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Inna REBANE

ON THE THEORY OF TIME DEPENDENCE OF RESONANT SECONDARY EMISSION SPECTRA OF IMPURITY CENTRES

The aim of the present paper is the calculation of time dependent spectra of resonance secondary emission (RSE) for two models of the crystal impurity centre. Calculations are based on the general formula of the secondary emission theory.

1. Initial formulas and the model

In [1] there was found the general formula describing the probability that by the time t a photon of frequency Ω will be emitted:

$$W(\Omega, t) = 2\,\mathrm{Re} \int_{-\infty}^{t} dt' \iiint_{0}^{\infty} d\mu\, d\tau\, d\tau'\, e^{i\Omega\mu} S(t'-\mu-\tau',\, t'-\tau) A(\mu, \tau, \tau'), \qquad (1)$$

where $S(t_1, t_2) = \langle s^*(t_1) s(t_2)\rangle_R$ is the double-time correlation function of the exciting electromagnetic field; $\langle \ldots \rangle_R$ means the average over the ensemble of emitters; the operator $s(t)$ gives the time dependence of perturbation of the impurity centre by the exciting light. $A(\mu, \tau, \tau')$ is the basic correlation function of the secondary emission of impurity centre. It is the very correlation function which determines the stationary spectrum of RSE at steady monochromatic excitation of frequency ω_0 [2]:

$$W(\Omega, \omega_0) = 2\,\mathrm{Re} \iiint_{0}^{\infty} d\mu\, d\tau\, d\tau'\, e^{i\Omega\mu}\, e^{-i\omega_0(\mu+\tau'-\tau)} A(\mu, \tau, \tau'). \qquad (2)$$

In [2] the correlation function $A(\mu, \tau, \tau')$ was found, supposing that the adiabatic approximation and the Condon approximation were valid, and also that the ground and excited electronic states were nondegenerate. It has the following form:

$$A(\mu, \tau, \tau') = \frac{B}{2\pi} \langle e^{i\tau' H_2} e^{i\mu H_1} e^{-i\tau H_2} e^{-i(\mu+\tau'-\tau)H_1} \rangle_1\, e^{-\Omega_{21}(\tau-\tau') - \frac{\gamma}{2}(\tau+\tau')}, \qquad (3)$$

where H_1, H_2 are the vibrational hamiltonians of the ground and excited electronic states, γ is the damping constant of the excited electronic state, Ω_{21} is the frequency of the pure electronic transition, $\langle \ldots \rangle_1 = \mathrm{Sp}(e^{-H_1/kT} \ldots)/\mathrm{Sp}(e^{-H_1/kT})$ means quantum statistical average over the initial vibrational states. In [2] the explicit form of the correlation function $A(\mu, \tau, \tau')$ for the impurity centre model was obtained, for which the secondary emission time spectra are calculated below.

Model 1. There exists one exponentially damping local (or pseudo-

local) vibration for which both the equilibrium position and frequency are changed in electronic transition. At the same time the condition

$$\Gamma \ll |\omega_2 - \omega_1| \ll \omega_1, \omega_2 \tag{4}$$

is fulfilled, where ω_1 and ω_2 are the vibrational frequencies in the ground and excited electronic states, and Γ is the damping constant of vibration. Temperature is so low that only the lowest vibrational level of the initial electronic state is populated in thermal equilibrium ($kT \ll \omega_1$; $\hbar = 1$).

Model 2. This model differs from model (1) by the circumstance that the local vibration frequency is not changed in electronic transition:

$$\omega_1 = \omega_2 \equiv \omega, \qquad \Gamma \ll \omega. \tag{5}$$

The corresponding correlation function $A(\mu, \tau, \tau')$ was obtained in [3].

While calculating the transient spectrum, the correlation function of the exciting field $S(t_1, t_2)$ is taken in the exponential form:

$$S(t_1, t_2) = S_0 \exp\left[i\omega_0(t_1 - t_2) - \Delta|t_1| - \Delta|t_2|\right]. \tag{6}$$

2. The general formula of secondary emission

After inserting formulas (3) and (6) in the general secondary emission formula (1) and after integration, an explicit expression for the probability $W(\Omega, t)$ was found for the two models described above.

