As observed by Woolridge, Ahearn, and Burton[2] in diamond, upon subsequently grounding the high voltage electrode, pulses of reverse polarity and of height equal to those originally observed are now seen; the pulse rate is also fully as great as that originally measured. As the space-charge field is depleted by the ionizing radiation, these "reverse" pulses correspondingly decrease in amplitude and frequency, until they likewise have vanished. The original potential may then by reimpressed, and another complete counting cycle is possible. This process has been repeated several hundred times with various crystals; to insure consistent results, the applied voltage is actually completely reversed after, say, one thousand counts. Over such a small interval the change in pulse height is entirely negligible.

In line with results of Street[3] and Hofstader,[4] pulse rise times were found to be masked by amplifier rise time; in our best tests this was about 0.2 microsecond, with a decay time of the same order.

The silver chloride crystal counter is thus a fast, high density counter of convenient dimension, well suited for detection and discrimination of particles of range upwards of the crystal thickness. In the coincidence equipment now under construction, the crystal voltage will be synchronously reversed between successive cyclotron beam pulses, to preclude missing counts caused by interference of amplifier blanking with beam pulses, as would otherwise be the case; the pulse spectrum will also be more clearly displayed by locking in the synchroscope sweep.

We wish to express our appreciation of the interest and encouragement of Professor Ernest O. Lawrence and the cooperation of the Laboratory staff.

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* This letter is based on work performed at the Radiation Laboratory under Contract No. W-7405-Eng-48 with the Atomic Energy Commission.

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Geophysics and the Radioactivity of Potassium

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THE recent publications of Gleditsch and Gráf[1] and of Bleuler and Gabriel[2] lead to a reduction of the effective half-period of K^{40} from 15.7×10^8 year to 2.4×10^8 year, and an increase of the present rate of energy production from about 5×10^{-6} cal. per year to 38×10^{-6} cal. per year per g of (ordinary) potassium. As Gleditsch and Gráf make clear, the importance of this revision for geophysics can hardly be overestimated. A few of the major problems which must be re-examined, if these changes are accepted, are the following:

1. The thermal history of the Pre-Cambrian periods.
2. The origin of the moon and of lunar topography.
3. The chemical and mineralogical differentiation of the silicate shell, and the segregation of the radioactive elements.
4. The formation of continents and ocean basins.
5. The origin of folded mountain ranges.

It seems possible, at first glance, that the new constants for K^{40} may aid in resolving some of the difficulties now encountered with all of these studies. On the other hand, certain new problems arise. For example, the most reliable radioactive age determinations[3] agree in giving ages over 1×10^9 and up to 2×10^9 year for a number of rocks and minerals. With the new values for heat production from potassium, however, it seems doubtful whether a permanent crust could have existed for more than 10^9 or at most perhaps 1.5×10^9 year. Prior to this time, repeated remelting or flooding of the crust must have occurred. Neither the data nor our understanding of the processes are sufficiently exact so that a flat contradiction may be said to exist; but there is at least a suggestion here that the new half-life may be too short. The purpose of this letter is thus to reiterate the importance for geophysical theory of a redetermination of the constants for K^{40} and, in particular, of the period of β-decay upon which the other results depend.

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The Role of Exchange Interaction in Paramagnetic Absorption

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ACCORDING to theory,[1-3] the paramagnetic absorption per ion in a system of ionic spins should be inversely proportional to the magnetic interaction between the ions, characterized by the so-called internal field H_i.[4] This theory has in general been confirmed by Volger[3, 5] for a number of hydrated chromic, manganous, ferric, and gadolinium salts. However, the paramagnetic absorption in a number of anhydrous compounds of the same ions and in a few hydrated cupric salts (notably in $CuCl_2\cdot 2_2HO$) is considerably higher than expected.

The absorption in the first-mentioned group of hydrated salts vanishes in accordance with the theoretical expectation[2] when a constant perpendicular field of the order of H_i is applied. In the anhydrous compounds and in the copper salts, on the other hand, the absorption already disappears in much smaller perpendicular fields.

Recently Zavoisky[6] and Cummerow and Halliday[7] have succeeded in observing an absorption band corresponding to the Larmor frequency in large perpendicular fields. In contrast with theoretical expectation, however, the width of this band in anhydrous compounds and copper salts appears to be considerably smaller than the internal field H_i.

From all this it appears that, in the anhydrous and copper salts, the effects of magnetic interaction (characterized by H_i) have been reduced as a consequence of exchange interaction[8, 9] between the ions.

The existence of the phenomenon of "exchange narrowing" may be proved mathematically by calculating the mean square and mean fourth power of the absorption frequency of an ensemble of paramagnetic atoms coupled together simultaneously by magnetic (dipolar) and exchange forces. The mean square or second moment is not influenced by the exchange terms since the exchange potential is isotropic and commutes with any Cartesian component of the total spin of the crystal. On the other hand, it may be demonstrated that the fourth moment contains cross terms involving products of the exchange integrals and the dipolar constants. As a result, the addition of exchange coupling enhances the mean fourth power of the absorption frequency. Since the mean square is unaffected, this enhancement is possible only if more of the line strength is located in the tail of the absorption line than otherwise, and if, at the same time, it is peaked more sharply at the center. Hence, the paramagnetic absorption at the resonance maximum is increased. Because of the sharpened peak, the spread in frequency required to reduce the intensity to half its maximum value is diminished and, hence, also the apparent line breadth or effective dipolar field. When exchange effects are important, the shape of the line is so distorted that the usual Gaussian assumption concerning its structure is a bad approximation.

The underlying theory will be considered more thoroughly by one of us (J. H. V. V.), but it may already be worth while to mention an analogy which exists with the narrowing of nuclear Larmor frequency bands of hydrogen in liquids and in compressed hydrogen gas. According to the views developed by Bloembergen, Purcell, and Pound,[10] the effects of magnetic interaction between the nuclear dipoles and of the coupling between these dipoles and the rotation of the molecule are reduced as a consequence of the small but very frequent perturbations caused by temperature motion and collisions between molecules. Correspondingly, in the case of the electronic spin considered in the present note, the exchange effects lead to a rapid interchange of the spins between different lattice points and diminish the coherence and efficacy of the magnetic interaction.

There are indications that the effects of internal electric fields in paramagnetic salts may also be reduced by exchange interaction.

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Erratum: Second Sound in Liquid Helium II

[Phys. Rev. **71**, 600 (1947)]

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OUR attention has been called to a regrettable error in our paper entitled "Second sound in liquid helium II." We ascribed to Tisza the formula

$$C=\left[-\frac{\rho_n}{\rho_s}\frac{\partial}{\partial T}\left(\frac{1}{S}\right)^{-\frac{1}{2}}\right],$$

whereas it was first derived by Landau. We regret our failure to acknowledge Landau's priority and assure him that this failure was unintentional.