sions existed, the simple case of the solar field being actually six dimensional,[1] as are also certain other physical solutions obtained by Weyl.

III. The author has found all solutions of $G_{ik}=0$ of the orthogonal form $\lambda_1 dx_1{}^2 + \lambda_2 dx_2{}^2 + \lambda_3 dx_3{}^2 + \lambda_4 dx_4{}^2$ in which the four coefficients are functions of one variable say x_1. An example of such a field is

$$x_1{}^{-2} dx_1{}^2 - x_1{}^4 (dx_2{}^2 + dx_3{}^2 + dx_4{}^2).$$

All cosmological solutions which satisfy the same hypotheses are determined and can be expressed by elementary, algebraic and transcendental functions.

The principal solution is

$$ds^2 = \frac{4dx_1{}^2}{c^2(1+x_1{}^2)^2} + \left(\frac{2x_1}{1+x_1{}^2}\right)^{\frac{2}{3}} \left[x_1{}^{2\alpha_2} dx_2{}^2 + x_1{}^{2\alpha_3} dx_3{}^2 + x_1{}^{2\alpha_4} dx_4{}^2\right],$$

where c is arbitrary and α_2, α_3, α_4 obey the relations.

$$\alpha_2 + \alpha_3 + \alpha_4 = 0, \qquad \alpha_2\alpha_3 + \alpha_3\alpha_4 + \alpha_4\alpha_2 = -\tfrac{1}{3}.$$

These fields can all be represented in flat space of seven dimensions. A paper on this subject has been sent to the *Mathematischen Annalen.*

IV. If we require the quaternary form ds^2 to be the sum of two binary forms, that is the sum of the squared elements of two surfaces, then the only cosmological solution (neglecting the trivial euclidean form) is $ds^2 = x_1{}^{-2}(dx_1{}^2 + dx_2{}^2) + x_3{}^{-2}(dx_3{}^2 + dx_4{}^2)$. This represents a quartic manifold of four dimensions imbedded in a 6-flat. The finite equations are

$$X_1{}^2 + X_2{}^2 + X_3{}^2 = 1, X_4{}^2 + X_5{}^2 + X_6{}^2 = 1.$$

This is apparently the simplest solution of Einstein's equations which has thus far been found, and the first one (beyond the obvious flat and spherical spaces) which in its finite form is algebraic.

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[1] See *American Journal of Mathematics,* Volume 43 (1921), pp. 126–133.

THE PRODUCTION OF ENHANCED LINE SPECTRA BY A NEW METHOD

THE ordinary spark spectrum differs from the arc spectrum in that certain lines are weakened, others are enhanced and new lines appear. In general the more violent the stimulus of the source the more intense are the new enhanced lines as compared to the weakened lines. It is customary to refer to the lines which are the more prominent in the spectrum produced by an arc as arc lines, while those which are enhanced by the spark are known as spark lines and constitute the pure spark spectrum.

Lorenser and Fowler, as well as Sommerfeld and Kossel, have shown that modern theories of atomic structure and radiation leave little doubt that the enhanced lines in the spectrum are due to radiation from atoms that have lost an electron, *i.e.,* ionized atoms; and that arc lines are due to radiation from the un-ionized or neutral atom. The varying facility of producing the enhanced lines of different elements depends, then, on the intensity of the forces which bind the electron to its nucleus and on the energy used in tearing the electron off. For example, no enhanced lines of lithium have ever been produced while the enhanced doublet of calcium, H and K, is strong even in the flame spectrum.

In a study of the enhanced lines of the calcium spectrum begun by examining the spectrum of calcium wires exploded by the Anderson method[1] it was found that as the size of the wires used was decreased, while the energy of the stimulus remained the same, the intensity of the enhanced lines increased. This increase in intensity indicated a more complete ionization of the calcium atoms. In seeking a way by which the amount of calcium in the source could be still further reduced a new source of light was developed.

A fine asbestos fiber about three centimeters long was saturated with an aqueous solution of some salt of calcium. The saturated fiber was fastened in place as the fine wires had previously been fastened and the charge of the high tension condensers thrown across it,

[1] *Astro. J.,* 51, 37, 1920.

as before. The fiber was not injured by the discharge but could be saturated and used again and again. About the same number of discharges as had been employed with the exploded wires produced satisfactory results. For convenience in discussion and because of its character this new light source has been tentatively called the super spark.

An inspection of the calcium spectrum thus produced showed a striking enhancement of the spark lines of calcium over the arc lines indicating that a large proportion of the emitting atoms were ionized. For the purposes of comparison a table is inserted showing for the present work with the exploded wire and super-spark and for the work of other observers with various sources—the relative intensities of the H and K lines of calcium, a prominent spark doublet, and the line 4227, a strong arc line. The ratio of these intensities is, we believe, a fair index of the relative proportions of ionized and unionized emitting atoms in the source.

THE RELATIVE DEGREE OF IONIZATION OF CALCIUM IN DIFFERENT SOURCES

Source	Intensity of H and K	Intensity of 4227	Ratio of Intensities
King's electric furnace	55	1000	1:19
Crew & McCauley arc	400	500	4:5
Lockyer spark	500	400	5:4
Loving vacuum arc	20	8	5:2
Exploded wire	600	150	4:1
Super spark	700	70	10:1
High chromosphere of sun	72	8	9:1
Class B stars	7	1	7:1

This table indicates that there can be produced in the laboratory the same degree of ionization as is shown to exist in the high chromosphere of the sun or in the spectra of the early (or hot) type B stars. The super spark seems to give a more highly ionized source than any yet produced in the laboratory.

The results of an extended study soon to be published of the super spark spectra of calcium and other metals may be briefly summarized here. For the metals studied in the groups one, two and three of the periodic table, an almost pure enhanced line or spark spectrum has been produced. As might be expected it has been impossible to get perfect ionization even in this source and the strongest lines due to the neutral atom still persist. A striking feature of the super spark is the amazingly small amount of material required to produce spectra. By use of a dilute solution of calcium chloride for example there is produced not only the calcium spectrum but also the spectrum of the other metals of the same group: Magnesium, barium, strontium, zinc and cadmium; and generally a few lines of other metals. These other metals could have been present only in minute amounts and yet their spectra rival in intensity that of the principal substance. Another striking characteristic is that practically only metallic lines are produced by the super spark,— the spectra of hydrogen, oxygen or of the acid radical of the salt used do not appear, and only the strongest air lines can be identified.

The super spark, it will be seen, gives a method by which a very powerful stimulus can be applied to any metal that can be obtained in the form of any of its partially soluble salts. It is not even necessary that the metal in question be the principal metallic constituent of the salt. Good results may be obtained for metals which appear only as minor impurities in the salt used.

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August 11, 1921.

THE IOWA ACADEMY OF SCIENCE

The thirty-fifth annual session of the Iowa Academy of Science was held at Simpson College, Indianola, on April 29 and 30. At the opening meeting on Friday afternoon President Knight gave his presidential address on "American science." The Academy divided into sections of botany, zoology, geology, and physics for the reading of papers, and at 5 o'clock adjourned for an enjoyable auto ride given by the Indianola Chamber of Commerce. At 6 o'clock the sections met for group dinners and at 8 o'clock Dr. J. Paul Goode of the University of Chicago, addressed the