1) A large-scale, linear, westward-trending, bathymetric feature lying immediately to the west of the ridge (Fig. 1) may be considered an additional extension of the Molokai Fracture Zone; thus one may extend the zone almost to a point of juncture with the Marcus-Necker Ridge.

2) The direction of the magnetic trend is altered somewhat, as it crosses the Hawaiian Ridge, from almost exactly eastward east of the ridge to east-northeastward west of the ridge; this change is in line with the much sharper southward bending of the Murray and Mendocino fracture zones to the north. At the point where the Molokai Fracture Zone magnetic trend encounters the ridge (Fig. 1), the other major structural direction, as defined by major rift zones having associated gravity and magnetic anomalies, is northwestward; this trend may be seen on the islands of Oahu, Molokai, Lanai, and Kauai. The same trend may also be seen in magnetic anomalies to the southwest of the islands, in the bathymetry south of the island of Hawaii, and in the trend of submarine volcanoes running northwestward from the island of Oahu. Apparently this northwestward trend represents a basic fracture zone and a discontinuity in the crust across which the major east-west fracture zones experience a discontinuous change in direction.

3) The tremendous length of the Molokai Fracture Zone, reaching as it does from the East Pacific Rise to the postulated "Darwin Rise" of Menard, strongly suggests that the fracture zones are not genetically related to the East Pacific Rise as has been suggested. Perhaps the greater vertical displacement along the fracture zones in the vicinity of the East Pacific Rise may well reflect the action of the forces forming the rise on the fault structures already existing.

The fact that the magnetic trend of the Molokai Fracture Zone can be traced for hundreds of kilometers, where there is little or no bathymetric expression, suggests that the western ends of the Murray and Clarion fracture zones also should be examined magnetically to determine whether they also extend farther westward than has been suspected.

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Radiation Absorption between the Ultraviolet and X-ray Bands

Abstract. *The recent initial exploration of photoabsorption in a previously unmapped portion of the spectrum, photon energies between approximately 20 and 500 electron volts or wavelengths between 20 and 600 angstroms, is reviewed.*

While the comparative capacity of matter to absorb electromagnetic radiation of various spectral characteristics has been regarded as an important subject of investigation, the absorption by single atoms or small molecules over a broad spectral range between photon energies of approximately 20 to 500 ev or wavelengths of 20 to 600 Å has remained essentially unmapped until the last few years. This gap in our knowledge is now being bridged, if only in a preliminary way.

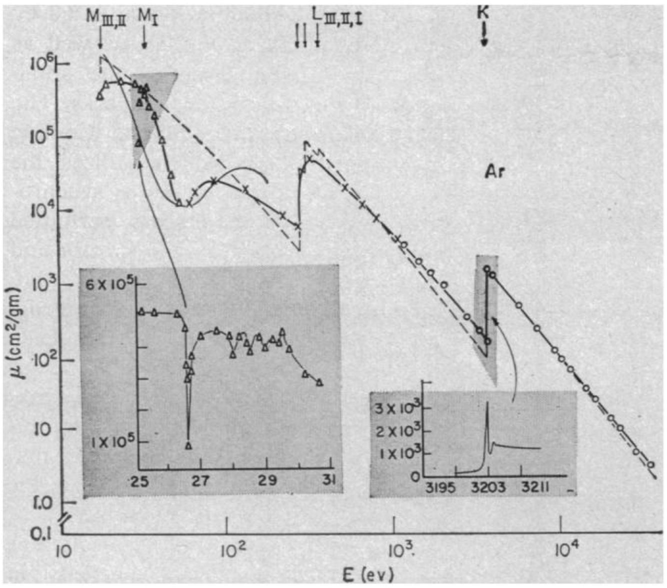
I now attempt to describe the absorption of photons by atoms as provided by data from several laboratories. The data pertain primarily to inert gases. Dependable surmises concerning other elements could probably be derived from it, but no serious effort appears to have been undertaken to this end.

