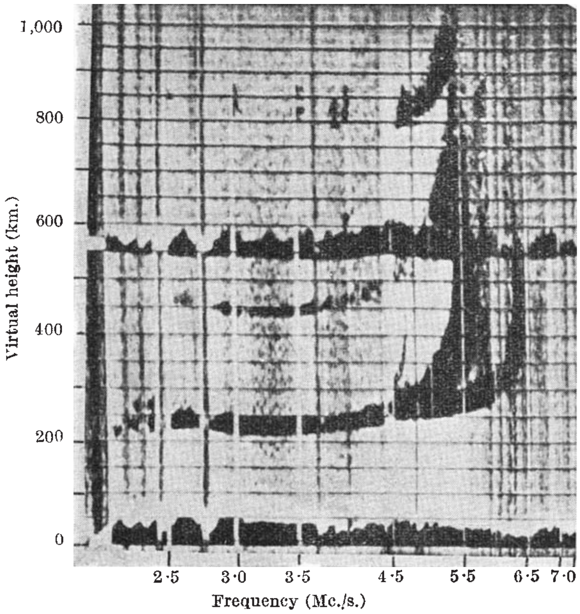

I wish to thank the Electrical Engineering Department of the University of Tasmania for the provision of facilities and assistance in building the apparatus, and also the Radio Research Board of the Commonwealth Scientific and Industrial Research Organization for a grant in aid of the investigation.

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Aug. 8.

[1] Scott, J. C. W., *J. Geophys. Res.*, **55**, 65 (1950).

Reflexion Coefficient of Radio Waves from Frozen Terrains

During the period January–February 1952, measurements were made in northern Canada in order to determine the reflexion coefficient of radio waves for normal incidence from deeply frozen land or sea. The frequency used was 1,600 Mc./s.

The method of measurement was to transmit a linearly polarized pulse signal vertically downwards from an aircraft flying at heights between 10,000 ft. and 20,000 ft. and to receive the signal re-radiated from the ground on a suitable receiver in the aircraft. Attenuation was inserted in the aerial lead of the receiver to maintain a constant received signal strength as the reflexion from the ground varied. The loop gain of the equipment was checked periodically to confirm that the performance of the equipment remained unchanged during the measurements. In addition, the signal was compared, whenever possible, with reflexions from open-water leads in Hudson Bay or the Great Lakes shortly before or after the measurements over the terrain in question. This was used as a standard for comparison.

It had been believed that the smallest reflexion coefficients likely to be met would not be lower than that from dry desert sand. This had already been checked over the shifting sand dunes of the Sinai Desert and also in desert areas in North Africa. The measurements agreed quite well with figures quoted previously by other authorities.

The reflexion coefficient from frozen muskeg and from the barren gravel areas north of the tree line in Canada was found to be roughly equal to that from dry sand. The frozen ice on Hudson Bay also gave a similar result. The ground temperatures were below − 35° F., and the ground and sea were frozen to a depth of several feet.

When flying over deeply frozen land where the land was heavily wooded, the land being covered with loose snow several feet deep and the trees thickly covered with snow and ice, a reflexion coefficient appreciably less than that from muskeg was observed. This was checked in two or three different areas, and the same figure was obtained on each occasion.

The figures of received signal power as compared with a sea reflexion were − 13 db. for sand, frozen muskeg or gravel, etc., and − 20 db. for frozen snow-covered forest. The accuracy of measurement was not worse than ± 2 db. The reflexion coefficient of sea water has been measured by other observers and is 0·83. Using this figure, the reflexion coefficients for various frozen terrains have been calculated and are as follows:

Terrain	Reflexion coefficient
Sea	0·83
Deep ice on sea	0·20
Frozen muskeg or barren gravel	0·20 to 0·25
Frozen lakes	0·25
Frozen snow-covered forest	0·08

Acknowledgment is made to the Chief Scientist, Ministry of Supply, for permission to publish this communication.

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Light Scattering by very Stiff Chain Molecules

Very precise light-scattering measurements by B. H. Bunce[1] on several thymonucleic acid preparations have shown that the scattering function of these gigantic macromolecules—the molecular weights are between 2·6 and 6·7 millions—differ remarkably from that of a random coil. The angular dependence of the reciprocal reduced intensity $1/P = I(0)/I(\vartheta)$, for all samples, reveals that the molecules are not perfectly coiled. The experimental points are situated between the curves for a random coil and that for a stiff rod.

Therefore it seemed worth while to compute the scattering function for a thread-like molecule of finite length with variable flexibility. In some previous work on viscosity and sedimentation[2] of such relatively short molecules, the usual 'pearl-necklace' model was chosen. By variation of the valency angle $\alpha = 180° - \beta$ between two consecutive links and the length of link b, all kinds of flexibility from the stiff rod ($\cos\beta = 1$), to the quite soft thread ($\overline{\cos\beta} = 0$), can be represented. This model is not very suitable for the consideration of light scattering; it can be replaced by the 'thread' model with continuous mass distribution and curvature introduced by Kratky and Porod[3] in the theory of X-ray scattering.

The measure of the flexibility is the persistence length a, the average value of the projection of an infinitely long thread on the tangent at one end of the thread : $a = b/(1 - \cos\beta)$.

This model fits much better the conditions for the scattering of visible light than for X-rays, as the fine structure of the macro-molecule, that is, the linking of the monomers, does not matter compared to the wave-length of some 1000 A.

