From the behaviour of these reconstructions we suggest that for high resolution detail to be preserved the irradiation dose should be $<0.01\ \mathrm{C\ cm^{-2}}$ and that the presence of periodic detail in images of this and similar materials recorded with greater values correspond increasingly to damaged material.

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Radiation pressure and 'aether drag' in a dispersive medium

ARNAUD[1] has pointed out that there should be no transverse 'aether drag' in an artificial dielectric consisting of parallel plane conducting elements, where the product of the phase and group velocities of electromagnetic waves should be equal to the square of the velocity of light *in vacuo*. This agreed with the formula derived by Player[2] and Rogers[3], who for some important examples of aether drag showed that the Fresnel drag coefficient $(1-1/n^2)$, where n is the refractive index, should more precisely be replaced by $(1-1/n_\phi n_g)$, where n_ϕ and n_g are respectively the (phase, or normal) refractive index and the 'group' refractive index.

The same factor $(1-1/n_\phi n_g)$ seems to arise in the division of momentum into what may be described as 'electromagnetic' and 'mechanical' components when a packet of radiation enters a dispersive medium[4]. If the momentum of the packet *in vacuo* is p, the total momentum associated with the packet in the medium is $n_\phi p$, of which a portion p/n_g corresponds to the 'electromagnetic' momentum and $n_\phi p(1-1/n_\phi n_g)$ to mechanical momentum bodily in the medium. Thus, for any medium in which $n_\phi n_g = 1$ as in a wave guide or artificial dielectric, the mechanical component of momentum is zero, and the total momentum should be entirely electromagnetic.

The foregoing conclusion was derived by a thought-experiment involving a modified Einstein light-box to which were applied the relationship $E = mc^2$ and the consideration that actions inside a closed system cannot change the position of its centre of mass. Ginzburg and Ugarov[5] have come to the same conclusion in a more detailed consideration of a particular case, where they conclude: "it is curious that for an isotropic (dispersive) plasma with $n^2 = 1-(\omega_0^2/\omega^2)$, the equation G^{M} (the electromagnetic momentum) $= G^{\mathrm{A}}$ (the total momentum) holds." For it is also true that for such a plasma $n_\phi n_g = 1$.

The Ginzburg and Ugarov conclusion applies to a medium where the electrons are free, and not when they are bound as in a dispersive non-conducting solid. In that case some of the wave energy is carried as potential energy of electron displacement, and there is a consequent sharing of momentum. With free charges there is no corresponding potential energy of mechanical displacement from fixed centres and so it is at least plausible that there is no mechanical momentum drawn from the wave momentum. A common factor in the artificial dielectric and the plasma is the presence of free(inside the conducting elements) rather than bound electrons.

A corollary of the absence of mechanical momentum when $n_\phi n_g = 1$ seems to be that any medium satisfying this condition will also exert no 'aether drag'. A moving plasma in free space should therefore conform to this expectation, a conclusion also reached by a more detailed argument for the particular case of a cold plasma by Ko and Chuang[6].

A moving plasma can exert an aether drag, in apparent contradiction to the foregoing conclusion, when the plasma consists of moving carriers inside a semiconductor moving parallel to the direction of the light, as observed by Moss, Burrell and Hetherington[7]. I thank M. A. Player for resolving this contradiction—the solution lies in the fact that the plasma is now embedded in a medium of refractive index different from unity, with its faces in motion relative to the frame of reference in which the plasma is stationary. Such a situation, as pointed out by Einstein[8] and Landsberg[9], gives a modified Doppler shift, and when this is allowed for, a result consistent with Moss's observation is obtained.

An interesting variation of Moss's experiment would be to look for an aether drag effect when the free carriers in a semiconductor are moving transversely to the direction of the radiation.

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Plasma convection in force-free magnetic fields as a mechanism for chemical separation in cosmical plasmas

DURING the past two decades, progress in space research has forced us to abandon the earlier idea of a cosmical plasma as being a homogeneous medium. Filament formation and chemical separation are two important phenomena that are often observed in cosmical plasmas and illustrate the importance of inhomogeneity. An average composition from the Sun's atmosphere used to be taken as a standard when expressing cosmic abundancies in general. Numerous observations, however, of the chemical composition in the solar wind from *in situ* measurements and from lunar soil and meteorite samples, indicate a great variability in these ratios[1]. The proton to α-particle flux ratio for solar flare energetic particle events varies widely between and within events[2]. Recent observations show that this variability is connected with the flare process itself and the earlier history of the flare, rather than propagation effects between the flare site and the observer. Some local chemical differentiation mechanism in the preflare history of the specific active region is probably responsible for the composition of the emitted, energetic particles. The phenomena of filamentation and chemical separation may be coupled, as in the presence of a temperature gradient, the plasma convection associated with filamentary structures provides an effective means of selective transport. The general principles of this mechanism are described here. These principles may be important not only in solar flares but in many other cosmical plasmas where force-free fields and thermal gradients occur.

Typical filamentary structures, such as prominences and solar flares, can often be pictured as helical twisted magnetic flux tubes[3–6], where the magnetic field is approximately force free. The electric current flows almost in the direction of the magnetic field.

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