A more complete account of these experiments and results is in preparation.

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Photoelectric Emission in the Extreme Ultraviolet

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EXPERIMENTAL studies on photoelectric emission from various metals for quantum energies up to 21.2 ev show general features which led the author to the conclusion that the common "free electron"-"surface effect" picture cannot even qualitatively account for the photoelectric phenomena at higher photon energies. These features are:

1. The number of electrons emitted per incident photon (yield Y) starts rising very steeply as soon as the quantum energy increases beyond a certain value (μ) which is appreciably higher than the work function (φ). With further increase of quantum energy, Y reaches a flat maximum followed by a slow decrease. These yields[1] for $h\nu>\mu$ are, by several orders of magnitude, greater than the highest ones known from the many studies at longer wavelengths.

2. The energy distribution curves of emitted electrons practically cut off at $E_1=h\nu-\mu$ and not at the usually much higher maximum $E_s=h\nu-\varphi$ related to the common surface effect.[2]

3. There is a surprising insensitivity to some changes in the surface condition and to exposure to air.

4. Higher temperatures generally seem to reduce the number of electrons of only the lowest energies. This "true" temperature effect appears to cause only a small change in the total emission and should be clearly distinguished from larger, essentially irreversible changes of Y during the first outgassing cycle, and also from possible, closely reproducible types of an "apparent" temperature dependence which may disappear after a sufficient increase in temperature.

The following theoretical model seems to offer a reasonable interpretation of the above phenomena: For sufficiently high photon energies, most of the electron emission originates inside the metal ("volume effect") by removal of an electron from an energy level μ (below vacuum potential). This level is supposed to represent electrons which are much more strongly bound than could be attributed to ordinary conduction electrons, thus offering a high cross section for "photoionization." The same primary process is considered responsible for absorption of the primary radiation. Assuming, as a first approximation, that all the emitted electrons come from one definite level μ, neglecting secondary effects of any kind, and assuming a constant coefficient D for electron transmission through the surface, one can predict the wavelength dependence of the yields. The total number of photoelectrons from level μ should be

$$Y=0.5D\{1-[1+(h\nu-\mu)/\varphi]^{-\frac{1}{2}}\} \text{ per incident photon.}$$

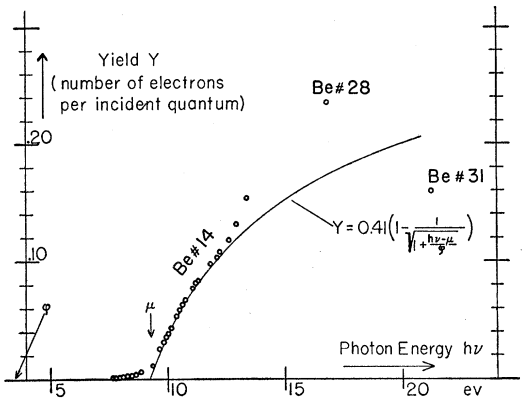

FIG. 1. Photoelectric yields of beryllium.

The derivation of this equation may be briefly outlined as follows: Escape of an electron through the surface is possible only when the kinetic energy related to its component of momentum normal to the surface is equal to or greater than the work function φ. This defines a maximum angle to the normal, α, beyond which no escape can be expected, determined by the relation $(h\nu-\mu)\cos^2\alpha=\varphi$. The ratio of the corresponding solid angle to the total solid angle represents the probability of escape under the assumptions of ideal random distribution of the original directions inside the metal, no absorption along the way to the surface and $D=100$ percent. For $h\nu-\mu\gg\varphi$ and $D=100$ percent the maximum possible yields would be 50 percent, independent of wavelength and nature of metal. The solid curve in Fig. 1 represents the above function for $\mu=9.2$ ev, $\varphi=3.7$ ev and $D=80$ percent and is compared with experimental data for outgassed beryllium.

The energy distribution of emitted electrons, cutting off at $E_1=h\nu-\mu$, is expected to show relatively high numbers of lower energy electrons extending down to $E=0$ because of collisions. There is also an interesting possibility that secondary radiation of maximum quantum energy $h\nu'=\mu-\varphi$ (emitted when a vacancy in level μ is filled by a conduction electron of maximum Fermi-energy) causes a regular photoelectric surface effect whenever $\mu>2\varphi$. This should contribute a subgroup with a maximum energy $E_2=\mu-2\varphi$. For $h\nu-\mu>\varphi$, the primary may cause emission of a secondary

