A Possible Tired-Light Mechanism

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Recent developments in physics and astrophysics lead us to introduce a new tired-light mechanism involving an interaction between a massive photon and Dirac's vacuum particles.

1. Tired-light mechanisms appeared in the literature as early as the late twenties, when Zwicky (1929), disturbed by the large values of the apparent recession velocities of galaxies, conceived a mechanism whereby photons could lose energy through an interaction with the medium located between the source and the observer. Rather than enter into a detailed historical review of these attempts, we will simply remind the reader that we have suggested other such mechanisms, beginning in 1971. The first idea we put forward (following an original idea by Finlay-Freundlich, 1953-1954, with the approval of Max Born, 1954 a and b) was 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 pseudoscalar boson, though the particle remained unspecified. Again, as pointed out by Schatzman (1979), this mechanism came up against a major difficulty: in principle, a sizeable redshift should be accompanied by a definite blurring of the image (even though the effect was strongly linked to the unknown characteristics of the hypothetical 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, regardless of the cosmology chosen, and assuming either a static or an expanding universe.

2. We know that the redshift-distance relation

$$z = f(d)$$

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

$$z = \frac{H_0 d}{c} + 0\left(q_0, d^2\right)$$

the term of degree 2 being noticeable only for very large *d*. This offers 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, tired-light mechanisms (whatever the detailed description) lead to an exponential law:

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

or, to a first approximation, 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, on the order of 0.5 perhaps.

Now recent determinations of the law $z = f(d)$ provide strong arguments in favour of reviving the tired-light mechanism or Segal's chronogeometry. At small z, Giraud has shown (at this meeting) that biases of the Malmqvist type cannot explain the non-linearity of the $z(d)$ relation, while on the other hand, at large z, LaViolette has shown that the tired-light prediction is compatible with observed data (1986).

3. Similarly, physics provides several good reasons to take a fresh look at the nature of the vacuum. An increasing number of physicists feel that the deBroglie-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, should no be regarded as obsolete (Bell, 1986). If the pilot wave theory is correct, *i.e.* if "empty" waves can travel without associated particles, then a material structure of the "vacuum" is needed. Recently, de Martini (1986) provided experimental evidence favouring such a material vacuum, and Badurek *et al*., using neutron interferometry, have found a strong, if not conclusive argument in favour of the pilot-wave description (1986). Consequently, 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 paper (1931), is to suggest a description of the effects of an interaction between a massive photon and the Dirac vacuum.

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

$$\int \frac{d^2 y}{dt^2} dt = -\frac{2 l r w}{y\left[\left(\frac{1}{2}\right)^2 + y^2\right]^{½}}$$

and the momentum transfer per vacuum particle:

$$\int m_0 \frac{d^2 y}{dt^2} dt = -\frac{2 m_o m_p w}{y\left[\left(\frac{1}{2}\right)^2 + y^2\right]^{½}}$$

where *k* is the length of the tube of linear density $r(l r = m_p)$, *y* being the coordinate across the path and *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:

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

where the masses m_o and m_p, which establish *k*, are still unknown.

5. A much more detailed publication is forthcoming. For the time being, our sole purpose is to draw the attention of cosmologists to a possibly relevant phenomenon: we expect new developments to occur in laboratory physics before decisive progress on the astrophysical side. We feel that one should look at such "exotic"

theories with an open mind. Recent discussions have shown that the classical standard face of the Big Bang cosmologies has suffered many complications: it has many scars indeed. It has indeed been possible to repair the standard theory, but only at the expense of its beautiful simplicity, which was, one or two decades ago, its greatest asset. This was of course always a purely esthetic argument, the value of which, in our view, has never been terribly convincing.

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