

## Festschrift Vigier

Papers in Honour of Jean-Pierre Vigier on the Occasion of his  
Seventieth Birthday

The present issue constitutes the proceedings of a workshop held to mark the seventieth birthday of Jean-Pierre Vigier. The ten participants in the workshop delivered and debated their papers during two and a half days of sessions held in a windowless cubicle deep in the labyrinthine office complex at La Defence near Paris in June 1990.

For many years after the last world war, Jean Pierre Vigier was a close collaborator of the French Nobel laureate and co-founder of quantum mechanics, Louis de Broglie, and he remains one of the most vocal defenders of the vision of the quantum world advocated by de Broglie. Consequently, any appreciation of Vigier's work must begin with a brief account of the evolution of de Broglie's thinking.

In his earliest writings, de Broglie had sought to rescue the wave-particle duality of quantum mechanics from the probabilistic formulation of the Copenhagen interpretation. Isolated at the Solvay conference in 1927, he became a reluctant convert to the Bohr-Heisenberg position. Much later, in the 1950s, a series of developments drew him back to his original deterministic standpoint. As de Broglie himself relates, Jean-Pierre Vigier bears some of the responsibility for this second heresy:

*For nearly twenty-five years, I remained loyal to the [Bohr-Heisenberg view], which has been adopted almost*

*unanimously by theorists, and I have adhered to it in my teaching, my lectures and my books. In the summer of 1951, I was sent the preprint of a paper by a young American physicist named David Bohm, which was subsequently published in the January 15, 1952 issue of the Physical Review. In this paper, Mr. Bohm takes up the ideas I had put forward in 1927, at least in one of the forms I had proposed, and extends them in an interesting way on some points. Later, J-P Vigier called my attention to the resemblance between a demonstration given by Einstein regarding the motion of particles in General Relativity and a completely independent demonstration I had given in 1927 in an exercise I called the 'theory of the double solution'. Recently, these various developments have brought my attention back to those questions... (La Physique quantique restera-t-elle indéterministe?)*

Thus, very early in his career, Jean-Pierre Vigier grappled with the problem of reconciling Generalized Relativity (Einstein's attempt at a total field theory in which particles are represented as singularities of the field) with the "double solution" theory of de Broglie, where the (mathematical) probability wave is accompanied by a (physical) pilot wave. His interest in cosmology and astrophysics, as Jean-Claude Pecker relates in his tribute to Vigier, was motivated by a desire to confirm the hypothesis, central to de Broglie's wave-particle conception, of a non-zero photon rest mass. In two texts written during the 1960s, de Broglie discussed the implications of a massive photon, concluding that the cosmological redshift

*...could be due to 'photon aging', i.e. a gradual loss of energy by photons during their long intergalactic voyage. This effect, hitherto unknown in any theory of light, even*

*theories that admit photons, could be due to a continuous loss of energy by the photon to its surrounding wave.*  
(C.R. Acad. Sci. Paris, **263B**, 9, 589)

The de Broglie photon is a compact region of high density transported by its pilot wave, a kind of bowling ball rolling across a gently undulating landscape. As the wave propagates, it repeatedly undergoes “weak” absorption into the surrounding medium. This vacuum interaction gives rise to both the “pilot” effect and de Broglie’s ingenious interpretation of the cosmological redshift.

*A photon arriving from a very distant nebula could have its [pilot] wave weakened through a slow attenuation or absorption by the extremely tenuous absorbing matter that we now know exists in interstellar space... This would result in a gradual decrease of the quantum  $h\nu$ , and hence a redshift, through a mechanism quite different from ‘strong’ photon absorption or the Compton effect. The actual mechanism would be the continuous ‘weak’ absorption of the [pilot] wave.* (Cahiers de physique, **16**, 147, 429)

Obviously, de Broglie’s weak photon interaction has none of the *ad hoc* character of which most tired-light mechanisms are accused; it follows directly from considerations at the fundamental level of quantum theory. The cosmos furnishes a laboratory in which the theoretical prediction might be verified.

Had de Broglie published this scheme in the early 1920s, before cosmological expansion was anointed as the obligatory interpretation of the redshift, physics might be very different today. On the one hand, his still vague notion of a deterministic wave mechanics, embodied in the double solution theory, would have received support

from convincing independent evidence in the form of the extragalactic redshift. Equally important, Hubble's conjecture that redshifts might be explained by "some hitherto unrecognized principle of physics" (*The Realm of the Nebulae*) would have found an echo in the world of quantum mechanics. Yet this decisive connection was not made. Physics was plunged into a dark age where material particles do not exist until observed, and space and time—not the quantities we measure, meters and seconds, but space *as such* and time *as such*, the abstractions—have been merged into a strange amalgam that can be curved and distorted. In this upside-down world, what is there to prevent physicists from believing that the Universe was created from nothing? Cosmology has essentially become a practice field for the Olympians of General Relativity whose prowess in science, like the expanding Universe they have constructed, is largely imaginary.

