

Assuming $\mu c^2 = 10^8$ ev from the data of the tables we calculated the following values for the "proper lifetime" of a meson (in microsec.):

$$\begin{aligned} \text{From Table I and II } (A = 15 + 34.6) \quad \tau_{\text{I}} &= 3.4 \pm 0.3 \\ \text{From Table II } (A = 15) \text{ and III } (A = 15 + 15) \\ \tau_{\text{II}} &= 2.55 \pm 0.4 \\ \text{From Table II } (A = 15 + 34.6) \text{ and III } (A = 15 + 49.4) \\ \tau_{\text{III}} &= 1.65 \pm 0.3 \end{aligned}$$

The τ_{II} value is in excellent agreement with the Rossi and Hall results. Our measurements agree also with Neher and Stever experiments, but differ from the Nielsen, Ryerson, Nordheim, and Morgan results. It was pointed out, however, that in discussing the latter measurements one finds some difficulties.² On the other hand, the difference existing in coincidence ratios Denver-Echo Lake, *with* and *without* absorber Σ , are not clear in Rossi and Hall experiments.

Finally we wish to call attention to our results which seem to point out that the ratio $\mu c^2/\tau$ increases with increased altitude and average meson energy.

Further studies are in progress to see if the conclusion of our experiments can be accepted.

* These experiments were made during the winter 1940-41 and we have not been able to publish them until now because of the international situation.

¹ H. V. Neher and H. G. Stever, *Phys. Rev.* **58**, 766 (1940); B. Rossi and D. B. Hall, *Phys. Rev.* **59**, 223 (1941); W. M. Nielsen, C. M. Ryerson, L. W. Nordheim, and K. Q. Morgan, *Phys. Rev.* **59**, 547 (1941).

² L. W. Nordheim, *Phys. Rev.* **59**, 554 (1941).

Electric Fields in Interstellar Space

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IN a letter¹ published in *The Physical Review*, Fred L. Mohler has pointed out that an inappropriate value of the collision cross section for atomic scattering of electrons was used in a paper² on "Electric fields produced by cosmic rays" by the author of the present letter. It is to be noted that the assumption made in this paper in regard to the composition of the interstellar gas is that there is one electron and one hydrogen atom per cm^3 and not as stated by Mohler. According to Dunham³ practically all of this hydrogen is ionized.

The formula for calculating the collision cross section suggested by Mohler was taken from a paper by S. D. Gvosdover.⁴ It was thought desirable, therefore, to recalculate the previously obtained results with Gvosdover's formulae for mean free path and mobility in a positive column consisting entirely of a mixture of electrons and ions. Under the same assumptions as made in the paper² referred to above it is found that the potential produced on a star of radius a as a result of interception or emission of cosmic rays as charged particles all of one sign is given by

$$V = -\frac{2m^{\frac{1}{2}}e^2\gamma A}{\alpha(kT)^{\frac{1}{2}}a},$$

where m and e are, respectively, the mass and charge of the electron, k is Boltzmann's constant, T is the translation temperature of electrons in interstellar space, α is the ratio of the density of electrons to ions, $4\pi A$ is the total current flow to or from the star in the form of cosmic rays, $\gamma = (\pi/4) \ln(K^2 T^2 / e^4 N_+)$ and N_+ is the density of ions in the interstellar gas. This equation for the potential is valid under the condition that $eE\lambda/1.5kT < 2$, where λ is the electron mean free path and E is the electric field in interstellar space. This puts a limitation on the value of A that may be used in the above equation, namely, $A < 10^{21}$ e.s.u. sec^{-1} . That is, Ohm's law is valid only in case $A < 10^{21}$ e.s.u. sec^{-1} . In the case of interception of charged cosmic-ray particles the current flowing to the star is well within this limit and the potential V thus produced on a star of radius equal to that of the sun becomes of the order of magnitude of 10^{-9} volt. For the case of a star emitting charged cosmic-ray particles at such a rate that the current is 10^{21} e.s.u. sec^{-1} the induced potential would be approximately 3 volts.

