A New Afterglow Phenomenon

A new afterglow phenomenon, which has been observed in three separate discharge tubes at different pressures, is illustrated in the accompanying spectra (Fig. 1). These

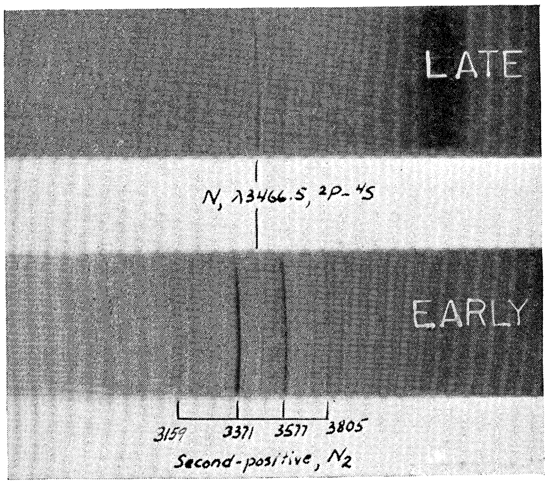

FIG. 1. Lower spectrum is of the early afterglow; the upper is that of the last part of the glow.

pictures were obtained on Eastman 33 plates in a small quartz spectrograph. They represent the early and late phases of a nitrogen afterglow at a pressure of the order of 20 mm. The bottom spectrum is that of the early and hence strong part of the afterglow, and the top one that of the last part of the glow. In order to obtain a plate strong enough to print it was necessary to expose the late part of the glow about three times as long as the early part. The contrast is striking. The forbidden nitrogen line, 3467, corresponding to the $^2P-^4S$ transition, is much more intense in comparison with the second positive N_2 bands late in the glow than it is in the early part. A long series of observations on the variation with pressure of this type of glow in the range thus far observed has shown that the ratio of forbidden to allowed radiation increases with pressure, a result which was quite surprising. In view of this, it is possible then to summarize the results in the present experiment by saying that the spectrum of the late phase of an afterglow corresponds to that of the early phase of a higher pressure afterglow or the effect on the spectrum of the afterglow as its lifetime increases is that of an apparent increase in pressure.

Observations on an afterglow at a lower pressure of about 10 mm shows this effect very clearly and these spectra will be published soon. It is believed that an explanation of this new afterglow effect will lead to an understanding of the puzzling afterglow phenomena which accompany discharges in nitrogen and further experiments are now in progress to study this effect under a variety of other conditions.

JOSEPH KAPLAN

Departments of Physics and Astronomy,
University of California at Los Angeles,
Los Angeles, California,
March 5, 1940.

Double Ionization by the Auger Effect: The Cause of a Satellite Intensity Anomaly for the X-Ray Diagram Line $M\alpha_1$

In a paper[1] published in 1936 the present author postulated an intensity anomaly due to the Auger effect, for the x-ray diagram line $M\alpha_1$, existing somewhere in the region immediately below atomic number 88. Some evidence in that paper was presented to show the existence of an Auger intensity anomaly.

Because of his interest Professor H. E. White reproduced in his book, *Introduction to Atomic Spectra*, some of the M-series plates[2] of the author's thesis (Cornell, 1931). Very recently, in looking at that book, it was of great interest to the present author to observe unmistakably the intensity anomaly which he had predicted (see p. 305).

To make this intensity anomaly more unmistakable, the plates are again reproduced. Fig. 1 shows the same $M\alpha$ lines; negatives were made, and finally a series of prints having the same maximum line density were secured. (The maximum density of the original plates was in the safe range to preserve density-intensity proportionality.) Hence it is felt that this presents a truer picture than Professor White's figure, although it was due to the original figure in Professor White's book that recognition of the Auger intensity anomaly was possible.

