with strong and weak interactions than with gravitational ones and will correspondingly find their next level of physical theory aligned with those interactions.†

Once again, we see the rather mysterious problems that arise out of the field/particle duality that occurs not only in classical electrodynamics but also in the other great field theory of classical physics, the general theory of relativity. It has long been known that Huygens' Principle can fail to hold in general Riemannian spaces, a failure which manifests itself in the "tail-term" ϕ^μ for the equation of motion, and it would seem that a charged particle also seems to contradict the strong equivalence principle, though once again no laboratory measurements have ever been able to measure such violations due to the weakness of gravitational fields on Earth, particularly with respect to electrons.

III. CONCLUSIONS

From the examples given in the preceeding section, one can see clearly that the relationship between fields, the archetype of twentieth century physical thought, and particles, has always been a little mysterious and controversial, and often inexplicable. A great deal remains unknown, a hundred years after Thomson first discovered the electron, the particle whose existence first begged the question as to how a charged point particle interacts with a continuous field, either an electromagnetic one, or even the "geometric" fields used by Einstein in constructing general relativity. Even today, when the electron (along with the other leptons, the muon and tauon) continues to exhibit no internal structure down to 10^{-15} m, reinforcing our conviction in its essentially point-like nature, no general existence and uniqueness proof exists for the Lorentz-Dirac integrodifferential equation, much less one assuring us of continuous dependence on initial data and other features we would expect in a full and complete physical theory. It was Dirac's belief that until we had a consistent and coherent classical theory of point charges, any attempt at quantization was doomed to merely reproduce, or even magnify, the flaws of the original classical theory, though others have argued that the entire notion of a point particle is, in the context of twentieth century physics with its uncertainty principles between position and momentum and energy and time, untenable and ought to be banished from physics. Yet the electron persists in its failure to exhibit any internal structure, and there remains no coherent theory of the electron as an extended entity. At present, the tension between particle and field in modern physics continues to push us towards a better understanding of the nature of matter and energy and which, if either, representation of physical reality is the more fundamental.

* The equations of motion of a non-rotating test body in free fall in a gravitational field are independent of the energy content of that body (here, energy content simply means *inertial mass*, since this is what is experimentally measured)

† [6], p. 223

[1] Lorentz, H. A. *The Theory of Electrons*, 2nd edition. New York: Dover, 1952

[2] Jackson, J. *Classical Electrodynamics*, 2nd edition. New York: John Wiley and Sons, 1975

[3] Parrott, S. *Relativistic Electrodynamics and Differential Geometry.* New York: Springer-Verlag, 1987

[4] Dirac, P. *Proc. Roy. Soc. London* **A167**, p. 148 (1938)

[5] Eliezer, C. *Proc. Camb. Phil. Soc.*, **39**, p. 173 (1943)

[6] Rohrlich, F. *Classical Charged Particles.* Reading, MA: Addison-Wesley, 1965

What is Research?

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(received July 28, 1997)

I am going to take a critical look at what it means to do research. The point of view I express is a personal one that seeks to disturb the calm and complacent consciences of those who, myself included, are dedicated to research. You may not agree with me, but I hope that at least you will take what I say as an invitation to reflect and perhaps even formulate fresh points of view.

It all began when our primary or secondary school teachers inspired us by telling us about the struggles and miracles of science. This did not impress all the pupils, but it did impress us. After all, here we are doing research. Our ability to solve problems that the other kids found difficult was a factor that sharpened our interest in the sciences. We felt a kinship with science and mathematics and experienced a certain ego-boosting pride, as if to say, 'here I count for something'.

As lovers of scientific knowledge, simply thinking about the great events in scientific history was enough to feed our intellects. We were told of the exploits of Galileo, Newton, Darwin, Einstein or Bohr, who for us became heroes worthy of emulation.

Eventually, we finished our degrees with high grades and were able at last to gain access to one of those 'high-tech' centres where, so we were told, research is done. 'But what exactly is it,' I ask, 'that we really do?'