¹ F. L. Mohler, *Phys. Rev.* **59**, 1043 (1941).

² F. Evans, *Phys. Rev.* **59**, 1 (1941).

³ T. Dunham, Jr., *Proc. Am. Phil. Soc.* **81**, 277 (1939).

⁴ S. D. Gvosdover, *Physik. Zeits. Sowjetunion* **12**, 164 (1937).

Isotope Effect in the Predissociation Phenomena of the CH and CD Molecules

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IN the course of a detailed investigation on the predissociation phenomena in the CH and CD spectra¹⁻³ the positions of several limiting curves of predissociation could be located in the energy vs. $\rho^2 J(J+1)$, i.e., energy vs. $\rho^2 J(J+1)$ schemata of these isotopic molecules. In this way the preliminary results reported in a previous letter⁴ became more precise and could be considerably extended, partly by observing the predissociation effects under various pressures in the light source, and partly by observing them on all three excited states of CH and CD.

A careful comparison of the corresponding effects in the CH and CD spectra revealed⁵ that the graphs of corresponding limiting curves of predissociation (constructed by adequate allowance of the isotopic corrections to the kinetic energy, i.e., by using $\rho^2 J(J+1)$ as abscissa for CD) can be brought in complete coincidence for both molecules only if one sets the equilibrium position of the CD ground state downward about 350 cm^{-1} units in respect to that of the CH molecule. As the electronic isotope effect does not amount to more than a few cm^{-1} units in any band system of CH and CD, the energies in the equilibrium positions of all CD states must be similarly shifted downward about the same value. The result reported is to be regarded as the experimental proof of the suspicion, that even for isotopic molecules the potential curves must not be strictly identical.⁶

It seems that the increase of the dissociation energy of a deuteride just reported is not restricted to the CD

molecule. Similar findings could be made for AID also,⁷ where the numerical value of the increase is about 190 cm^{-1} and for CaD, where an effect of about 100 cm^{-1} is suspected. For HgD, however, no noticeable increase seems to exist.

During the course of the analysis of several CH bands, attention was paid to a peculiar group of lines around 4324A mentioned first (together with the corresponding "isolated line group" in CD) by Fagerholm.⁸ When an acetylene-flame served as light source, this group developed as a band similar to the ${}^2\Delta-{}^2\Pi$ bands of CH in this region and analysis rendered it quite certain that it is the (2, 2) band of this system. We were not successful in the analysis of the corresponding CD band and by searching for the reason, it became clear that it was a small, but still observable broadening of all CD lines, which prevented an exact evaluation of the true combination differences. This behavior of the CD lines is the more peculiar since the Doppler width for the CD lines must be smaller than for the CH lines. The satisfactory sharpness of foreign and CH lines on the same plates guarantees the reality of an actual broadening. This is confirmed also by the fact that the broadening and the fuzziness of the CD lines are more pronounced on the longer wave-length side, where the line broadening $\Delta\lambda$ corresponding to a given $\Delta\nu$ value is obviously larger. The broadening effect has the order of magnitude of a few tenths of a cm^{-1} unit.

¹ L. Gerö, Zeits. f. Physik **117**, 709 (1941).

² L. Gerö, Zeits. f. Physik **118** (1941).

³ L. Gerö and R. Schmid, Zeits. f. Physik **118**, 210 (1941).

⁴ L. Gerö and R. F. Schmid, Phys. Rev. **59**, 528 (1941).

⁵ For comparing predissociation phenomena in isotopic molecules see L. Gerö and R. Schmid, Zeits. f. Physik **118**, 250 (1941).

⁶ In the case of H₂, HD and D₂ this has been established by I. Sandeman, Proc. Roy. Soc. Edinburgh **59**, 130 (1939).

⁷ E. Olsson, Dissertation, Stockholm 1938. Concerning evaluation, see reference 5.

⁸ E. Fagerholm, Naturwiss. **25**, 106 (1937).

