The appearance of the para-exciton line in the Cu_2O luminescence spectrum cannot be due to a lowering of the degree of forbidenness by the deformation [1]. It is likewise impossible to attribute the lifting of the forbidenness to the nonmonotonic pressure dependence of the para-exciton line intensity.

It must be emphasized once more that the appearance of the para-exciton line in the luminescence spectrum has a resonant character. As noted earlier, the para-exciton line appears only when the distance between the short-wave component of the ortho-exciton and the para-exciton level becomes equal to the energy of the Γ_{12}^- phonon (ω = 110 cm^{-1}), i.e., when the short-wave component of the phonon mode of the ortho-exciton happens at the para-exciton level. We have established that the para-exciton phonon-mode intensity is independent of the pressure, and therefore the appearance of the Γ_2^+ line in the emission spectrum can likewise not be attributed to an increase of the para-exciton concentration.

We believe that the appearance of the para-exciton line in the specturm of deformed Cu_2O is due to resonant scattering of the ortho-exciton by the para-exciton level with excitation of a phonon, followed by a radiative transition to the ground state.

In conclusion, the authors are deeply grateful to Professor S.A. Moskalenko and M.I. Shmiglyuk for a discussion of problems in the theory of ortho- and para-excitons in Cu_2O crystals.

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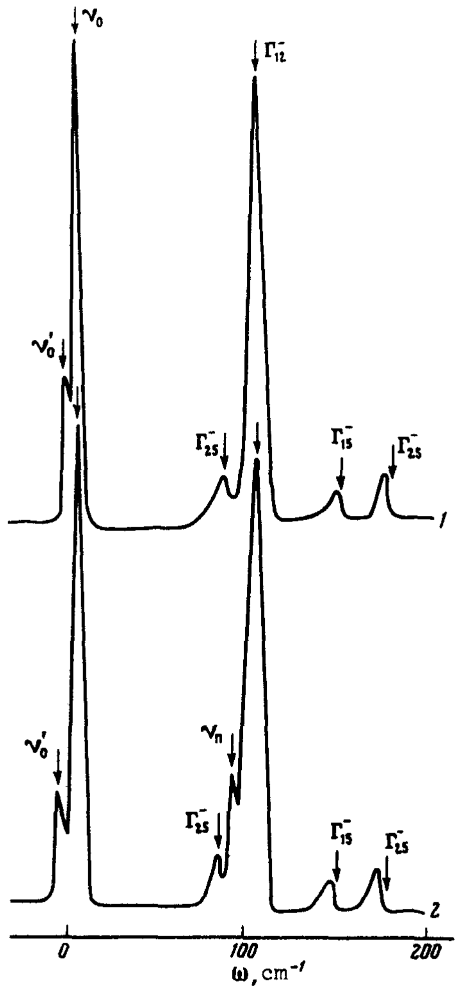

Microphotographs of the luminescence spectra of single-crystal Cu_2O at pressures P ≈ 7 kg/mm^2 (1) and ≈ 10 kg/mm^2 (2); the ortho-exciton lines are marked ν_0 and ν_0', and the para-exciton line ν_p. The phonon frequency ω is reckoned from the unshifted position of the ortho-exciton level. T = 1.8°K, P || C_4.

THE NEW ISOTOPE Tl^{189}

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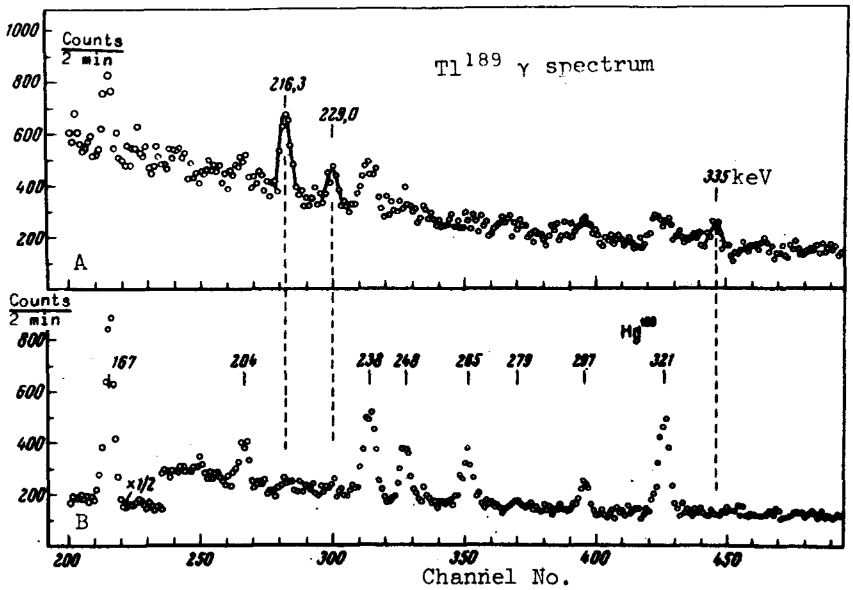
The purpose of the present study was a search for the new isotope Tl^{189}. The level scheme of the daughter isotope is unknown.



Typical parts of spectra of Tl^{189} (A) and Hg^{189} (B) sources. The numbers over the peaks are the energies.

A nuclear-spectroscopy investigation of Tl^{189} was made possible by the use of the YaSNAPP experimental setup at JINR, with allowance for the yield of Tl^{189} in Pb + p reactions [1], as well as the existence of a procedure for rapidly separating thallium from a PbF_2 target.

