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Electronic Features of High-Head Trailers

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ABSTRACT: This study investigated and analyzed the electro physical properties of high-temperature superconductor's market-condensates using the Mossbauer spectroscopy method. In addition, the spectra of various high-temperature superconductors have been studied, and their scientific relevance and difference have been studied.

KEYWORDS: superconductivity, Bose condensate, crystal, isomer, Mossbauer, spectrum, pressure, probe nuclei, Doppler, electron, vacuum, spectroscopy, metal oxide, emission, honey, mother isotope, peronos, localized, momentum, probe, spin, radioactive, oxygen, temperature, source, ceramics, mother atom, lanthanum, doping, gradient, charge, correlations, nuclei, quadruple.

I. INTRODUCTION

The phenomenon of superconductivity is associated with the appearance of Cooper pairs and the formation of their Bose condensate [1]. Therefore, the distribution of electron density at the nodes of the crystal lattice of the superconductor should differ at temperatures above and below the temperature of the transition to the superconducting state Tc.

The isomeric shift of I.S. The Mössbauer spectra are determined by the electronic fabric on the nuclei under study, and it is obviously possible to detect Cooper pairs and their Bose condensate by measuring the temperature dependence of the center of gravity S of the Mössbauer spectra of superconductors. The temperature dependence of S at constant pressure P is determined [2].

II. RELATED WORKS

$(^{\delta}S/^{\delta}T)_P = (^{\delta}\, I.S./^{\delta}\ln V)_T\, (^{\delta}\ln V/^{\delta}T)_P + (^{\delta}D/^{\delta}T)_P + (^{\delta}\, I.S./^{\delta}T)_V$. (1)

The first term in (1) represents the dependence of the isomic shift on the volume V; the second one describes the effect of the second-order Doppler shift D and in the Debye approximation has the form [2].

$(^{\delta}D/^{\delta}T)_P = -(3E_0/2Mc^2)F(T/0)$ (2)

where k is the Boltzmann constant; E0 energy of the isomeric transition; M-mass of the probe core; c is the speed of light in vacuum; 0-Debye temperature; F (T / 0) Debye function.

The third term in (1) is responsible for the temperature dependence of the isomeric shift — the appearance of this term is caused by a change in the electron density on Mossbauer nuclei, and this effect is expected upon the transition of the matrix to the superconducting state.

The detection of Cooper pairs by Mossbauer spectroscopy should be most favorable for the case of high-temperature superconductors if a probe is used for which *2G >> 10.* The choice of objects for research should also take into account the need to introduce a Mossbauer probe into the lattice nodes. These conditions are fulfilled for the case of the ^{67}Zn Mossbauer probe in copper metal oxide lattices using the emission version of Mossbauer spectroscopy on the ^{67}Cu (^{67}Zn) isotope: for ^{67}Zn / 2G ~ 200 and the parent isotope ^{67}Cu can be introduced into the copper nodes during the synthesis, so the daughter isotope ^{67}Zn is also appears in the copper node of the lattice [2].

III. METHODS

If we use the emission version of spectroscopy on the ^{67}Ga (^{67}Zn) isotope, then for the case of copper metal oxides containing rare-earth metals (REMs), the parent isotope ^{67}Ga appears at the sites of rare-earth metals [4] and it becomes possible to study the spatial in homogeneity of the electron density created by the Bose condensate of Cooper pairs.

Finally, we note that the ^{67}Zn Mossbauer probe is a two-electron center with negative correlation energy [5] - its charge state can only change by carrying two electrons simultaneously, and the electron pair localized at the center has zero total moment, orbital moment and spin. On the other hand, according to the BCS model, at T <Tc, electrons with opposite momenta are paired, so that the total momentum, orbital momentum and spin of the Cooper pair are also equal to zero. It is the combination of these factors that should be conducive to observing the Bose condensation effect using the ^{67}Zn probe.

In this article, the research results are presented for the ^{67}Zn probe in the $Nd_{1.85}Ce_{0.15}CuO_4$, $La_{1.85}Sr_{0.15}CuO_4$, and $Tl_2Ba_2CaCu_2O_8$ lattices. As the control object, for which no transition to the superconducting state is observed, copper oxide Cu_2O was chosen.

Mossbauer sources of $Nd_{1.85}Ce_{0.15}\,^{67}CuO_4$, $La_{1.85}Sr_{0.15}\,^{67}CuO_4$, $Tl_2Ba_2Ca\,^{67}Cu_2O_8$ and $^{67}Cu_2O$ were prepared by diffusion of radioactive ^{67}Cu into $Nd_{1.85}Ce_{0.15}CuO^4$ (T = 22K), $La_{1.85}Su_2C_2C_2C_2Co_{2.15}CuO_2$ (T = 22K), $La_{1.85}Su_2C_2C_2C_2Co_2Cu_2C_2Co_2C_2O_2Cu_{0.15}$ (T = 60K) and Cu_2O in evacuated quartz ampoules at 450^0 C for 2 hours in an oxygen stream. For $La_{1.85}Sr_{0.15}CuO_4$, diffusion of radioactive ^{67}Ga was also carried out. No changes in Tc were observed for control samples.