History teaches us not to separate individual experience from general events. Hence, when Galileo observed the satellites of Jupiter, he was also demonstrating that not everything revolves around the Earth. Newton's laws were not formulated for the purposes of engineering applications but to reveal the non-teleological mechanism of our Universe. When Laplace told Napoleon that he had solved the system of equations which explain the motions of the planets without the need to invoke God, the important point was not his mathematical jugglings but the struggle to arrive at the truth without resorting to ancient mythologies. Darwin put humankind in its place within the animal kingdom. Etc.

Changing ideas about the Universe are what drives the scientist. Before becoming a data collection on Nature, science was mainly devoted to combating superstition, the principal aim was rigorously to realize the dreams of Epicurus and Lucretius to overthrow the idea of the gods controlling the Universe, to emancipate Nature from the grip of haughty lords and dark, mysterious forces, to demystify the Universe and face truth head on. In other words, knowledge for the sake of knowledge, the elevation of mankind with an understanding of his surrounding without needing to resort to white lies.

We live in different times. Nowadays oppression does not come from powers making claims on behalf of divinity. The value that motivates today's world is called Money rather than God. The conspiracy between capitalism and democracy is all-consuming, their enemies having either of two destinies: be absorbed or be eliminated. The applied sciences have always been allied to capitalism; they drive technology and flood the market with products labelled with a price. The pure sciences or those with non-industrial applications, such as for the most part astronomical researches, were revised in terms of their driving principles; they were adapted to the needs of our times, absorbed. Present-day utilitarianism revolts at the idea of knowledge for its own sake. Even Buddhism, with its initially antimaterialist ideas, has been rendered into a marketable product in the book shops or in the form of courses on transcendental meditation. Culture has also been turned into a 'cultural industry', to use Adorno's expression. Scientific knowledge has become a milch cow on which to grow fat, an industry providing jobs to some state employees in order to make possible for them to live with their spouses and their children in the welfare state.

Those research ideals have been left behind. Intellectual restlessness, the search for truth created those colossi of knowledge who moved among the different fields like salmon among rapids. Today, such pirouettes have become impossible because knowledge has become heavy and sluggish. You will see an elephant skipping before you see a scientist knowing so many fields as our scientific forefathers did. Nowadays, a scientist has to specialize. Scientists have been specializing for quite a long time, but it is now a question of microspecialization. There are experts on cool stars, the Galactic bar, certain types of chemical reactions, etc. The most a scientist can hope to achieve is mastery of a few microspecializations, in which to invest their efforts or creative interests. It is hard to imagine someone getting into a specialization because it is his only interest, unless the system has made him crazy enough to believe that his topic is the centre of the world. This clearly is not so. Rather, it is more a case of converting the scientific process into an industrialized mass-production system. Everybody attends to his own cog so that the system runs smoothly.

It is a treason to our scientific forefathers' ideals. Descartes gave science a sense for mankind as a search of truth in his 'Rules for the direction of the mind', and expressed in the first rule:

> Thus, if somebody wants seriously to research the truth of the things must not choose a peculiar science, since all of them are related among themselves. Rather, he must only think about increasing the natural light of reason, not in order to solve this or that school's difficulty but to get an understanding about life that shows us the behaviour we have to choose.

And, what does the scientific industry produce? The answer depends on the observer. From inside, we see tons of printed paper which is not read by anybody except some few specialists, each one about his topic. From outside we get a hermetic impression, such as we said 'what amazing things must this people be discovering!, it must be so difficult and advanced that it is not accesible to my level of understanding'. That is the impression which is of interest to give to those who pay the taxes to the state in order to contribute further money to research. Those who are decicated to applied sciences have a easiest task because they promise technological advances. The pure sciences – with no application – in order to not loose the thread of statal subventions, must also talk about long-term technological progress in a country. If it is necessary, they lie. If the technological argument does not work, they attempt to impress people with the knowledge content. If it is necessary, they exaggerate. They say that a satellite or a telescope is going to create a revolution in astronomy, that we are going to observe the whole Universe and some parts of other ones,... and then the artifact arrives and .... the revolution has been rather small. Perhaps they scrape something else about some galaxy which was not in our collection.

We must not deceive ourselves. The more the history advances, the more difficult the achievement of a relevant truth is. The Newton's scientific activities during some year of his life with a notebook and a pen were more fruitful than that of thousands of the best actual scientist in their whole life with millions of dollars. It seems that there are many writtings, many data, ...but in the last analysis our comprehension of the nature in a global sense advances nearly imperceptibly. Great efforts bear less fruit.