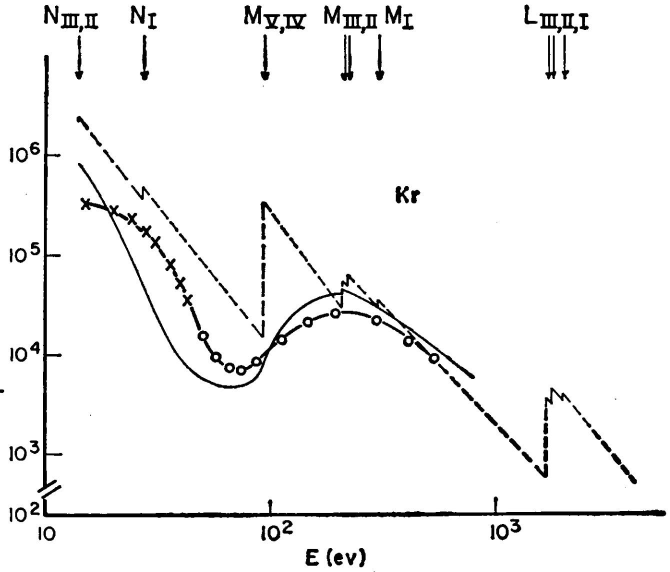
The development of absorption spectroscopy covering the range between the ultra violet and x-ray wavelengths has been delayed by the lack of suitable radiation sources and by the strongly disturbing influence of any extraneous matter that might come across the optical path. However, among those who contributed to recent progress are Lukirskii and co-workers (*1*) who extended x-ray techniques down to 60 ev and Tomboulian *et al.* (*2*), as well as Samson (*3*), who extended the application of line sources from sparks. The development by Madden and Codling of a spectrograph which utilizes the National Bureau of Standards synchrotron as a light source has permitted continuous coverage of the spectra and brought out fine structures over photon energies up to 150 ev (*4*). Progress toward a general theory has been made by Cooper (*5*), and particular calculations by others (*6*). The emphasis in our laboratory, reflected in this paper, has been on identifying the major properties of the spectra and the underlying physical mechanisms.

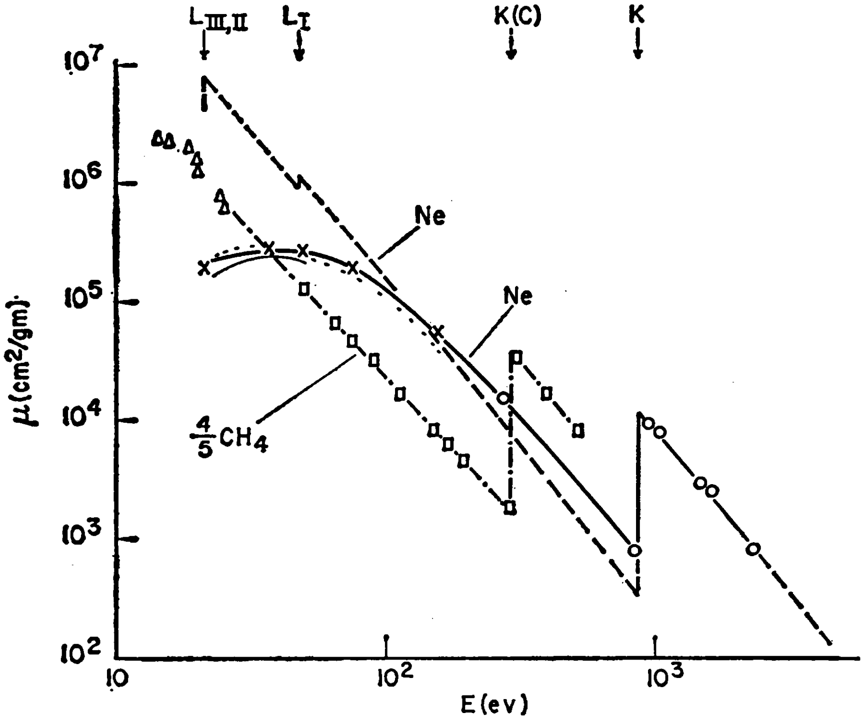
Prior to 1960, tentative expectations concerning absorption coefficients in our range of interest were based on extrapolation to lower photon energies of the hydrogen-like behavior observed in the x-ray range. The dashed line in Fig. 1 shows this behavior for argon, with the characteristic linear drop toward higher energies, on the logarithmic scale. The drop is interrupted now and then by the familiar "edges" which mark the onset of absorption by the electrons of the successive internal shells or subshells. The argon data are emphasized here because they exhibit many novel features. The inset on the right shows the fine structure of the *K*-edge; this structure consists of lines which correspond to excitation from the *K*-shell to outer discrete orbitals and which are broadened by autoionization (Auger effect) so that they merge into one another. The experimental data fit the dashed line on the right side of Fig. 1 rather well, but large, qualitative departures occur at lower energies.

