# OBSERVATION OF CASCADE TRANSITIONS

PHYSICS

1965

SovietRxiv

## Abstract

## Full Text

UDC 539.184.5

**PHYSICS**

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# OBSERVATION OF CASCADE TRANSITIONS UNDER ELECTRON EXCITATION OF CADMIUM

*(Presented by Academician A. N. Terenin, February 13, 1965)*

In the study of optical excitation functions of spectral lines ($^1$) and of the lifetimes of excited atoms by the delayed-coincidence method ($^2$), cascade transitions may play an important role. Thus, in ($^1$) it is suggested that cascade transitions are one of the causes of secondary maxima in optical excitation functions. In ($^2$), cascade transitions from upper, longer-lived levels are used to explain the distortion of the results of measurements of the lifetimes of certain helium and neon levels. Using the delayed-coincidence method, one can experimentally observe the population of the level under study by a cascade, i.e., confirm the validity of the assumptions made in ($^{1,2}$).

We observed population of a level by a cascade while measuring the lifetime of the cadmium level $5^3D_3$. The general principles of the measurement method are described in ($^2$). To excite cadmium atoms, an electron gun with an oxide cathode was used. A violet bulb with an electron gun and an ampoule of metallic cadmium was placed in an electric furnace. The vapor pressure of cadmium was calculated from the formula in ($^3$). A generator of rectangular $10^{-9}$-sec pulses was connected through a transformer to the first grid of the electron gun. The operating repetition frequency of the pulses was $5 \cdot 10^4$ Hz. The accelerating voltage on the second grid of the gun was adjustable over a wide range and was maintained with an accuracy of $\pm 0.1$ V. Excitation of cadmium atoms took place in the equipotential space between the second grid and the anode of the gun. The generator pulses fed to the coincidence circuit were delayed by a delay line with continuous adjustment in the range from 0 to 1 $\mu$sec. The resolving time of the double-coincidence circuit was $9 \cdot 10^{-9}$ sec.

The cadmium radiation (through a monochromator) was recorded by a photomultiplier with an antimony-cesium photocathode. The lifetime of the $5^3D_3$ level was determined from the transition $5^3P_2$—$5^3D_3$ ($\lambda$ 3610 Å). In doing so it must be taken into account that our optical system could not resolve the neighboring lines 3610; 3612 Å (transition $5^3P_2$—$5^3D_2$) and 3614 Å (transition

Fig. 1. Dependence of the logarithm of the number of coincidences $\log N_{\text{coinc}}$ on the delay time $\tau_3$ for the level $5^3D_3$, line 3610 Å (transition $5^3P_2$—$5^3D_3$). Exciting-electron velocity: 1 –8.7 eV, 2 –7.9 eV

Figure 1: Fig. 1. Dependence of the logarithm of the number of coincidences $\log N_{\text{coinc}}$ on the delay time $\tau_3$ for the level $5^3D_3$, line 3610 Å (transition $5^3P_2$—$5^3D_3$). Exciting-electron velocity: 1 –8.7 eV, 2 –7.9 eV

$5^3P_2$—$5^3D_1$). The intensities of these three lines are in the ratio 100 : 17.8 : 1.2 ($^4$). Therefore the main signal in the electrophotometric device is due to the intensity of the 3610 Å line. In addition, the 3612 and 3614 Å lines cannot substantially affect the results of our observations, since from the data of ($^{4,5}$) it follows that the lifetimes of the levels $5^3D_3$, $5^3D_2$, and $5^3D_1$ are almost identical.

Figure 1 presents the dependences of the logarithm of the number of coincidences $\log N_{\text{coinc}}$ on the delay time $\tau_3$ when this line is recorded. Curve 1 was taken at an exciting-electron velocity of 8.7 eV. It is clearly seen that the points are grouped about three straight lines with different slopes. Straight line *a*, with zero slope, corresponds to the background, independent of the delay. Straight line *b* is due to cascade transitions from the longer-lived level $4^3F_4^0$. Straight line *c* corresponds to depopulation of the $5^3D_3$ level, popu-

by electron excitation and cascading transitions from the level $4^3F_4^0$. Graph 2 was taken at an exciting-electron velocity of 7.9 eV, i.e., under conditions in which the level $4^3F_4^0$ is not excited. In this graph, straight line *a* also corresponds to the background, and straight line *c* to depletion of the level $5^3D_3$. In our opinion, the absence in graph 2 of a segment analogous to segment *b* in graph 1 shows that the level $5^3D_3$, at an exciting-electron velocity of 7.9 eV, is not populated by cascade transitions.

Such a process of depletion of the level $5^3D_3$, so far as we know, is observed experimentally for the first time. It should be noted that these observations make it possible, under the given excitation conditions, to estimate quantitatively the role of cascade transitions in the population of the level under study, since at an exciting-electron velocity of 8.7 eV the concentration of excited cadmium atoms at the level $4^3F_4^0$ is $6.7 \pm 0.3$ times smaller than the concentration at the level $5^3D_3$.

**Fig. 1.** Dependence of the logarithm of the number of coincidences $\log N_{\text{coinc}}$ on the delay time $\tau_3$ for the level $5^3D_3$, line 3610 Å (transition $5^3P_2$—$5^3D_3$). Exciting-electron velocity: 1 –8.7 eV, 2 –7.9 eV.

In the method described, measurements at threshold velocities of the exciting electrons in some cases encounter considerable difficulties. This is connected with the following circumstances:

1. If near the excitation threshold the intensity of the measured lines is small,

then the signal-to-noise ratio is small.

2. If the upper long-lived level is energetically separated from the level under study by an amount smaller than the spread in the velocities of the exciting electrons, then selective excitation of the level under study is impossible. According to our measurements, the lifetimes of the levels $4^3F_4^0$ and $5^3D_3$ are, respectively, $(11.5 \pm 0.4) \cdot 10^{-8}$ and $(1.6 \pm 0.1) \cdot 10^{-8}$ sec.

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Received
10 I 1965

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*Note: Figure translations are in progress. See original paper for figures.*