The Fe $K\beta'$ and $K\beta_5$ Lines of FeS₂ and Fe₂O₃

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S. YOSHIDA¹ has studied the Fe K absorption structure of a number of Fe compounds. In the same paper, he reports the wave-length of the Fe $K\beta_5$ line of a few of the same compounds. The absorption spectra were photographed with a Johann focusing spectrograph. For the $K\beta_5$ lines, he used fluorescence excitation with a Siegbahn spectrograph. Among other findings, he concludes that "in the cases of the semi-conducting compounds the energy distance between the $K\beta_5$ and the beginning of the main absorption edge is smaller than in the cases of the ionic compounds," which is "roughly in agreement with the theory of electrical conductivity in solids."

His experimental findings are reinforced by work of the present author^{2,3} with a Johansson focusing spectrograph, on the Fe $K\beta_5$ lines of two of the same compounds Yoshida studied: FeS₂, and Fe₂O₃ (hematite). Table I presents the

combined results of the two researches. The separation of the edge from the line, in electron volts, was calculated with $R_\infty = 1.097 \times 10^5\text{ cm}^{-1}$ equivalent to 13.54 eV. The values given have been recalculated from Yoshida's original data. Where only his data are involved, the results

TABLE I. Separation of the Fe K absorption edge, and the Fe $K\beta_5$ line, in FeS₂ and Fe₂O₃.

	BEGINNING OF THE K EDGE—x.u. (YOSHIDA)	$\lambda K\beta_5$ x.u.	$K-K\beta_5$ ev	AUTHOR
FeS ₂	1739.4	1741.1 1741.3 ± 1	6.9 7.7 ± 3	Yoshida McDonald
Fe ₂ O ₃ (hematite)	1739.4	1741.7 ± 1	9.3 ± 4	McDonald
FeCO ₃	1739.0	1741.2	9.3	Yoshida
Fe ₂ (SO ₄) ₃	1737.5	1741.2	15.1	Yoshida

are close to the calculated values given in the original paper, but are not exactly the same. The present author has not been able to discover precisely how Yoshida carried out his calculations to get the values published by him.

Table I shows agreement between the two authors in the observed position of the line in FeS₂. Presumably the limits of error were about the same in both studies. The separation of edge and line is less than in Fe₂O₃ (hematite), which is semi-conducting, although less so than FeS₂ (mareasite or pyrites).⁴ Yoshida also confirms the observation of the present author that mareasite and pyrites produce indistinguishable spectra.

Neither FeCO₃ in the pure state, nor Fe₂(SO₄)₃, are conducting. It must be concluded that the FeCO₃ is impure. Probably the salt actually examined was the basic carbonate, which might well be of a conductive nature. If this is not so, the results on FeCO₃ are not consistent with those from the other compounds.

Ya. M. Fogel⁵ has studied the $K\beta_1$ and $K\beta'$ lines of Fe in a number of Fe compounds. He finds that the $K\beta'$ line is sharp in one group of compounds, including Fe₂O₃; whereas in Fe, Fe₃C, and FeS₂, it is broad. This same effect showed up in the previous work by the present author^{2,3} as an increase in the limit of error from ±0.1 x.u. to ±0.2 x.u. Fogel confirms the previous determination of the position of the line in Fe₂O₃ at 1756.9 x.u.

His mean wave-length for the Fe $K\beta'$ in FeS₂ was calculated from the positions of the edges of the band as 1755.6 x.u. In the work of the present author, the position of the line was measured as 1756.6 ± 2 x.u., by setting directly on the line with the crosshair of the microscope in a measuring engine. Both researches were carried out with focusing spectrographs and fluorescent radiation.

The conclusion may be drawn that the Fe $K\beta'$ line in FeS₂ is quite asymmetrical with the peak toward the long wave-length edge.

¹ S. Yoshida, Sci. Pap. Inst. of Phys. Chem. Res., Tokyo **38**, 272 (1941).

² J. C. McDonald, Phys. Rev. **50**, 694 (1936).

³ J. C. McDonald, Phys. Rev. **50**, 782 (1936).

⁴ International Critical Tables, **6**, 154.

⁵ Ya. M. Fogel, J. Exper. Theoret. Phys. (USSR) **10**, 1455 (1940).