Departures are not unexpected here, as the hydrogen-like approximation to atomic mechanics breaks down for lower photon energies. These photons are absorbed by electrons in the outer portions of atoms, where the average electric field varies far more sharply than the Coulomb field does within the hydrogen atom. Two other effects that also become more important in the outer shells are (i) deviations from the average field at each point, which are due to correlations between electron positions and which cause effects of "configuration interaction"; and (ii) electron-exchange effects.

The inset on the left of Fig. 1 shows the fine structure associated with the M_1 threshold. Not only does this struc-







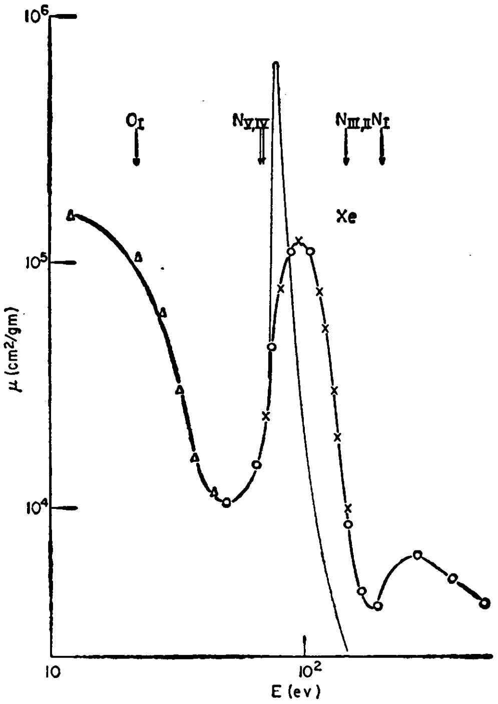


Fig. 1 (top left). Double-logarithmic graph of the mass absorption coefficient of radiation of different photon energies in argon. [This coefficient is defined as $t^{-1}\log[I(0)/I(t)]$, where t is the thickness of an absorbing layer of matter, expressed in grams per square centimeter, and $I(t)$ is the radiation intensity transmitted.] The hydrogen-like theory (dashed line) fits experimental data reasonably well for higher energies only. Insets show different aspects of the fine structure of "absorption edges." Some edges, predicted by the hydrogen-like theory and labeled by arrows on the upper margin, do not appear in the experimental data. △, J. A. R. Samson (*3*); ○, H. W. Schnopper (*12*); X, A. P. Lukirskii *et al.* (*1*); --, hydrogen-like theory; —, J. W. Cooper theory (*5*).