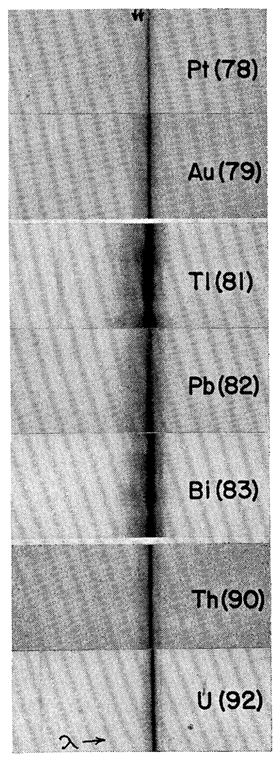

FIG. 1. $M\alpha$ lines of several elements. (The Pt and Au lines were taken with a quartz crystal; the rest by means of a calcite crystal.)

In reference 1, the writer pointed out that the radiationless transition $(M_{III}\rightarrow M_V)_z$ plotted on an energy scale against atomic number (see Fig. 2), intersects the $N_{IV,V}$ shell (for $z+1$ as an M-electron is already missing) in the region of $z=88$. This causes the Auger effect, acting to doubly ionize atoms for some atomic numbers below $z=88$, and preparing the respective atoms for the occurrence of the $M\alpha$ satellite group. (This work was patterned after the concepts of Coster and Kronig.[3])

Thus below $z=88$, for some atomic numbers, satellites should occur with considerable intensity: we should expect an intensity anomaly such as has already been described.[1, 4] The radiationless transition $M_{III}\rightarrow M_V$ initiated by electron ionization of the M_{III} shell, occurs with simultaneous ejection of an $N_{IV,V}$ electron. This process is especially probable when the normalized radial wave function for the

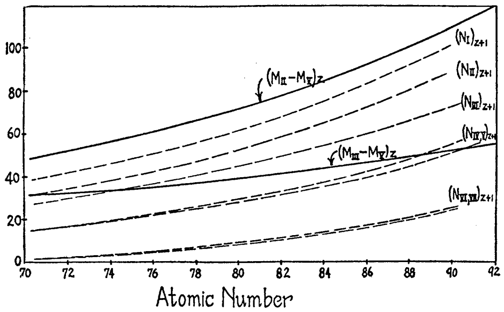

FIG. 2. The radiationless transition $M_{III} \rightarrow M_{V}$ on a ν/R scale plotted against atomic number, Z, and the ionization energy of the N-shells for $Z+1$.

ejected electron strongly overlaps the particular wave function for the $N_{IV,\,V}$ electron.

Now turning to Fig. 1, we see that the intensity of the satellite group on the left (short wave-length side) of each $M\alpha$ line increases from $z=78$(Pt) up to roughly $z=82$(Pb); beyond, at Th(90) and U(92), the satellite group intensity has decreased very markedly. Thus there exists an unmistakable intensity maximum due to the Auger effect, and we may say definitely that for the $M\alpha_1$ satellites the initial state is $M_V N_{IV,\,V}$; the final state $N_{VII} N_{IV,\,V}$.

F. R. HIRSH, JR.

California Institute of Technology,
Pasadena, California,
February 26, 1940.

[1] F. R. Hirsh, Jr., Phys. Rev. **50**, 191 (1936).
[2] F. R. Hirsh, Jr., Phys. Rev. **38**, 914 (1931).
[3] D. Coster and R. deL. Kronig, Physica **2**, 13 (1935).
[4] F. R. Hirsh, Jr., Phys. Rev. **48**, 722 (1935).

Cosmic-Ray Intensities and Air Masses

Blackett[1] has shown that the "temperature effect" of cosmic rays is due to the vertical shift of the layer in which mesotrons are formed and has further suggested that it may be possible to correlate cosmic-ray data with the structure of depressions. Loughridge and Gast[2] have pointed out that cosmic-ray intensities in America show a noticeable change at the fronts separating different air masses.

