A POSSIBLE TIRED-LIGHT MECHANISM

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Recent developments in physics and astrophysics lead us to reintroduce a new tired-light mechanism, implying an interaction between a massive photon and the particles of Dirac's vacuum.

1. The tired-light mechanisms have appeared in literature as early as in the late twenties, when Zwicky (1929), worried by the large values of the apparent recession velocities of galaxies , conceived a mechanism according which photons could lose energy through some interaction with the medium located between the source and the observer. Without entering in a detailed historical review of these attempts, we would like to recall that we have suggested similar mechanisms since 1971. The first idea we developed was (as did earlier Finlay-Freundlich, 1953-1954, with the approval of Max Born, 1954 a et b) a photon-photon interaction. This mechanism (Pecker, 1974) was difficult to accept and we looked instead for possible interactions between the photon and some massive pseudo-scalar boson, a particle to be specified. Again, as noted by Schatzman (1979), this mechanism met a large difficulty : in principle, a notable redshift should be accompanied by a clear blurring of the images; in spite of the fact that such an effect was strongly linked to the unknown characteristics of the alleged particle, the criticism was essentially valid. Our new suggestion replies to Schatzman's criticism; it has the same qualities as other mechanisms of the same kind, namely a qualitative prediction of both redshift and cosmological background radiation, in the reference-frame of any cosmology, either assuming a static or an expanding universe.

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2. One knows that the redshift - distance relation

$$z = f(d)$$

depends upon the kind of cosmological theory one adopts. In classical Friedmann-like universes, the law is :

$$z = H_0 \frac{d}{c} + O(q_0, d^2)$$

the term of degree 2 being noticeable only for very large and being a possible way to determine the deceleration factor q_0 . In Segal's chronogeometry, the tangentiality of the local space with the local minkowskian leads to a square law :

$$z = K_0 d^2$$

Finally, the tired-light mechanisms (whatever the detailed description) lead to an exponential law :

$$1 + z = \ln \left(H_0 \frac{d}{c} \right)$$

or, in first approximation, to a linear law :

$$z = H_0 \frac{d}{c} + H_0^2 \frac{d^2}{2c^2}$$

the term of degree 2 is noticeable only for large values of z, of the order 0,5 perhaps.
One should note, therefore, that recent determinations of the law $z = f(d)$ give a strong argument to revitalize the tired-light mechanism, or the Segal's chronogeometry. At small z , Giraud has shown (during this meeting) that biases of the Malmqvist's type cannot explain the non-linearity of relation $z(d)$; on the other side, at large z, LaViolette has shown the tired-light prediction to be very adequate to observed data (1986).

3. On the other side, physics gives new reasons to look at the nature of vacuum with new eyes. Physicists feel more and more that one should not consider as obsolete the de Broglie-Bohm-Vigier point of view according to which the deterministic pilot-wave description could be just as adequate as the Copenhagen point of view to describe the microphysics of interactions (Bell 1986). If this is true, if "empty" waves can travel without associated particles, then a material structure of the "vacuum" is needed. Recently, de Martini (1986) has provided an experimental evidence favoring such a material nature, and Badurek et al., through neutron interferometry, have given a strong, if not decisive, argument for the pilot-wave description (1986). And the Dirac

proposal (1951), revisited by Sinha et al. (1986), may be quite appropriate : The vacuum is a covariant superfluid medium, made of fermions and antifermions - massive of course. Our contribution, inspired in part by the famous Tolman, Ehrenfest, Podolski (1931) paper, is to suggest a description of the effects of an interaction between a massive photon and this Dirac's vacuum.

4. Let us assume that photons, of rest mass m_γ , interact with the vacuum's particle of mass m_o . There is, along the interaction path ℓ , a transfer of energy and momentum from the travelling photon to the vacuum's particles. It gives to the vacuum's particles a motion towards the trajectory (a sort of pinch effect). The loss of photon energy and of photon momentum can be computed. The acceleration towards the track resulting of this acceleration is

$$\int \frac{d^2y}{dt^2}\, dt = - \frac{2\lambda p \ell}{y\left[(\ell/2)^2 + y^2\right]^{1/2}}$$

and the momentum transfer per vacuum particle :

$$\int m_o \frac{d^2y}{dt^2}\, dt = - \frac{2\, m_o\, m_\gamma\, \ell}{y\left[(\ell/2)^2 + y^2\right]^{1/2}}$$

where λ is the length of the tube of linear density p $(\lambda p = m_\gamma)$, y being the coordinate across the path, t the time.

The effect has a perfect geometrical symmetry, being in essence the result of an interaction between a photon along its trajectory with a strictly symmetrical potential. Hence, Schatzman's criticism does not apply to this mechanism.

The redshift-distance law is obviously of the "tired-light" type :

$$\frac{\Delta\nu}{\nu} = e^{kd} - 1$$

where the masses m_o and m_γ, which fix k, are still unknown.

5. A much more detailed publication is forthcoming. For the time being, our sole purpose is to attract the attention of cosmologists on a possible relevant phenomenon; we expect new developments to occur in laboratory physics before decisive progress on the astrophysical side. It seems to us that one should look at these now "exotic" theories with an open mind. The recent discussions have shown that the classical standard face of the Big Bang cosmologies has suffered many

complications; it has many scars indeed; but, if one has been able to repair the standard theory, it is undoubtedly at the expense of its beautiful simplicity which was, some one or two decades ago, its best asset : it was, truly enough, a purely aesthetic argument, of which the value, in our eyes, has never been definitely convincing.

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DISCUSSION

DEKEL: Let me just clarify your quotation from my talk "no theory really works." All I meant was that if all the observations discussed here, and their interpretations at this stage are correct, (which is not at all evident) then the scenarios we can come up with are hybrids which are perhaps not as straightforward and elegant as we would wish them to be. But they are still based on conventional physics within the standard cosmology.

PECKER: I did not mean to imply that you expressed the need for "new physics." But, so far as I am concerned, comments such as yours encourage me (and should encourage others) not to close the possibility of new avenues. I feel that the standard big bang has become too much of a dogma for not always scientific reasons. And its weaknesses are now obvious.