Fig. 2 (bottom left). Mass absorption coefficients of neon and CH_4. The CH_4 data have been reduced by a factor of 4/5 to make them comparable to those of neon on a molecule-for-molecule, or electron-for-electron, basis rather than on an equal-mass basis. There is a strong depression of neon absorption at low energies as compared to hydrogen-like predictions; this depression is compensated by enhanced absorption at high energies. The CH_4 data parallel the hydrogen-like predictions for neon. X, J. A. R. Samson (*3*); ○, A. J. Bearden (*13*); □, A. P. Lukirskii *et al.* (*1*); △, N. Wainfan *et al.* (*14*); --, hydrogen-like theory; —, M. J. Seaton (*6*); ...., K. G. Sewell (*6*).

Fig. 3 (top right). Mass absorption coefficient of krypton compared with different theoretical predictions. The absorption by outer-shell electrons, below 100 ev, resembles that of argon. The absorption by inner shell electrons resembles that by the outer shell of neon. Several absorption edges are missing or are barely detectable. X, J. A. R. Samson (*3*); ○, A. P. Lukirskii *et al.* (*1*); --, hydrogen-like theory; —, J. W. Cooper (*5*).

Fig. 4 (bottom right). Mass absorption coefficients of xenon showing a high and sharp maximum in the 100-ev region. △, J. A. R. Samson (*3*); ○, A. P. Lukirskii *et al.* (*1*); X, D. L. Ederer (*2*); —, J. W. Cooper theory.

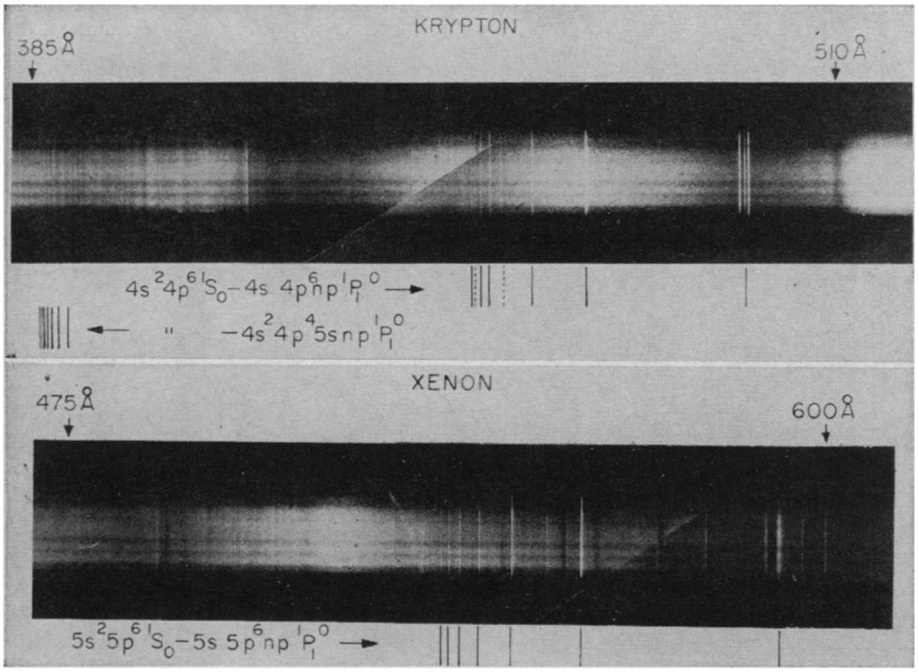


Fig. 5. Sample absorption spectra of Kr and Xe showing extensive line structures due mostly to two-electron excitations superimposed on continuous absorption. [Courtesy R. P. Madden and K. Codling]

ture depart radically from that of the *K*-edge, but the edge itself is not observed, except perhaps for a slight depression rather than increase of the absorption. The remarkably different profiles observed in the fine structure of edges have been shown to be variants of a single family of curves. The replacement of an absorption rise by a slight drop at the M_1 edge of argon has been plausibly attributed to configuration interaction (*7*), but no quantitative account of this (or any related) edge effect has yet been given.