Our polar continental (*Pc*) air mass[3] originates in Manchuria and Siberia and comes to Japan proper as the Northwest monsoon in the colder half of the year. The tropical maritime (*Tm*) air mass flowing from the North Pacific subtropical high pressure belt comes to Japan proper as southerly tropical air mainly in the warmer half of the year. The polar maritime (*Pm*) air mass originates in Okhotsk sea and the sea to the east of Japan and comes to Japan proper as the mild Northeast wind in the rainy season. The *Pm* air mass found in Japan is shallow, but plays an important weather rôle. The mass is seldom thicker than 2000 m and is usually overrun by *Tm* air mass; the interaction of these two air masses results in the formation of a stationary front and is responsible for the gloomy and rainy weather of the Bai-u period of Japan. There are two other modified polar continental air masses, which lose their original coldness and dryness in the lower layers. One comes to Japan proper by the sea route from Northwest, and the air mass type transforms from the fresh one (*Pc*) to the modified one (NPc_1). The other arrives in north and central China by the land route and then comes to us by the sea route with the general westerly wind (NPc_2).

Cosmic-ray intensities under various typical air mass conditions prevailing in Tokyo during the year 1937 were picked up from the results obtained with a Steinke cosmic-ray meter inside 10 cm Pb and were given together with their barometer effects in Table I. The air masses were identified from the synoptic charts analyzed by the Forecasting Division of the Central Meteorological Observatory, Tokyo.

We see from the table that (1) both the correlation coefficient and the barometric coefficient are relatively high in the fresh *Pc* air mass and *Tm* air mass, and show a gradual decrease as the air mass type transforms from the fresh one to the modified one. (2) The correlation coefficient and the barometric coefficient are very low in *Pm* air mass, which is shallow and is overrun by *Tm* air mass. (3) The reduced cosmic-ray intensity is relatively low in warm air (*Tm* and *Pm*), but is high in cold air (*Pc*).

The explanation of these results on the basis of the instability of the mesotron will shortly be given in this column.

This work was done as a part of the program of the cosmic-ray sub-committee of the Japan Society for the Promotion of Scientific Research.

Y. NISHINA
Y. SEKIDO
H. SIMAMURA

Institute of Physical and Chemical Research,
Tokyo, Japan,

H. ARAKAWA

Central Meteorological Observatory,
Tokyo, Japan,
February 20, 1940.

[1] P. M. S. Blackett, Phys. Rev. **54**, 973 (1938).
[2] Donald H. Loughridge and Paul Gast, Phys. Rev. **56**, 1169 (1939).
[3] H. Arakawa, Bull. Am. Met. Soc. **18**, 407 (1937).

TABLE I. *Correlation of air mass conditions and cosmic-ray intensities.*

AIR-MASS TYPE	*Pc*	NPc_1	NPc_2	*Pm*	*Tm*
Number of observations (6 hour mean)	49	75	24	30	67
Mean observed cosmic-ray intensity (*J*)	1.6266	1.5933	1.5881	1.5658	1.5647
Correlation coeff. between the atmos. pressure and the cosmic-ray intensity	−0.75	−0.44	−0.50	−0.04	−0.64
Barometric coefficient (percent per cm Hg)	−1.46	−0.92	−1.08	−0.15	−1.22
Reduced intensity to normal atmos. pressure 755 mm Hg (*J*)	1.6269 (+2.0%)	1.5944 (0.0%)	1.5943 (0.0%)	1.5670 (−1.7%)	1.5672 (−1.7%)
	(Annual Mean Value of $I_{755}=1.5943J$)				

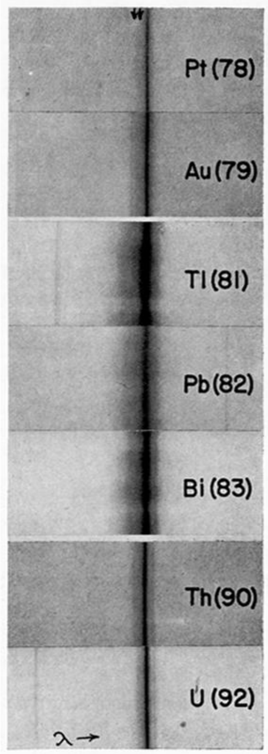

FIG. 1. $M\alpha$ lines of several elements. (The Pt and Au lines were taken with a quartz crystal; the rest by means of a calcite crystal.)