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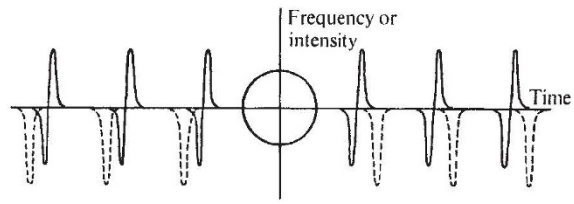

Fig. 1 Schematic diagram of the only type of propagation anomalies in the solar region consistent with the observed anomalies (refs. 5 and 6) and not at variance with other available empirical results.

Difficulties concerning a Finite Photon Rest Mass

Pecker, Roberts and Vigier have suggested that much, if not all, of the cosmological redshift might be attributable to inelastic photon–photon scattering—if the photon possesses a finite rest-mass[1]. Pecker and Vigier have attempted (private communication) to apply Vigier's ideas to the electromagnetic propagation anomalies observed by Sadeh and others[2,3]. We agree in part with the ideas of Vigier and his co-workers, but their hypothesis, as regards these phenomena, cannot be completely correct as stated.

For the case of the cosmological redshift Pecker *et al.* note that, had the photon a finite rest-mass, inelastic photon–photon scattering of extra-galactic photons on the photons of the cosmological black-body background radiation should occur. By successive interactions a photon should be progressively reddened, they claim, as it travels through inter-galactic space. They propose, in effect, a partial mechanism for the well-known "tired light" hypothesis. We have investigated the tired light hypothesis as a possible solution of the so-called "missing mass" problem[4]. It seems that the assumption of the tired light hypothesis is a workable solution of that problem. Insofar as this is the case, this solution of the missing mass problem is indirect, supportive evidence for Vigier's hypothesis.

But the mechanism of Pecker *et al.* is defective because it only partially meets the requirements of a tired light effect. Their hypothesis does not avoid the most critical problem of all non-Doppler explanations of the cosmological redshift: Olbers paradox. Although they have advanced a plausible mechanism for the reddening of individual photons, a mechanism for the reduction to the observed level of the total electromagnetic energy flux incident on the Earth from extra-galactic sources is absent. If a mechanism cannot be devised to achieve this reduction, then inelastic photon–photon scattering must be rejected as the source of the cosmological redshift. (Perhaps this difficulty might be avoided by taking the electromagnetic field to be a finite range, Yukawa type field by, for example, substituting a Yukawa potential for the Coulomb potential.)

As regards electromagnetic propagation anomalies in the solar environment, Pecker and Vigier's proposed effect is the same as that proposed for the cosmological redshift. But now the solar electromagnetic radiation field replaces the cosmic background radiation. They deduce that scattering on this field should lead to a reddening of electromagnetic radiation from planetary and stellar sources as they appear to pass near the Sun. Thus, for Sadeh's observations of the 21 cm line of Taurus A, Pecker and Vigier predict a frequency shift, the maximum shift being about 100 Hz.

Such an explanation of Sadeh's effect would be pleasing were it not for the observations carried out by Goldstein and Levy *et al.*[5,6]. They made long-term observations of the various properties of the plane-polarized, unmodulated 2.3 GHz carrier signal of Pioneer 6 as it approached and receded from occultation by the Sun. They observed several unexplained, periodically recurring transient propagation anomalies, but no long-term alterations in the signal properties that could not be ascribed to simple causes.

To test if the various propagation anomalies are the result of an anomalous photon-graviton interaction, we have investigated to see whether transient propagation anomalies (Fig. 1) are manifested in the optical-frequency deflexion observations. The results seem to be positive[7]. Transients of this sort seem to be the only type of propagation anomalies compatible with all available observations, those of Sadeh and Goldstein included. If such transients exist, whether they are the result of photon–photon and/or photon-graviton scattering is impossible to say at present. But, irrespective of the possible existence of these transients, Pecker and Vigier's hypothesis, as currently formulated, is inadmissible on the above empirical and theoretical grounds. If inelastic photon–photon scattering takes place, the mechanism must be more complex than that advanced by Pecker and Vigier.

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Photon Mass, Quasar Redshifts and Other Abnormal Redshifts

As stated in a recent *Nature* editorial[1] "the first claims that quasar redshifts were not caused by Doppler velocities of recession were met with general disbelief". In spite of this, experimental evidence has been accumulating in favour of such non-velocity shifts (see, for example, refs. 2, 3). Burbidge (unpublished) has shown a significant anti-correlation between the apparent distance of a quasar and a nearby galaxy and the brightness of that galaxy (hence a correlation with its distance): this suggests a physical association, in many cases, between two objects, a QSO and an ordinary galaxy, displaying very different redshifts.

Here, we discuss the application to quasars of a mechanism[4] which provides a simple explanation of the essential observational paradoxes which have prevented a coherent understanding of the nature and distance of QSO sources.

The new mechanism rests on the possible existence of a non zero photon mass $m_\gamma < 10^{-48}$ g. We prefer this mechanism to others (such as Hoyle and Narlikar's[5]) because this one explains not only the QSO redshifts but several other phenom-