A notable departure from behavior similar to that of hydrogen in Fig. 1 is the minimum of absorption of 50 ev which had been predicted by Cooper (*5*). This minimum absorption occurs because the dominant contribution to absorption by outer-shell electrons vanishes for a single value of the photon energy. Such a minimum should occur in all but a limited class of strong absorptions; indeed, it was previously known (*8*) to occur in the photo-ionization by ultraviolet light of alkalis and alkaline earths near threshold. The zero point of a specific type of photoionization (3*p* to ionized *d* in our example) marks the transition between two somewhat different mechanisms of atomic response to radiation, characterized by dipole moments of opposite sign. On the high-frequency side of the zero point the response is similiar to that of hydrogen; on the low-frequency side it resembles a resonance whose characteristics are well delineated but whose mechanism has not been satisfactorily described.

Cooper's curve in Fig. 1 was calculated on the assumption that each absorbing electron moves in a fixed potential well. The curve's departure from the form of the experimental data reflects the inadequacy of this approximation, which was primarily due to the failure to consider that the net effect of exchange is attractive on an electron in its bound state and is repulsive in its ionized state. Calculations that take exchange into account correctly provide better agreement with experiment, but they have thus far failed to provide a complete, consistent theoretical approach. Therein lies an unsolved, rather fundamental, problem of atomic theory.

An additional type of departure from hydrogen-like behavior is more apparent in the spectrum of neon (Fig. 2) than in that of argon. In the course of photoionization, an electron most frequently acquires one unit of angular momentum. Therefore it may have to overcome an appreciable barrier of centrifugal potential as it leaves the atom. This circumstance tends to hinder the escape of a low-energy photoelectron and thereby to depress photoabsorption near its threshold, but it tends to favor photoabsorption at higher energies, as illustrated by the left-hand portion of the neon spectrum. The importance of this effect depends on the balance between the electric attraction and the centrifugal force, which is critical over a large volume in certain atoms, but not so under hydrogen-like conditions. Photoabsorption at energies far above the threshold is also enhanced for electrons whose initial bound state extends over regions where the nuclear attraction is attenuated to a quite different degree. The magnitude of these effects is illustrated by comparison of the photoabsorption spectra of methane (CH_4) and neon in Fig. 2. The behavior of the eight valence electrons of CH_4 is much more hydrogen-like than that of the eight *L*-electrons of neon. The CH_4 electrons spread out farther away from the molecular center, where centrifugal forces are weaker; also, the strongest nuclear attraction affecting them corresponds to an effective atomic number of approximately 4, whereas a value of 8 prevails in the inner portion of the neon atom's *L*-shell.

The spectrum of krypton (Fig. 3) displays the same features as that of argon with regard to photoabsorption by its outer electrons, whereas the absorption by its inner-shell *d* electrons —from 100 ev up—resembles that of the outer electrons of neon. Indeed the $M_{\mathrm{IV,V}}$ edge, corresponding to the onset of absorption by 3*d* electrons, is so depressed as to have been barely observed. The spectrum of Xe (Fig. 4) shows a very striking maximum of absorption near 100 ev. The maximum absorption exceeds by a factor of 30 the absorption just to the right of the $N_{\mathrm{IV,V}}$ edges at 70 ev. This behavior of the absorption by 4*d* electrons has been attributed (*5*) to the combined effect of the centrifugal depression at the edge and of the "Cooper minimum" around 125 ev. The absorption thus concentrated within narrow limits necessarily attains a high peak value. Notice that no "Cooper minimum" was expected or observed for the absorption by the 3*d* electrons of Kr. The He spectrum is rather hydrogen-like, as one would expect.

Besides all these gross features, the observation of photoabsorption spectra has revealed, since 1963, very extensive systems of lines due to simultaneous excitation of two electrons to discrete states (*4*). The total amount of absorption provided by two-electron processes—including simultaneous excitation and ionization—is not large, amounting to no more than about 10 percent of that of single-electron transitions. However, the concentration of some of this contribution into lines and its interference with the contribution of ordinary photoionization make it quite conspicuous, as shown in Fig. 5. Moreover, as emphasized by Goldberg (*10*), two-electron transitions loom even larger in spectral ranges where one-electron absorption is unlikely, such as in the ultraviolet spectra of alkaline earths where photoionization experiences a minimum.