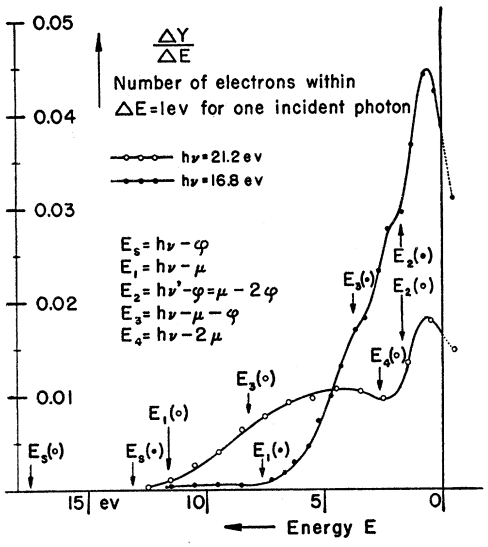

FIG. 2. Differential energy distribution of electrons emitted from beryllium for two different photon energies.

from level φ, adding another group ($E_3=h\nu-\mu-\varphi$). If $h\nu>2\mu$, the primary photoelectron has enough energy for a "secondary ionization" leading to another group having the maximum energy $E_4=h\nu-2\mu$ outside the metal. It should be pointed out that E_1 and E_4 do not depend on the work function explicitly, and E_2 is the same for different wavelengths of the primary radiation. Beryllium has been chosen to illustrate this model, because the simple assumption of only one definite level seems to be a fair approximation. Figure 2 presents experimental energy distribution curves for two different wavelengths ($h\nu=16.8$; 21.2 ev). If one uses $\mu=9.2$ ev as estimated from the experimental spectral yield distribution, and $\varphi=3.7$ ev, then the energies E_1, E_2, E_3, and E_4 derived from this model are those indicated by vertical arrows in Fig. 2. No matter how much of our model will survive further theoretical investigation, the experimental curves of Fig. 2 show clearly that only a negligible number of emitted electrons could have come from levels near the top of the Fermi band, and that a fairly sharp increase of the cross section for photon-electron interactions in a metal occurs at much deeper levels than those which are important for thermal emission, field emission, and the common photoelectric surface effect.[3]

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Nuclear Magnetic Octupole Moments of the Stable Gallium Isotopes*

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THE three zero-field hyperfine structure intervals of the metastable $^2P_{\frac{3}{2}}$ state of Ga^{69} and Ga^{71} have been remeasured[1] to higher precision to establish the existence of a nuclear magnetic octupole moment.

The atomic-beam magnetic resonance method was employed; the transitions were induced by the Ramsey technique[2] of separated oscillating fields. One oscillating field was phase modulated at 93 cps with respect to the other so that the oscillating fields were alternately in phase and 180° out of phase. The alternately in-phase and out-of-phase Ramsey patterns produced were electronically subtracted by a synchronous detector and displayed on an oscilloscope (see Fig. 1).

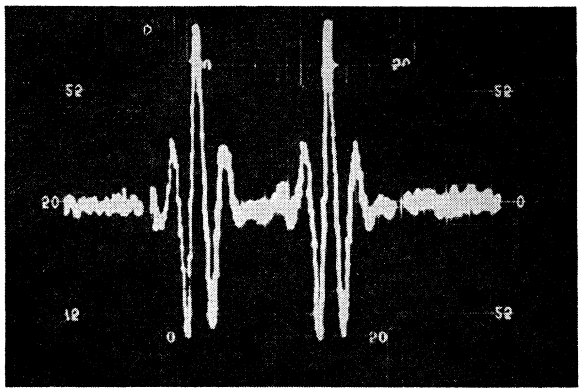

FIG. 1. Typical oscilloscope photograph showing the quadratic Zeeman splitting of the ($F=2$, $m_F=0$)↔(1,0) and (2,1)↔(1,1) transitions in an external magnetic field of 0.4 gauss. The Ramsey technique (see reference 2) of separated oscillating fields was used. The two blank portions of the trace calibrate the picture in frequency. The width at half-maximum of each central peak is 500 cps.

The intervals were measured in several external fields ranging from 0.2 gauss to 1 gauss, extrapolated to zero field, and corrected[3] for the perturbing effects of the neighboring $^2P_{\frac{3}{2}}$ ground state as well as the admixture of (4s)(4p)(5s) electronic configuration (see Table I).

The magnetic dipole, electric quadrupole, and magnetic octupole interaction constants,[4] a, b, and c, are calculated from the corrected intervals to be

Ga^{69}

a: 190.794280±0.000150 Mc/sec
b: 62.522470±0.000300 Mc/sec
c: 84±6 cps

Ga^{71}

a: 242.433950±0.000200 Mc/sec
b: 39.399040±0.000400 Mc/sec
c: 115±7 cps,