In his initial 1917 excursion into relativistic cosmology, prior to the discovery of the extragalactic redshift effect, Einstein took the generally held view that the Universe must be static, as there was no apparent need to account for systematic high velocities on the large scale. To keep his finite, self-contained, three-dimensional world-model in equilibrium, Einstein added a constant term to the field equations that ensured a quasi-static distribution of matter. In a later study on particle structure, he derived this cosmological constant from the assumption of a negative pressure within particles that would scale down to the value of the gravitational constant in the more rarefied conditions of the vacuum.

The next major advance was by de Sitter, who leapt into the fray with an exhaustive series of commentaries on what he called the "material postulate of relativity of inertia"—simply the notion that space is uniformly filled with an inertia-inducing "world-matter" (the same substance from which gravitating bodies are made). Working

within the geometrical framework of General Relativity, de Sitter then investigated variants of the Einstein quasi-static spherical space that did not satisfy the inertia postulate, *i.e.* empty universes. In one case, he found that redshifts should appear in light from sources at great distances.

*The frequency of light vibrations diminishes with increasing distance from the origin of coordinates. The lines in the spectra of very distant stars or nebula must therefore be systematically displaced toward the red, giving rise to a spurious positive radial velocity.*  
(M.N.R.A.S. **78**, 3.)

Reports of redshifts measured in nebula just months before might, de Sitter felt, confirm his hypothesis. However, when Friedmann's dynamic solutions to the original field equations of General Relativity (without the cosmological constant) were established as legitimate a few years later, the balance swung in favour of an expanding relativistic model, and few were able to resist its appeal. Before long, the cosmological constant was declared a blunder. Weyl was probably already very much in the minority in 1930 when he wrote:

*It is not my opinion that we can vouch for the correctness of the 'geometrical' explanation which relativistic cosmology offers for this strange phenomenon [i.e. redshifts] with any amount of certainty at this time. Perhaps it will have to be interpreted in a more physical manner, in correspondence with the ideas of F. Zwicky.*  
(Science, **86**, 936)

A year earlier, Zwicky had made the suggestion that light particles, like any form of matter, should undergo gravitational influences from bodies they graze in their passage through intergalactic space. In the

absence of a full relativistic development, his proposal was powerless to diminish the appeal of expansion, though Hubble was to return to the notion in the 1930s.

The history of non-relativistic tired-light mechanisms dates back at least to 1920, long before Zwicky's gravitational drag model, when William MacMillan of University of Chicago, delivered a series of lectures outlining the results, largely qualitative, of his thinking on the problem of cosmology (*Science*, **51**, 67; **62**, 63.). It is a text of remarkable scope and insight. His vision of cosmology as a discipline merits close attention:

*Cosmogony deals only with the mode of origin of the various celestial objects. But the mode of origin is of no more interest than the mode of dissolution, and both of these are particular stages in a process of transformation that goes on unceasingly. The study of these transformations in their widest possible aspect is what I understand by the word cosmology. It does not belong to astronomy any more than it does to physics and chemistry, for cosmology is as much concerned with the life history of molecules, atoms and electrons and their inter-relations, as it is with the life history of planets, stars and galaxies.... To the cosmologist, each of these things is a physical unit which comes into existence, plays its allotted role upon the stage of time, and passes out of existence.... Throughout all these transformations, we recognize that there is something which persists, and that something we call energy. Energy itself is not defined, but it can be measured and with that measurement we must remain content, for the thing itself escapes us.*

To establish some guidelines for an investigation of the cosmos, he sets out a series of postulates, beginning with a few candid words on the worth of General Relativity.

*(1) There exists a physical universe, external to myself, with which I have experience.*

*I am not sure whether or not all the adherents of the modern theory of relativity use this postulate. At times it seems to me they do not. At any rate, there are people who seem perfectly happy with a mathematical formula. As for me, I am not happy unless I can see what lies behind the formula; that is to say, a qualitative understanding of a situation is of even greater importance than a quantitative one.*

*Inasmuch as the relativists do not concern themselves with a physical basis for the transmission of radiant energy, their scheme being a purely mathematical one, I am not sure they have any need for postulate 1....*

He follows this with hypotheses on Euclidean space, Newtonian time and conservation laws within the framework of a Universe that is unbounded in space and time. In a space that is uniformly filled with matter on the large scale, the physical world must extend infinitely in the macrocosm and microcosm, entropy being an essentially local phenomenon:

*The energy within a region of space does not increase or decrease unless there is a corresponding decrease or increase in some other region of space. The universe does not change always in any one direction.*

His discussion of the cycle of energy in a cosmological perspective culminates in what is essentially a tired-light hypothesis and a speculation as to the composition of elementary particles. From the postulate of energy conservation, MacMillan deduces that:

*...radiant energy can and does disappear into the fine structure of space, and... sooner or later this energy reappears as the internal energy of an atom, the birth of an atom with its strange property of mass being a strictly astronomical affair....*

*The rate at which radiant energy is being absorbed in space, and consequently the rate at which atoms are being formed, must be very small relative to the standards of a physical laboratory.... Assuming the rate of loss of energy to be proportional to the distance travelled, we find that the radiant energy decreases according to an exponential law, and since the reliable distances are certainly very great the loss must, with equal certainty, be very low....*

*There is nothing particularly strange about the idea that atoms, or electrons, are formed from smaller units by the addition of a suitable quantum of energy....*

MacMillan's arguments went unheeded in the stampede to relativistic cosmology. The "geometrical" approach of General Relativity has held an increasingly mathematized theoretical physics in its thrall for the better part of this century. The fact that the standard model gives rise to questions which, *ipso facto*, it cannot answer—questions like "What came before the Big Bang?"; or "What lies outside the expanding Universe?"—tells us that General Relativity is



simply not robust enough to venture out into the Universe unaided. The specialist will usually dismiss such questions as meaningless; according to the principles of General Relativity, *time* began only with the primordial explosion of the Big Bang, and what is expanding is *space* itself!

Hubble, of course, never bowed to the Doppler interpretation. The superiority of a non-expanding universe from the observational standpoint was so evident to him that he could write, in 1937: “[a static model] would probably be accepted without hesitation if it were not for the fact that, at the moment, we do not know of any permissible interpretation of redshift other than actual motion.” (*Observational Approach to Cosmology*) In the closing lines of a lecture series published the previous year, he issued this caution:

*Thus the explorations of space end on a note of uncertainty. And necessarily so. We are, by definition, in the very centre of the observable region. We know our immediate neighborhood rather intimately. With increasing distance, our knowledge fades, and fades rapidly. Eventually, we reach the dim boundary—the utmost limits of our telescopes. There, we measure shadows, and we search among ghostly errors of measurement for landmarks that are scarcely more substantial.*

*The search will continue. Not until the empirical resources are exhausted, need we pass on to the dreamy realms of speculation. (The Realm of the Nebulae)*

In the absence of a physically verifiable non-velocity mechanism that could redden the light reaching terrestrial instruments from distant galaxies, the linguistic convenience of expressing distances in

terms of velocity fatally enforced the Doppler interpretation as truth. Continued acceptance of an expanding Universe has been won chiefly by grafting cumbersome assumptions onto the model—so many “epicycles” that detract from its simplicity and, being forced solutions, only lead to greater complication when the model must account for further observational findings. If the expansion hypothesis could be criticized as a forced solution in the 1930s, the accumulation of observational evidence in the past six decades that defies straightforward explanation within the Big Bang model has transformed it into a veritable Hydra. Adherents of the standard model have resorted to pathetic exercises in cosmo-alchemy in order to preserve the expansion hypothesis from ruin. Claims of experimental proofs are simply self-delusion. (When the results of the recent cosmic background measurements were made known, and the data contradicted all the predictions of the standard model, the experiment was miraculously proclaimed as irrefutable proof of expansion!)

The emperor’s nakedness has not gone unnoticed, and the number of astronomers and physicists with eyes to see is surely going to grow in the coming years. At least two dozen mechanisms that account for the redshift without Doppler motion have been put forward, many, as the Einsteinian legacy would dictate, inspired by solutions to the equations of General Relativity or deductions from its general principles. Indeed, given the vast array of astrophysical environments, it is not unreasonable to suppose that there are multiple redshift mechanisms, which might be understood as variants of an underlying principle inherent in the structure of matter. (In the Doppler interpretation of extragalactic redshifts, the path to further knowledge about this structure is effectively blocked.) Alongside the theoretical development, the vistas of observational astronomy have expanded rapidly. With the advent of X-ray, gamma-ray and radio astronomy,

the discovery of quasars, the fine structure of the redshift (*i.e.* its division into discrete steps), discordant (read “intrinsic”) redshifts, and precise measurements of the cosmic background, we are vastly better equipped to “pass on to the dreamy realms of speculation” about the nature of the Universe, which once again reveals itself as unchanging and static on the very large scale.

