pointed out by the present writer (Bulletin of the American Mathematical Society, vol. 20, 1914, pp. 524–31), but the exceptions there are all imaginary, for the slope of the curve at the initial point has to be equal to $\sqrt{-1}$. The result is that the limit then takes a discrete set of values. It has to be one of the numbers 0·94, 0·86, 0·80, 0·74, . . . ; the particular one depending on the contact of the curve with the minimal straight line at the given point. If there is no contact the value is unity, but if the contact is of order $k-1$, then the value is $\frac{2\sqrt{k}}{k+1}$.

For Euclidean space of three dimensions it comes out that the limit can take all real and complex values. The Minkowski space is four-dimensional, and here also continuous variation is possible; but the essential point is that on account of the *minus* signs in the interval formula the exceptional cases which were imaginary in the Euclidean geometry now become physically real. This does not mean, however, that experimental verification would be easy. Particles have been found in radio-emanations where the initial velocity is more than nine-tenths that of light, but as long as the velocity is actually less than that of light the limit we are dealing with is unity. As the velocity is increased the limit thus remains unity. It takes the exceptional value 0·94 only when the initial velocity is actually that of light. Therefore, as the initial speed is increased continuously up to c, the limit jumps suddenly from unity to 0·94. The limit of the limit equals 1, but the actual value attained equals 0·94. *Such a discontinuity is perhaps beyond the possibility of experimentation, but there is no doubt of its theoretical validity.*

If, instead of the Minkowski formula, we use the general Einstein relativity theory, we have a curved manifold of four dimensions instead of a flat manifold. The formulæ, involving the potentials g_{ij}, are much more complicated, but again we find exceptional values for the limit of the ratio of the arc to the chord whenever the initial velocity is that of light—that is, whenever the world-line is tangent to a null geodesic on the curved manifold representing the field of gravitation.

EDWARD KASNER.

Columbia University, New York, September 20.

The Softening of Secondary X-rays.

DR. A. H. COMPTON's letter to NATURE of November 17, p. 366, on the softening of secondary X-rays directs further attention to a problem of very great importance. There is distinct evidence with these rays of a change of periodicity which varies with the angle of scattering. Such a variation is, perhaps, unique in physics, and no satisfactory explanation of the facts has been found. Let us consider the history of the case.

In 1913 (*Phil. Mag.*, vol. 26, p. 611) I stated that when homogeneous rays struck any target the scattered rays were softer (*i.e.* of lower frequency), and that this softening increased with the angle of scattering. This view was a deduction from experiments with a heterogeneous primary beam consisting of the γ-rays of radium. The experimental results were verified by Dr. Florance (*Phil. Mag.*, vol. 27, p. 225, 1914).

In 1919, working at University College with heterogeneous X-rays, I again found that the secondary rays were less penetrating than the primary. At the time I was not successful in obtaining a homogeneous primary beam of sufficient intensity, for such a beam can be obtained only by reflection from a crystal. Later on I was informed that Mr. S. J. Plimpton, on continuing the problem at University College, had found evidence which apparently showed that when the primary rays were homogeneous, the secondary rays were of the same frequency. Hence, in a paper to the Journal of the Franklin Institute (November, 1920), I endeavoured to account for the softening observed with heterogeneous X-rays by assuming them to consist of thin pulses, which became thicker and softer, and hence of smaller apparent frequency as the scattering angle increased. Plimpton published his results in the *Philosophical Magazine* for September, 1921.

The work of Compton (*Phil. Mag.*, vol. 41, p. 749, 1921, and *Phys. Rev.*, vol. 18, p. 96, 1921), however, confirms my original view, although it may perhaps be advisable to substitute the term "secondary rays" for "scattered rays." On working with homogeneous X-ray beams he finds the same change as when ordinary X-rays of corresponding penetrating power are used. Thus secondary X- or γ-rays, even when homogeneous, decrease in frequency as the angle of scattering increases, and this remarkable relation is independent of the scattering medium.

I have always looked on the secondary rays as scattered rays, because the theory of scattering first given by Sir Joseph Thomson ("Conduction of Electricity through Gases," 1906, p. 321), and since developed by other writers, accounts so well for the variation in intensity of the secondary radiation with angle of scattering, and also for the observed polarisation *of the secondary radiation. This theory, however*, in its present form does not account for the changes in periodicity referred to above.

Compton suggests that the greater part of the secondary radiation is fluorescent, *i.e.* that it is produced by the secondary β-rays which are always emitted when X- or γ-rays strike any substance, and that the change in periodicity can be accounted for by means of the Doppler principle. I believe that it can be proved that only a negligible portion of the secondary X-rays can be accounted for in this way, and hence that this suggestion does not help us out of our difficulties.

J. A. GRAY.

McGill University, Montreal, November 12.

University Relief for Central Europe and Russia.

I SHALL be grateful for space to bring before readers of NATURE the following facts concerning the activities of the Imperial War Relief Fund, Universities' Committee. This committee, which was created at an Inter-University Conference which met at University College, London, on July 7, 1920, at the invitation of Lord Robert Cecil, and under the auspices of the Imperial War Relief Fund, has set before it the aim of presenting to the British universities the appeal of the universities in the war-stricken areas of Europe.

During the first year of the existence of the Universities' Committee 32,000*l.* was raised in co-operation with every university in Great Britain and Ireland. The committee at the opening of this university year carefully considered the problem of the Central European universities at the present time, and decided that it would be absolutely necessary for us to maintain the relief work promoted by the committee in co-operation with universities all over the world throughout the coming year.

I may say briefly that the financial panic which has swept through Austria in particular during the