Mossbauer spectra were recorded with a ^{67}ZnS absorber. The absorber temperature for all spectra was 10 (2) K, while the temperature of the source could vary in the range from 10 (1) to 80 (1) K.

IV. ALGORTHMS USED

The Mossbauer spectra of all ceramics were quadruple triplets, the isomeric shift of which corresponds to $^{67}Zn^{2+}$ ions. Typical spectra for $La_{1.85}Sr_{0.15}CuO_4$ ceramics

For the ^{67}Cu (^{67}Zn) spectra, it was assumed that the parent atoms of ^{67}Cu occupy copper sites during diffusion doping (data [6–8] support this) and, therefore, the $^{67}Zn^{2+}$ probe formed after ^{67}Cu decay is located at copper sites. For the $La_{1.85}Sr_{0.15}CuO_4$: ^{67}Ga spectra, it was assumed that, as a result of diffusion doping, the parent ^{67}Ga atoms occupy the lanthanum sites and, therefore, the $^{67}Zn^{2+}$ probe formed after the decay of ^{67}Ga is also located at the lanthanum sites.

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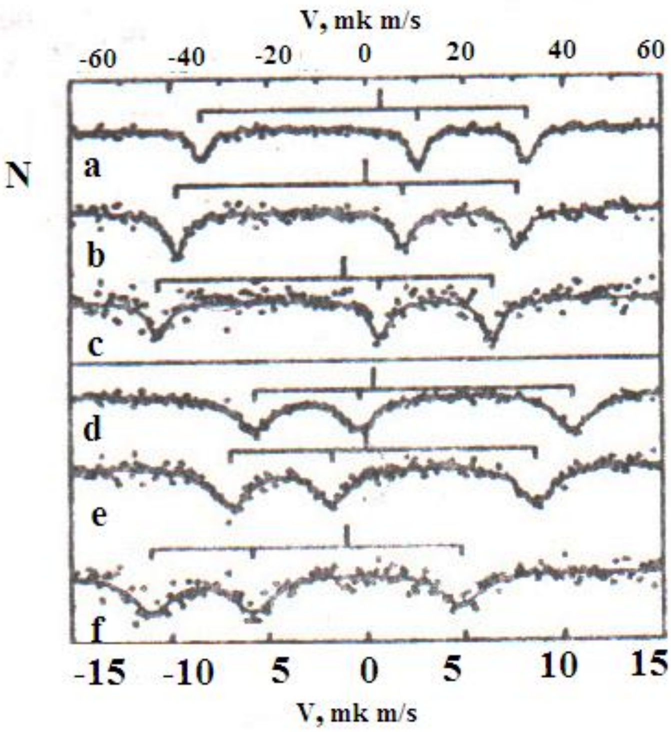

Fig. 1. Mossbauer spectra $La_{1.85}Sr_{0.15}{}^{67}CuO_4$(*a,b,c*) and $La_{1.85}Sr_{0.15}CuO_4$:^{67}Ga(*d, e, f*) at different source temperatures [absorber temperature 10(1)K]: 10(*a*), 37(*b*), 70(*c*), 11(*d*), 37(*e*), и 75(*f*); N- counting rate in relative units.