Ironically, the geometrical approach of relativity has made greater headway in the quantum world than in the large-scale Universe. We noted earlier that de Broglie’s return to the deterministic view of quantum mechanics was partly motivated by Vigier’s conjecture of a possible reconciliation between Generalized Relativity and de Broglie’s double solution theory. As Vigier explains, Generalized Relativity amounted to treating massive particles as lumps of the ubiquitous world-matter (*à la de Sitter*):

*...in this schema, there is really nothing other than a single, unique substance resembling a geometrically describable space containing particle-singularities. This substance constitutes what might be called matter; its continuous part forms the material field, while the singularities represent particles. (Physique relativiste et physique quantique)*

The double solution theory, as we saw above, supplemented the standard wave equation of quantum mechanics, seen as a purely statistical entity, with a physically real wave which would propagate in phase with the probability wave in Galilean space-time. This new classical field was the bearer of the particle-singularity. A *rapprochement* between the two lines of thinking seemed plausible for mathematical as well as epistemological reasons.

*It is striking that the quest for a solution to the difficulties raised by relations between the gravitational field and*

*particles in it, on the one hand, and the connection between the particle and wave aspects of matter, on the other hand, should lead to mathematically similar approaches. In the final analysis, both rest on hypotheses as to the structure of elementary particles. [They] orient physical theory in a new, unexplored direction, since they attempt to solve these difficulties... by exploring a material reality at a deeper level than the phenomena under study rather than through an idealistic re-interpretation of the concept of cognition. (ibid.)*

Though differing in essential details from MacMillan's radiation-matter coupling, the reconciliation between gravitation and quantum mechanics Vigier has sought rests on the same premise as MacMillan's quest for "that something which persists" throughout the manifold transformations that occur in nature on the macrocosmic and microcosmic scales. This is because a fusion of the de Broglie and Einstein theories of particles

*...opens the way to an explanation of the qualitative transformations that underlie quantum phenomena. Experience shows that particles are transformed into one another (radiation produces pairs; neutrons decompose into mesons and protons, etc.). This suggests the existence, beyond the qualitative differences, of something common to all particles. In my opinion, here lies the profound meaning of the view, shared by Einstein and Louis de Broglie, that particles can be approximated as singular regions in a material field." (ibid.)*

The monumental task of preserving the de Broglie-Einstein conception of the particle/wave problem, and especially, developing de Broglie's application of this idea to the photon via the theory of the

weak photon interaction in the material vacuum, has fallen squarely on the shoulders of Jean-Pierre Vigièr: and he has performed his work with vigour and tenacity. He is currently involved in a project to confirm the existence of gravitational waves, which are predicted by General Relativity and imply the existence of a chaotic background, a dynamic ether that would redshift electromagnetic waves passing through it.

Yet the intractable difficulties raised by the relativistic approach, and in particular the devastation it has wrought in attempts to extrapolate to the cosmic scale, indicate a need for a reappraisal of basic assumptions. Accordingly, many of the contributors to this volume—and to the journal—have begun to explore new pathways, questioning such basic constructs as mass and energy, field and force, inertia and gravitation, relativity and invariance. The singularities that emerge in General Relativity must in turn be seen as signs of complex processes taking place deep within particles, even photons. They cannot be made to vanish by sheer mathematical ingenuity. Evidently, what is required is a radically new conception of the structure of matter and the nature of its interactions at the level of the vacuum.

The reader should not expect to find a mature theory, complete in every detail, or even unanimity on basic concepts, in the pages of this volume. At best, one might glimpse signs of convergence and parallels in methodology; that a clear grasp of every detail should emerge *en bloc* is certainly too much to ask after a prolonged period of confusion. Nevertheless, it is to be hoped that, through further collaboration and a frank exchange of views, researchers who are uncomfortable with the large volume of observed phenomena that is left unexplained in the standard model will succeed in painting a more coherent picture of the “material reality at a deeper level” that must underly the structures in the macrocosm and the microcosm—whether we call it the “fine structure of space” (MacMillan), the Dirac

ether, “world-matter” (Einstein-de Sitter), the “hidden thermostat” (de Broglie)... or the *απειρον*. The era of speculation, for Hubble still a remote prospect in the 1930s, has now begun.

I would like to thank Tandberg Satellite Systems for providing the facilities and logistical arrangements for the workshop, as well as Toivo Jaakkola for valuable assistance in the preparation of the texts published here. Finally, I would like to express my appreciation to all those who contributed to this volume for their patience and hard work. I can only hope that the finished publication is worthy of their efforts. Included in the collection are a paper by P.N. Kropotkin, who was unable to attend the workshop due to ill health, and the abstract of a paper the late R.A. Waldron was to have presented at the proceedings.

Roy Keys