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PROPOSAL FOR THE DETECTION OF DISPERSION IN RADIO-WAVE PROPAGATION THROUGH INTERGALACTIC SPACE*

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The recent discovery that the quasistellar radio source[1] CTA 102 may be a radio variable,[2] with a period of about 100 days, opens up the possibility of detecting the ionized intergalactic gas postulated by certain cosmological theories.[3] According to these theories the free-electron density lies in the range 10^{-5}-10^{-4} cm^{-3}, corresponding to a plasma frequency ν_p in the range 30-100 cps. Radio waves of higher frequency ν would propagate through the gas with a time lag $\frac{1}{2}\nu_p{}^2/\nu^2$ per unit time. If CTA 102 has a red shift ~0.5, as its apparent magnitude would indicate, fluctuations in its ratio luminosity would be observed several days later (for $\nu_p \sim 100$ cps) at 50 Mc/sec than at high radio frequencies. More local ionized regions would be expected to introduce less dispersion than this. Accordingly, it might be possible to detect the ionized intergalactic gas, or else to disprove these particular cosmological theories. If shorter term variations than 100 days are also present, it should be possible to work at higher frequencies than 50 Mc/sec, which would facilitate the observations.

If intergalactic dispersion is detected and if a number of identified extragalactic radio sources turn out to be variable, it should be possible to distinguish observationally between the various models of the universe. The reason is that the observed dispersion will provide a relation between red shift and light-travel time for the sources, some of which are known to lie beyond the range of the linear Hubble law. This relation will be independent of any intrinsic evolutionary effects in the sources, effects which render ambiguous most observational tests of evolutionary cosmologies.

A straightforward calculation shows that for Robertson-Walker models without continual creation, the total time lag for radiation which reaches us with frequency ν_0 is given by

$$\frac{1}{2}\frac{(\nu_p)_0{}^2}{\nu_0{}^2}\int_t^{t_0}\frac{1}{R(t)}dt, \qquad (1)$$

where $(\nu_p)_0$ is the present value of the intergalactic plasma frequency, t and t_0 are the instants of emission and reception, and $R(t)$ is the scale factor that governs the expansion of the universe. For instance, in the Einstein–

de Sitter model,

$$R(t)=(3t/2\tau)^{2/3},$$

where τ is the reciprocal of the Hubble constant. Then the integral in (1) has the value

$$2\tau\{1-(1+z)^{-1/2}\}, \qquad (2)$$

where the red shift z is calculated from the general relation

$$1+z=R(t_0)/R(t).$$

The calculation for the steady-state model is a little different, since there is no need to allow for a change of ν_p with time. Instead of (2) we now obtain

$$\tfrac{1}{2}\tau\{1-(1+z)^{-2}\}. \qquad (3)$$

Thus, to distinguish between these two models we must measure the time lag out to red shifts z large enough so that (2) and (3) are substantially different. These two functions differ by more than 15% at $z\sim0.2$. This red shift is less than that of many identified radio sources, probably including CTA 102.

We are grateful to Dr. J. V. Jelley for drawing our attention to the fact that optical radiation would suffer a small but finite dispersion in passing through the intergalactic gas.

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DIAMAGNETIC RING CURRENT THEORY OF THE NEUTRAL SHEET AND ITS EFFECTS ON THE TOPOLOGY OF THE ANTISOLAR MAGNETOSPHERE

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This Letter is intended to point out the existence of special orbits in the tail of the magnetosphere which will carry solar plasma from the dawn to the dusk side. As this plasma drifts westward through the tail it will constitute a westward-flowing diamagnetic ring current which will weaken the field in the equatorial plane. It is suggested that this mechanism is responsible for the formation of the neutral sheet observed by IMP-1.[1]

An indication that solar plasma may be injected into the tail of the magnetosphere on the dawn side follows by symmetry from the fact that protons of solar-wind energy can pass across the boundary of the magnetosphere into the magnetosheath on the dusk side. Neglecting corotation considerations for the moment, a proton of solar-wind energy in the tail of the magnetosphere will drift westward until it reaches the boundary on the dusk side. In the interior the magnetic moment of the particle is an adiabatic invariant of the motion, and it will follow a contour of constant magnetic field strength. However, the boundary layer is on the order of 1 radius of curvature thick, and the adiabatic invariant condition no longer holds. Therefore the particle is no longer constrained to follow a contour of constant field strength, the boundary layer will not be able to contain the particle, and it will escape into the magnetosheath.

Figure 1 illustrates one such orbit in the equatorial plane. A solar-wind proton passes through the shock front and has its motion partially randomized by the turbulent fields in the magnetosheath. If the angle of approach is right, it will subsequently cross the boundary of the magnetosphere and drift across the tail. Such particles never enter stable trapping regions since they can be injected only where a contour of constant field intersects the boundary. They are thus in the class of very-low-energy cosmic rays which remain in the vicinity of the earth for an extended length of time but never enter the Störmer forbidden trapping region.

Solar-wind protons drifting across the tail