The fight for the economic power and social status promotes fights among specialist from different fields rather than searching 'the truth' altogether. Astronomers ask money because they are disemboweling the cosmos secrets; the particle physics are disemboweling the matter secrets; the biologist the life secrets; ... What impatient people who wants to reveal all of nature's mysteries and does not want to leave anything for the next generations! Some data are still not totally exploited and we are thinking about getting the next ones. Fast!, before any others make the discovery! Impatience has never been typical of wise people. I know well your little secret: will to power. In regard to this topic, Nietzsche has made a deep psychological analysis of man intentions.

The fight among specialists from different branches is similar to that for defending the lands in the medieval age. The 'authorities of the matter', as they call themselves, are like lords of some lands who keep fervently their kingdom. When an intruder tries to insert his nose in a speciality which is not his, he will soon receive a cohort of 'authorities' reading his rights. Generally, the lands are also fenced with a language and symbolism to be crossed only by experts. In some ocassions, I would say that formalisms are made to frighten to other people, in order to make the entrance difficult.

Saying that doing research is collaborating in the peace and fecundity of mankind progress is slightly silly. Nations do not invest in research today because of beautiful phrases like the one above. Nations, like persons, look for prestige. A country sends its sportsmen to the Olympic games to win prestige, in order to get people to say: 'sportman with certain nationality won a medal...', and then the national hymn will be played and all that. Next day, the newspapers publish in their pages 'our sportsmen won some medals in ...'. This 'our' makes the reader feel proud to belong to his country and then he will like to produce for his society. In the same way, the state pays scientists, even non-technological ones. If they are not useful for industrial production, they are at least useful to produce prestige. It is very beautiful to find in the news: 'scientist of our research centers discovered...', it makes the citizens believe they lives in a true country. There are meetings about science even in undeveloped countries, do they also want to collaborate for the peace and fecundity to the mankind progress while their citizens live on the poverty?

The great spanish philosopher Miguel de Unamuno, expressed in the presence of this events: 'let them invent!'. This expression has more containt than a simple rebuff. If we are interested in knowing the truth, the way is not the microspecialization. Let the nations invest their efforts, their own pride will announce the news to the world and the ideas you were interested in will arrive in your ears. Of course, this position does not include neither a job nor a medal, only wisdom and prudence.

In some place of the 'The tragic sense of life', Unamuno says:

> Yes, yes, I see it; a huge social activity, a powerful civilization, a lot of science, a lot of art, a lot of industry, a lot of morality, and then, when we have filled the world with industrial wonders, with large factories, with paths, with museums, with libraries, we will fall down exhausted near all this, and it will be, to whom?, was the man made for the science or the science for the man?

That is, to whom? Perhaps, the historic moment when we must raise again the question about we do has already arrived. Where are we going? The scientific method is awfully eroded. That thing with a reason for being at the beginning of modern age as a promoter of positive knowledges; that later lights century and its enlightenment; ... all that is part of the past. Today, science is as crushed as the contemporary art. In words by P. K. Feyerabend in his 'Against method':

> Science failed to be a variable human tool to explore and change the world and rendered itself into a solid block of knowledge, impermeable to human dreams, wishes and hopes.

Science looses its first attractiveness, simple technical operations remain. Which is the thing in whose name we do research?, in the name of truth?, of economy?, of prestige? Science as an amusement still remains but even the growing pedantry and heaviness limit this.

Doing research is fighting, what is any other thing the human being could do? Fight against powers or to get powers, that depends on us. Science can be a revolution or deadlocked idleness. Still waters, without pushing the stones along their history, tend to form bogs.

Recomended lectures:
Some lectures of the classical philosophers that I mentioned above, and many others that I have not cited, are always recomended, of course. In this journal, I have also found some interesting articles related in some way with the topic such as:

- Apostol M., 1996, 'The State of the Physics', Metaphysical Review, 2(8), 7.

- Smith T. P., 1997, 'Why are we in Physics?', Metaphysical Review, 3(6), 1.

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Timothy Paul Smith - editor

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