V. G. Zinov, A. D. Konin, and A. I. Mukhin. *X-ray spectra of negative muons in chemical compounds*. It is known from experiments on x-ray emission in cascade transitions of electrons in atoms that the effect of chemical binding on the intensities of different lines of the same or different series of a given element is negligible.[1] The energies of muon levels in an atom are 200 times higher than those of electron levels having the same quantum numbers. Muon orbits with principal quantum numbers below 14 lie below the electron shell. This makes it plausible to suppose that the effect of chemical binding on cascade transitions of negative muons in atoms with the emission of hard x rays would be even more negligible.

The mere recording of the characteristic radiation of negative muons is a fairly ordinary occurrence. In studying the capture of muons by atoms in chemical compounds, however, we establish some rather complex and unexpected regularities.[2]

The principal result of that work was the discovery that the probability for an atom to capture a muon depends strongly on the chemical composition of the specimen. In those experiments we measured the absolute intensity of the x radiation per stopped muon. Careful comparison of the characteristics of the spectra of pure elements and their chemical compounds forced us to doubt that the structure of the spectra remains un-

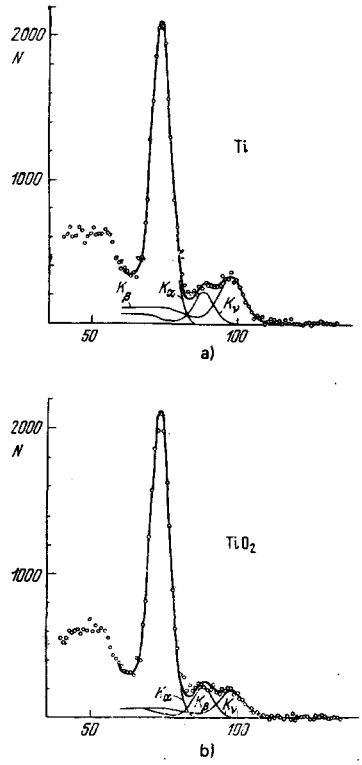

FIG. 1. K-series x-ray spectra of titanium accompanying atomic capture of negative muons in the pure metal (a) and in its oxide (b).

changed.

In 1965 we had finished the first experiments that were specially designed to investigate the structure of the K-series mesic x-ray spectra following atomic capture of negative muons in chromium, vanadium, and their oxides.[3] In these experiments we established the previously unknown fact that the relative intensities of the K-series lines of the pure elements change substantially (by a factor of 1.4) when the element forms a chemical bond with another element.

The earlier results[4] were fully confirmed by new measurements made in 1966 under better conditions with different apparatus, in which more statistical data were accumulated (see Fig. 1).

The phenomenon established by these experiments can be qualitatively understood in terms of the theory of large mesic molecules developed by Ponomarev.[5] According to this theory a definite fraction of the muons stopped in matter are first captured in one of the stationary levels common to the entire molecule. There are many possible causes that can affect the subsequent fate of the muon. Radiative transitions will play the most important part. Since the probability for a radiative transition is proportional to the cube of the transition energy and the orbital angular momentum selection rule is not in effect because the molecular system does not have central symmetry, there should be intense emission of high-energy x rays from crossover transitions direct to the ground state of the mesic atom. When an element enters into a chemical bond the weight of the common molecular level changes. This changes the pattern of the cascade muon transitions and therefore changes the relative intensities of the different emission lines of a given series.

Considerably later, studies were undertaken in various laboratories throughout the world that provided direct confirmation of the validity of the phenomena that we had previously established.[6-9] Moreover, measurements with pions[8,9] revealed the great generality of the phenomenon.

In these studies the priority of our work was recognized. At present, a deeper study of this phenomenon constitutes a significant part of the scientific program of all new accelerators of the "meson factory" type.[10]

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