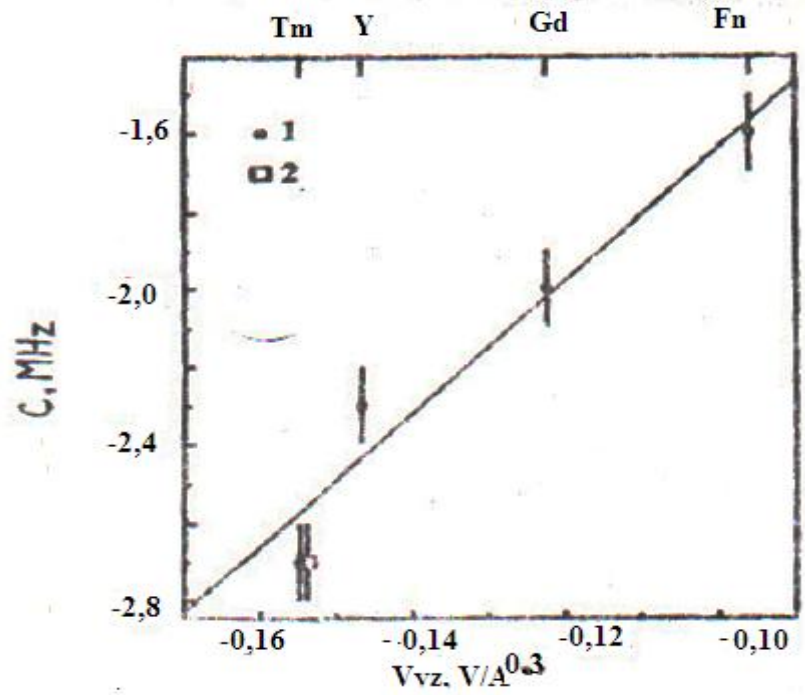

Fig. 2. The dependence of the constant quadruple interaction C for rare-earth metal sites [experimental data were obtained by ^{67}Ga (^{67}Zn) Mossbauer emission spectroscopy] on the principal component of the crystal-field tensor of the

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electric field gradient *Vzz* at the same sites [calculation results in the approximation of point charges] for $R_2Ba_2Cu_3O7$ (R = Y, Eu, Gd, Tm) [Points 1] [8]. Point 2 represents our data for the lanthanum sites of the $La_{1.85}Sr_{0.15}{}^{67}CuO^4$ lattice.

This assumption is supported by the fact that Mossbauer emission spectroscopy on ^{67}Ga (^{67}Zn) isotope for compounds $R_2Ba_2Cu_3O_7$: ^{67}Ga (see Fig. 2), the point for $La_{1.85}Sr_{0.15}CuO^4$: ^{67}Ga lies on the straight line, made under the assumption that the mother atoms $_{67}Ga$ (and, therefore, $_{67}Zn^{2+}$ daughter probes) occupy the sites of the rare-earth metal R (here the C-constant of the quadruple interaction for the $^{67}Zn^{2+}$ probe is determined from the experimental spectra, and *Vzz* is the principal component of the tensor of the crystal gradient of the electric field calculated from put on point charges).

The temperature dependences of the center of gravity of the spectrum S, measured relative to its value at Tc, differ significantly for the control and superconducting materials (as an example, Fig. 3 shows such dependences for $La_{1.85}Sr_{0.15}CuO^4$ and CuO^2), although when passing through Tc for all compounds sharp no jumps in S are observed.

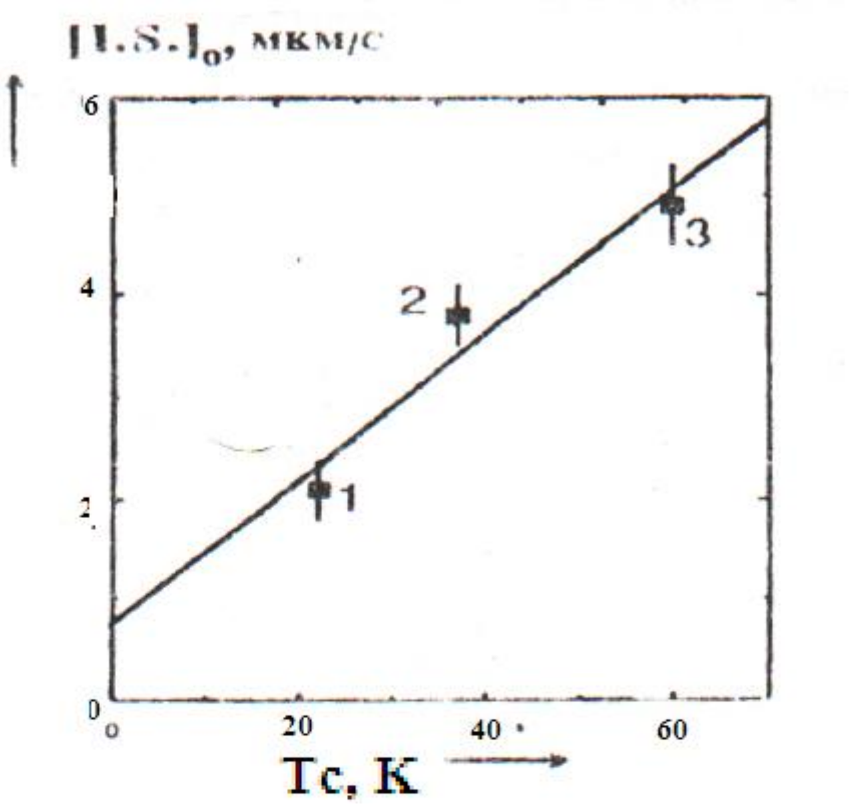

Fig. 3, Temperature dependences of the center of gravity S of the Mossbauer spectrum of ^{67}Zn, measured relative to its value at 37 K, for $La_{1.85}Sr_{0.15}{}^{67}CuO^4$ (1); $La_{1.85}Sr_{0.15}CuO_4$: ^{67}Ga (2) and $^{67}Cu_3O$ (3). The theoretical temperature dependence of S is given for the case of the second-order Doppler shift at 0 = 400 K.