Experimental Procedure

To obtain the neutron-deficient thallium isotopes, a PbF_2 target (~300 g) was bombarded with 660-MeV protons from the extracted beam ($I \sim 5 \times 10^{11}$ protons/sec) of the JINR synchrocyclotron.

The thallium was separated from the target by a gas thermochromatographic method in the "on-line" regime [2].

After the end of the bombardment, the thallium fraction was separated with a mass separator [3]. The separated isotope was extracted from the receiving chamber by a rapid transport system [4].

The γ spectrum was measured with a Ge(Li) detector having a volume 38 cm^3 and a resolution 3.5 keV at 600 keV.

Pulse height analyzers of the AI-4096 type were connected to the computers (Minsk-2 or Minsk-22) used for the reduction of the γ spectra.

In one experiment, the cycle of preparing the source and measuring its γ spectra was repeated several times, owing to the low activity of a single source. The measurement regime was maintained constant in this case. The bombardment time ranged from 5 to 12 minutes, and the separation time was ~1.5 min. The measurement of the source γ spectrum was started ~7 min after the end of the bombardment.

To estimate the mercury impurity in the thallium sources, we measured separately the γ spectrum of an Hg^{189} source obtained under the same conditions as the Tl^{189}.

Results

Three different experiments yielded respectively three series of Tl^{189} γ spectra in the energy interval 50 - 700 keV. The first series was obtained from one source, and the second and third from sums over seven sources. A typical part of one summary spectrum is shown in Fig. A. Figure B shows the same part of the γ spectrum of Hg^{189}, obtained from a single source.

In the investigated Tl^{189} spectra, we determined the energies (E_γ) and the relative intensities (I_γ) of the obtained peaks, and from the variation of their intensities (4 - 7 measured points) we determined the half-lives. These data were compared with the published data on the decay of Hg^{189} and Au^{189} [5], as well as with our own measurements of Hg^{189} decay. We also took into account the contamination due to tails of neighboring-mass isotope peaks.

This analysis left three lines with hitherto unknown characteristics, viz., E_γ = 216.3 ± 0.7, 229.0 ± 1.5 and 335 keV.

Discussion

The lines with new characteristic data were identified on the basis of the following analysis:

E_γ = 216.3 ± 0.7 keV. This line appeared in all three experiments, with values of E_γ and $T_{1/2}$ which coincided within the limits of the measurement errors.

There is an Hg^{189} line having a close value of E_γ, but its assignment to this isotope gives rise to contradictions in the half-life values and in the ratios of the relative intensities (I_γ) to other Hg^{189} lines (see A and B in the figure). The values of I_γ for the Hg^{189} lines are known [5] and were confirmed, in the main, by our measurements, thus making it possible to take the contribution of Hg^{189} into account in the data reduction and to determine the half-life of the remaining component, namely $T_{1/2}$ = 1.5 min.

The 215.7-keV transition of Tl^{191} [6] coincides within the limits of errors with the observed line. This isotope can contaminate our sources, in principle, but its half-life is much larger (5.2 min), and its other strong lines appeared only in the form of traces. The possible interfering contribution of Tl^{191} was therefore taken into account only when determining the errors in the half-life values.

E_γ = 229.0 ± 1.5 keV. This line had sufficient intensity only for reduction in the summary spectra.

After subtracting the contribution of the two nearby Hg^{189} lines (228.9 and 231.0 keV [5]) from the intensity of the peak observed in the spectra, on the basis of the known values of I_γ and the measured intensity of the 238.2-keV Hg^{189} line, a component with half-life $T_{1/2}$ = 1.2 min was left in both cases. There is no known transition with such characteristics in the decay of the neighboring isotopes.

E_γ = 335 keV. This line appeared only in the summary spectra, and its intensity made it possible to determine its half-life only roughly, $T_{1/2} \sim 1.5$ min. There is no known transition having this energy in the decay of the isotopes of the isobar chain with mass A = 189. If this line is assigned to the decay of Tl^{191}, which has a 336.5-keV transition [6], a contradiction is encountered for reasons similar to those discussed above in connection with the assignment of the 216.3-keV line to Tl^{189} decay, although the reliability of such an assignment is decreased by the large error in the determination of the lifetime.

The summary results of the study of the three new lines are given in the table.

Results obtained for the new isotope Tl^{191}

E_{γ}, keV	I_{γ}	$T_{1/2}$, min	
216.3 ± 0.7	100	1.5 ± 0.5	
229.0 ± 1.5	~40	1.2 ± 0.6	1.4 ± 0.4
335	~70	~1.5	

The agreement in the half-lives of the analyzed lines indicates, in all probability, that they belong to the decay of one and the same isotope having a state with a half-life $T_{1/2}$ = 1.4 ± 0.4 min. In view of the procedure used to obtain this isotope, it is identified as Tl^{189}.

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MECHANISM OF PLASMA HEATING BY AN ELECTRON BEAM IN A MIRROR TRAP

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It is universally conceded at present that plasma heating under beam-instability conditions is the result of the interaction of particles with electromagnetic oscillations excited by a beam of electrons in the plasma.

In spite of the similarity of the experimental results obtained in different investigations, there is still no meeting of the minds concerning the plasma heating mechanism and the origin of the hot particles [1 - 2]. The reason for the various opinions concerning the heating mechanism is that the