passage of the wave, the particle that was at rest at (x_0, y_0, z_0) will have the velocity 4-vector:

$$\tfrac{1}{2}(\exp a)(1 + b^2y_0^2 + c^2z_0^2) + \tfrac{1}{2}(\exp - a),$$
$$\tfrac{1}{2}(\exp a)(1 + b^2y_0^2 + c^2z_0^2) - \tfrac{1}{2}(\exp - a),$$
$$by_0,$$
$$cz_0,$$

where φ and β have been assumed to vanish in front of the wave and to be constant behind the wave, the value of φ then being $\tfrac{1}{2}a$, while

$$b = (\exp\beta)\int du \exp\{-2(\varphi-\beta)\}\beta'(2-u\beta')u^{-1},$$
$$c = -(\exp-\beta)\int du \exp\{-2(\varphi+\beta)\}\beta'(2+u\beta')u^{-1},$$

both integrals being extended through the entire wave-zone. Clearly, this system of test particles in relative motion contains energy that could be used, for example, by letting them rub against a rigid friction disk carried by one of them.

To evaluate the amount of available energy carried by the wave it would be necessary to evaluate the reaction on the wave of massive particles moved by it, and so far this is unknown.

The more general wave with a variable plane of polarization[6] given by

$$ds^2 = (\exp 2\varphi)(d\tau^2 - d\xi^2) - (\tau - \xi)^2 [\cosh(2\beta)(d\eta^2 + d\zeta^2) + \sinh(2\beta)\cos(2\theta)(d\eta^2 - d\zeta^2) - 2\sinh(2\beta)\sin(2\theta)\,d\eta d\zeta]$$

(where φ, β, θ are all functions of $\tau - \xi$) has also been examined. For this wave the empty-space condition is

$$2\varphi' = (\tau - \xi)[\beta'^2 + \theta'^2 \sinh^2(2\beta)]$$

Full details of work proceeding at this College on gravitational waves will be published elsewhere.

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Direction of the Friction Force

It is universally assumed that the force resisting the sliding of one body over another acts in a direction opposite to the relative velocity. However, no recent test of this law appears to have been carried out, and it seemed worth while setting up a simple experiment to measure any possible transverse component of the friction force.

The apparatus was similar to that described earlier[1], and consisted of a hemispherically ended $\tfrac{1}{4}$-in. diameter steel rod pressed by means of a dead weight on to the flat surface of a rotating 3-in. diameter steel disk. For this experiment the arm holding the rod was mounted on a dynamometer capable of measuring independently forces in two directions at right angles[2], and the signal from its strain gauges was fed into a Sanborn 2-channel recorder. The rod was carefully arranged in relation to the disk so that the ordinary friction force F_0 effected one channel of the recorder only, and thus if any component F_t acted transversely it would be detected by the other channel.

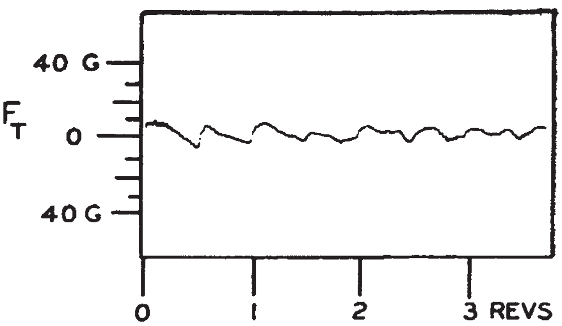

Fig. 1. Transverse friction trace obtained during sliding. Initially two maxima and two minima are found for every revolution

Fig. 1 shows the trace obtained from this channel under typical sliding conditions, load 1,000g, speed 5 cm./sec., lubricant a machine oil. Transverse friction forces of up to $\pm$ 6g are observed during the first revolutions, reaching extreme values twice per revolution as the rider crosses diagonally the unidirectional lapping marks (height 10 μin. r.m.s.) on the disk. If sliding is continued over the same track these effects soon disappear, but random fluctuations of up to $\pm$ 2g persist and seem to be caused by off-centre contact of asperities on the two surfaces. During this run the ordinary friction force remained rather steady at 122 $\pm$ 6g and the two sets of fluctuations were independent.

The ratio of transverse to ordinary friction force F_t/F_0, 0·05 as observed initially, corresponds to friction forces diverging by 3° from their generally assumed direction, while even after some time values of F_t/F_0 of 0·017, corresponding to fluctuations in direction by 1°, are common. These values of F_t/F_0 are of the same order of magnitude as is the parameter σ/F_0 denoting intrinsic fluctuations in magnitude of the ordinary friction force[1] and seem to arise in a similar way, and hence it is probable that, as for the latter ratio, much larger values are possible in the extreme case of very rough surfaces and very low loads.

The results suggest that for most purposes the friction force may continue to be assumed co-linear with the sliding direction. The new friction parameter F_t seems to lend itself well to two uses; first, by studying the rate at which the systematic component of the friction force disappears during continued sliding over the same track, it is possible to estimate the rate at which the initial surface configuration is changing without having to stop the experiment to examine the surfaces microscopically; secondly, the F_t trace can be analysed by auto-correlation techniques, with the important advantage over the F_0 trace used in earlier work[3] that the fluctuating component, of interest for this purpose, is unaccompanied by a large constant term.

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