According to Kratky and Porod, two thread elements, dl_1 and dl_2, separated by the length l_{12} of the chain, on the average give rise to a scattered intensity proportional to

$$\exp - k^2s^2R^2{}_{12}/6,$$

where $k = 2\pi n/\lambda$, $s = 2\sin\vartheta/2$, $R^2{}_{12} = 2a^2\,(x_{12} - 1 + \exp - x_{12})$, $x_{12} = l_{12}/a$, provided the distribution-function of their mutual distance r_{12} does not differ too much from the Maxwellian. This does not apply to the stiff rod, $x = 0$, and is also a bad approximation for small values of $x \sim 1$, but gets rapidly better with increasing x.

With this simplification, the scattering function for the molecule reads :

$$P(\vartheta) = \frac{1}{L^2}\int_0^L\int_0^L \exp\left(- k^2s^2R^2{}_{12}/6\right) dl_1\, dl_2 =$$

$$\exp p\left[F(p,x) - \frac{p}{1\,!}F(p + 1,x) + \frac{p^2}{2\,!}F(p + 2,x)\ \ldots\right],\ x \gg 1,$$

with

$$F(p,x) = \frac{2}{(px)^2}\,(px - 1 + \exp - px)\quad p = k^2s^2a^2/3.$$

The accompanying graph shows $1/P(\vartheta)$ for various values of x, where the variable

$$v = 3p\left[\frac{x}{3} + F(1,x) - 1\right] = A(a,x)\quad \sin^2\frac{\vartheta}{2}$$

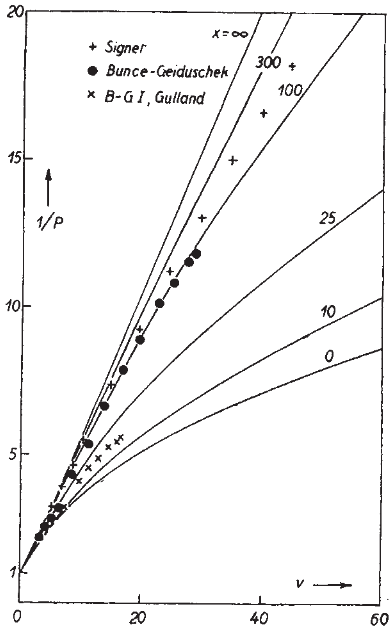
is chosen in such a way that the initial slope is the same for all curves. The curve $x = 0$ is the known scattering function for rods. Even at very large values of x, the limiting curve $x = \infty$ is not reached. In fact, the deviations are quite noticeable at as large a value as $x = 300$.

The experimental data of Bunce on various samples fit into this picture very well. The following dimensions may be deduced :

Sample	M	x	a	L	R	M/L
Present writer	$6{\cdot}7 \times 10^6$	150	287 A.	43,000 A.	4950 A.	156 M.U./A.
Bunce–Geiduschek	4·0	100	263	26,300	3750	152
Bunce–Geiduschek degraded*	2·64	16	541	8700	2970	305
Gulland	4·0	16	541	8700	2970	462

* The sample had been left for 20 hr. in an acid solution of pH 3·0.

In the first two samples, the structure of the thymonucleic molecule seems to be very similar, the persistence length a being markedly the same in both. The last two samples also agree completely with each other in their geometrical dimensions. The large value of a signifies that the coil is twice as extended. The overall length, however, is much smaller than that of the first two samples. Hence, the mass density M/L is increased to 305 and 462 M.U./A. The shortening of the chain may be the consequence of an internal association of neighbouring chain segments. The additional linkages coupled with the increased density evidently stiffen the molecule and yield a more extended coil. Very careful preparation may prevent such an internal association, which takes place also on degradation in acid solutions.



Reciprocal reduced intensity, $1/P(\vartheta)$, plotted against $v = A(a,x)\,.\,\sin^2\vartheta/2$. The experimental points for the Gulland and Bunce–Geiduschek degraded samples coincide

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Ljubljana. June 5.

[1] Bunce, B. H., thesis, Cambridge, Mass. (1951).

[2] Peterlin, A., *J. chim. Phys.*, **47**, 669 (1950); **48**, 13 (1951); *J. Polymer Sci.*, **8**, 173 (1952).

[3] Porod, G., *Monatsh. Chem.*, **80**, 251 (1949). Kratky, O., and Porod, G., Proc. Int. Coll. Macromol. Amsterdam, 250 (1949).

'Newtonian' Time in General Relativity

A result recently given by Eisenhart[1] suggests an interesting application in general relativity. According to it, we can choose co-ordinates in which a line element showing spherical symmetry would take the form :

$$ds^2 = - r^2(d\theta^2 + \sin^2\theta d\varphi^2) + \gamma dt^2 + 2adrdt,\quad \gamma = \gamma(r,t),\quad a = a(r,t) \quad (1)$$

and a radial null vector w^μ will have $w^2 = w^3 = w^4 = 0$, so that the velocity of light along radial directions (given by w^1/w^4) is infinite. Hence we may call the co-ordinates (r,t) the 'Newtonian' co-ordinates.

Several well-known solutions in general relativity take up very simple forms when expressed in these co-ordinates. Schwarzschild's exterior solution has :

$$a = 1,\quad \gamma = 1 - 2m/r. \quad (2)$$

Here m is the constant giving the mass of the particle at the origin. If, however, we take m to be an arb-