showed no such emphasis, and there is a strong suggestion that these frequencies (20-30 kc.) pass with markedly less absorption through the rock. This question must stand over for a fuller investigation. The selectivity did not appear to be a function of the receiving instrument.

Audio Frequencies.—When 500-cycle frequency alternating current was impressed on the full ten turns of the 100-foot diameter circular loop, powerful signals were received with headphones both with and without a three-stage amplifier, using a 400 turn 3×2 sq. ft. rectangular coil, at depths of 100 ft. and of 300 ft. Of particular interest is the fact that detection was readily made without amplifier, in the Mammoth Dome, 900 ft. on an inclined line from the horizontal loop. We conclude that the electromagnetic effects of a 500-cycle frequency passed through 900 ft. of continuous rock. It is intended to publish a full report on these experiments in due course.

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New Determination of the Curvature Radius of Space-time.

As communicated in a cablegram of April 10 (NATURE, April 20, p. 618), my statistical formula, concerning any two groups of stars 1, 2,

$$R^2 = \frac{c^2[\overline{(rv_r/v)_1^2} - \overline{(rv_r/v)_2^2}]}{\overline{v_1^2} - \overline{v_2^2}},$$

which is fully derived in a monograph on "The Size of the Universe", shortly to be issued by the Clarendon Press, Oxford, when applied to 29 Cepheids observed by R. E. Wilson of Albany, yielded for the radius R of de Sitterian space-time the value $3 \cdot 0 \times 10^{11}$; when applied to 35 stars of the O-type observed by J. S. Plaskett of Victoria, gave $R = 3 \cdot 2 \times 10^{11}$; and when applied to 246 stars taken from Young and Harper's list, $R = 3 \cdot 4 \times 10^{11}$ astronomical units. The latter batch of objects consisted of those of R. K. Young and W. Harper's "1105 Stars" (*Publ.* Domin. Astrophys. Observatory, Victoria, B.C., vol. 3, No. 1, Ottawa, 1924) numbered 500 to 1105, the distances of which, r, equal or exceed 50 parsecs, and the radial velocities of which are less than 100 km./sec. In the formula just quoted, c is the velocity of light, v_r the radial and v the resultant velocity, relative to the sun. (It may be noticed that in Young and Harper's memoir the radial velocities are corrected for the solar motion, but Prof. Young was kind enough to send me a complete list of the original velocities reduced, as usual, to the sun.)

Since the coincidence of these three R-values has seemed very encouraging, I have recently returned to the complete list of Young and Harper's stars, taking in also all those numbered 1 to 499, and, again, satisfying the conditions $r \geqq 50$ parsecs, $v < 100$ km./sec. This gave in all 460 stars, for which all data (r, v_r, μ, and therefore v_t and v) are available. Having divided this material into two groups of 230 stars each, ranging from $r = 50$ to 100 and from 100 to 1000 parsecs, and applied to these the above formula, I had the satisfaction of finding the said R-values corroborated excellently. In fact, the laborious computation, completed on July 11, gave for the nearer sub-group

$$\overline{s_1^2} = \overline{(rv_r/v)_1^2} = 2109 \text{ parsec}^2, \quad \overline{v_1^2} = 1754 \text{ km.}^2/\text{sec.}^2,$$

and for the more distant one

$$\overline{s_2^2} = 16{,}930, \quad \overline{v_2^2} = 2185,$$

where s_1, s_2 are, by the way, the actual distances of the several stars from their perihelia. Now, these values, substituted into my formula, give

$$R = 1 \cdot 76 \times 10^6 \text{ parsecs},$$

or $3\ 63 \times 10^{11}$ astronomical units, or $5 \cdot 74$ million light years, in excellent agreement with the Cepheid and the O-stars results. In view of the numbers of the last group (460 stars), the latter value has by far the greater weight, and can be accepted with confidence, at least to two figures, as the actual value of the space-radius.

The complete list of data for the $29 + 35 + 460$ celestial objects will be found in "The Size of the Universe", now in proof, and a good number of details will be given sooner, in a paper announced for the next meeting (Aug. 26–29) of the American Astronomical Society at Ottawa.

Here it may still be added that the greatest possible distance apart of two points in elliptic (polar) space is $\frac{1}{2}\pi R$, and thus *nine million* light-years. In view of this, distances such as 140 million light years attributed by Shapley and Hubble to a group of fainter spiral nebulæ are entirely out of the question and (since my radius is stoutly supported by several hundred stars of a variety of kinds) must be subjected to a thorough revision. It seems that even the distances of the Magellanic Clouds, or at least that of the greater one, which of late served as a yardstick for several estimates, has been exaggerated. In fact, in a letter of Feb. 11, 1929, Prof. Shapley, kindly answering a number of my questions, says that the distances of the globular clusters are now being revised, and warns me that "the Large Magellanic Cloud will probably move in considerably when the present study of magnitudes and variable stars is completed". The latter warning was particularly agreeable to me, since I had just at that time derived the Cepheid value 3×10^{11}, which was some 15 times smaller than that obtained from the Magellanic Clouds (in conjunction with the clusters) in 1924. One can now confidently expect that when these objects, Clouds, and all "move in considerably closer, they will also confirm the radius of the order of 3×10^{11} a.u.".

I do not hesitate at any rate to assert that there are, in our world, no distances exceeding nine million light years, so that the present placing of Virgo (140 million) is utterly inadmissible.

The total volume of space being $\pi^2 R^3 = 54 \times 10^{18}$ cubic parsecs, there is ample room for some millions (but not 10^{16}, as Hubble imagines) galaxies comparable in size with our own Milky Way.

LUDWIK SILBERSTEIN.

Cinema Laboratories Corporation,
New York, July 19.

The Possibility of Observing an Emission Spectrum of the Calcium Substratum in the Galaxy.

IN a very interesting paper, "Physical Properties of a Gaseous Substratum in the Galaxy" (*Astrophys. Jour.*, **69**, p. 7; 1929), Gerasimovič and Struve have recently given strong evidence of a uniform gaseous medium of calcium in interstellar space. The absorption coefficient per parsec for the interstellar K line was found by them to be $3 \cdot 4 \times 10^{-4}$. If such a general calcium substratum exists, the question may arise: Is the density of this substratum strong enough to allow the emission spectrum of the Ca^+ atoms to be expected in the spectrum of the night sky?

The mechanism by which the emission spectrum would be produced must be analogous to that giving the spectra of diffuse nebulæ. We have thus two