The second term in (1) describes the effect of the second-order Doppler shift. As can be seen from fig. 3, the experimental data for the control sample of Cu_2O in the selected temperature range are satisfactorily described by the dependence (2) carried out for 0 = 400 K For superconducting samples, the experimental data at T> Tc are also described by the dependence (2) carried out for O = 360 K ($Nd_{1.85}Ce_{0.15}CuO_4$), 400K ($La_{1.85}Sr_{0.15}CuO_4$) and 260K ($Tl_2Ba_2CaCu_2O_8$) (According to the measurements of the specific heat, the Debye temperatures for $Nd_{1.85}Ce_{0.15}CuO^4$, $La_{1.85}Sr_{0.15}CuO_4$, and $Tl_2Ba_2CaCu_2O_8$ are respectively 300 K [9], 420 K [10], and 270 K [11]).

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V. RESULTS

Finally, the third term in expression (1) describes the temperature dependence of the I. S. isomer shift and the appearance of this term is caused by measuring the electron density on ^{67}Zn nuclei. The value of I. S. at a given temperature T can be found as the difference [I. S.] t = ST-DT is the ST- and DT center of gravity of the spectrum and the Doppler shift at temperature T, respectively). The increase [I. S.] t with decreasing temperature in the region T <TC indicates an increase in the electron density on ^{67}Zn nuclei due to the cooper pair coexistence and their bosecondensation. Limit values are. [I. S.] $_o$ = S_o-D_o must depend on the size of the Cooper pairs, i.e. from the value of Tc. The validity of this conclusion is illustrated in Fig. 4, where the dependence is given [I. S.] o from TS: with an increase in TS (i.e., with a decrease in the radius of the Cooper correlation), the value [I. S.] $_o$ increases, which reflects the fact of an increase in the electron density on ^{67}Zn nuclei.

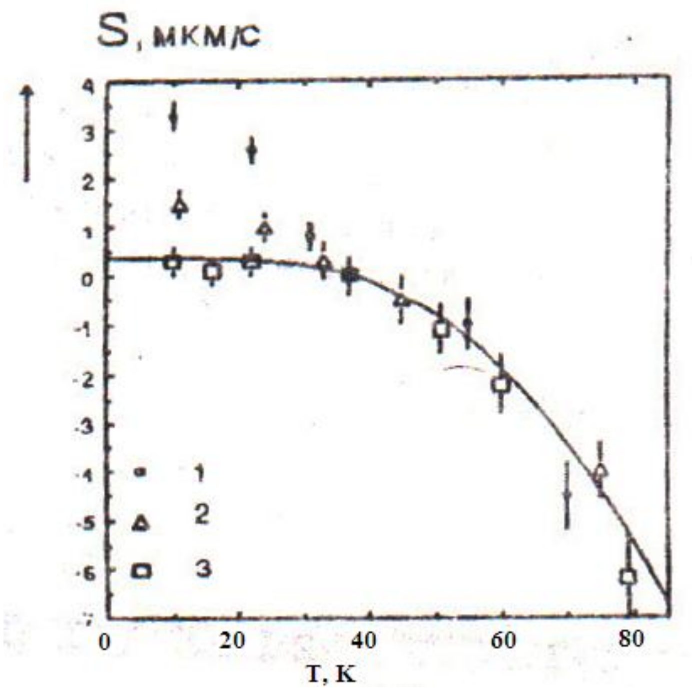

Fig. 4. Dependence [I. S.] o from TC. Dots represent compounds $Nd_{1.85}Ce_{0.15}CuO_4$ *(1)*, $La_{1.85}Sr_{0.15}{}^{67}CuO_4$*(2)* and $Tl_2Ba_2Ca^{67}Cu_2O_8$ *(3)*.

Note that the value of $[I.\ S.]_o$ = 1.5 (3) µm / s for $^{67}Zn^{2+}$ centers at lanthanum sites is substantially less than the value of $[I.\ S.]_o$ = 3.8 *(3)* µm / s for $^{67}Zn^{2+}$ centers at copper sites (see Fig. 3). Obviously, this is a consequence of the spatial in homogeneity of the electron density created by the Bose condensate of Cooper pairs.

VI. CONCLUSION

Thus, it was found that for $Nd_{1.85}Ce_{0.15}CuO_4$, $La_{1.85}Sr_{0.15}CuO_4$, and $Tl_2Ba_2CaCu_2O_8$ superconductors in the region T> Tc, the temperature dependence of S is determined by the second-order Doppler shift, while in the region T <Tc, the appearance of Cooper steam and their Bose condensation. Lowering the temperature increases the influence of the indicated process on the value of S, since the fraction of the Bose condensate increases with decreasing temperature.

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