Photoabsorption by molecules in our spectral range should display the combined influence of three effects: (i) the absorption by the constituent atoms, (ii) the special properties of valence bond orbitals from which electrons can be ejected, and (iii) the geometrical arrangement of the atoms. Only the first tentative steps toward the observation and analysis of molecular photoionization spectra have been taken thus far (*11*).

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22 April 1966

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Cesium-137 Body Burdens in Alaskan Eskimos during the Summer of 1965

Abstract. *Cesium-137 body burdens of Anaktuvuk Pass, Alaska, residents during the summer of 1965 were about 30 percent less than during 1964. Lower amounts of cesium-137 in the people reflected a similar decrease of this isotope in caribou flesh, which serves as the principal food of the natives.*

Cesium-137 body burdens in Eskimo residents of Anaktuvuk Pass, Alaska, were measured during the summer of 1965, in continuation of a study begun during 1962. The purpose of this note is to update periodic reports of these data (*1*).

The measurements were made with a sodium iodide (thallium-activated) crystal (53 by 76 mm) and a photomultiplier tube connected to a compact single-channel γ-ray analyzer-scaler. This instrument had been previously calibrated with the shadow-shield counter used and described in our earlier reports. Two consecutive 1-minute counts for radioactivity were usually made of each individual; variation between these counts was consistently less than 5 percent. Five measurements of two individuals obtained at 3- to 12-hour intervals over a 2-day period varied about ten percent, which is considered to be the normal accuracy of this instrument in the range of ^{137}Cs body burdens encountered in these people.

The amount of radiation in the whole body (count/min) of all available village residents was determined on 23 to 24 July and on 24 August. During this period, I conducted a special study of the biological half-time of ^{137}Cs in 28 members of four families who agreed to abstain from their normal diet of caribou meat (*2*).

A control group of 26 adults (over 21 years of age) was selected in 1963 to provide continuity of data in certain individuals who would be available when the counts were made. This group originally consisted of 12 men and 14 women; one male member of the group died in December 1964. Average ^{137}Cs body burdens in the control group generally were slightly less than the average for the entire adult population because of the higher proportion of women, whose bodies generally contain lower amounts of ^{137}Cs than those of men (*3, 4*). The reexamination of the same individuals, rather than a population sample, was considered desirable, although it makes little difference when the entire available population is examined each time.

I have arbitrarily divided the Anaktuvuk Pass Eskimo population (approximate total, 110) into three age categories on the basis of the performance of the counting equipment and the physiological phenomena: (i) Children, 3 to 14 years; (ii) minors, 15 to 20 years; and (iii) adults, over 21 years. The population (available for examination) of Anaktuvuk Pass is comprised of about 35 children over the age of 3 years, 10 minors, and 40 adults. Examination of the ^{137}Cs body burdens of these various categories of persons on regular diets during the summer of 1965 (Table 1) shows that there was essentially no difference between the July and August values for the adults and minors. However, the children's ^{137}Cs body burdens decreased during the elapsed month, probably because several subjects participated in the U.S. Government's Project Headstart, which included a school lunch program featuring processed food containing lower ^{137}Cs concentrations than their usual diets.

Cesium-137 body burdens of the Anaktuvuk Pass residents were essentially constant during July and August, being about 30 percent lower than those recorded during the same period of 1964. This decrease reflects a lower ^{137}Cs concentration in caribou flesh which forms the food base of these people (*4*). Samples of caribou flesh from representative family food caches were analyzed and the data were compared with data of previous years (Table 2). The trend of ^{137}Cs body burdens of Anaktuvuk Pass residents closely parallels that of the ^{137}Cs in caribou flesh, which was also 30 per-