Let us present the results for model (1) introducing the following denotations. Let M be the number of the vibrational level into which the centre is excited, L_2 — the number of the initial vibrational level in the excited electronic state, L_1 — the number of the final vibrational level of the electron-vibrational transition, and let us give the denotations:

$$\Delta\Omega_{L_2L_1} = \Omega - \Omega_{21} + \omega_1 L_1 - \omega_2 L_2, \tag{7}$$
$$x = \Omega_{21} - \omega_0 + \omega_2 M.$$

$\Delta\Omega_{L_2L_1}$ is the frequency shift of the emitted photon Ω from the maximum of the line $L_2 \to L_1$, and x — the shift of the maximum of the exciting pulse ω_0 from the maximum frequency of the M-th absorption line. It is supposed that $\Delta, x \ll \omega_2$, where Δ is the width of the exciting packet of light.

The probability of the RSE can be presented in the form of a sum whose members correspond to the lines in accordance with the fixed transitions

$$W(\Omega, t) = \sum_{L_1=0}^{\infty} \sum_{L_2=0}^{M} W^{L_2L_1}(\Omega, t), \tag{8}$$

where (at $t \geqslant 0$)

$$W^{L_2L_1}(\Omega, t) = \frac{BS_0}{2\pi} |\langle 0|M\rangle|^2 \cdot |\langle L_2|L_1\rangle|^2 \cdot \binom{M}{L_2} \times$$
$$\times \sum_{k=0}^{M-L_2} \binom{M-L_2}{k} (-1)^{M-L_2+k} \left[\frac{1}{2\Delta} C_{7,k}^{L_2L_1}(\Omega) + \right. \tag{9}$$
$$\left. + \sum_{i=1}^{6} \frac{C_{i,k}^{L_2L_1}(\Omega)}{\alpha_{i,k}^{L_2L_1}(\Omega)} \left(1 - \exp\left(\alpha_{i,k}^{L_2L_1}(\Omega) \cdot t\right)\right) + c.c.\right].$$

Here $|\langle 0|M\rangle|^2 = e^{-\xi^2}\cdot\frac{\xi^{2M}}{M!}$ is the Franck-Condon factor for the absorption; $|\langle L_2|L_1\rangle|^2 = e^{-\xi^2}\sum\limits_{n=0}^{L_1}\sum\limits_{l=0}^{L_1-n}\sum\limits_{l'=0}^{L_1-n-l}(-1)^{l+l'}\frac{\xi^{(L_2+L_1-2n-l-l')}}{l!\,l'!\,n!\,(L_1-n-l-l')!}\times$ $\times\frac{L_2!}{(L_2-n-l)!\,(L_2-n-l')!}$ is the Franck-Condon factor for the emission $L_2\to L_1$ (ξ^2 — dimensionless Stokes losses).

The spectrum $W^{L_2L_1}(\Omega, t)$ consists of the components whose time behaviour is determined by the damping constants $\alpha_{i,k}^{L_2L_1}(\Omega)$ and their spectral dependence by $C_{i,k}^{L_2L_1}(\Omega)$.

$$\alpha_{1,k}^{L_2L_1}(\Omega) = i\Delta\Omega_{L_2L_1} - \Gamma(L_1+L_2) - \frac{\gamma}{2}, \qquad \alpha_{4,k}^{L_2L_1}(\Omega) = ix - \Gamma M - \Delta - \frac{\gamma}{2},$$

$$\alpha_{2,k}^{L_2L_1}(\Omega) = i(\Delta\Omega_{L_2L_1}+x) - \Gamma L_1 - \Delta, \qquad \alpha_{5,k}^{L_2L_1}(\Omega) = (\alpha_{4,k}^{L_2L_1}(\Omega))^*, \tag{10}$$

$$\alpha_{3,k}^{L_2L_1}(\Omega) = -2\Gamma(M-k) - \gamma, \qquad \alpha_{6,k}^{L_2L_1}(\Omega) = -2\Delta.$$

$C_{i,k}^{L_2L_1}(\Omega)$ — are different for the cases $L_2 < M$ and $L_2 = M$.

$$C_{1,k}^{L_2L_1}(\Omega) = \frac{A_{3,k}(x)}{i\Delta\Omega_{L_2L_1} - \Gamma(L_1+L_2) - 2\Delta - \gamma/2} - C_{3,k}^{L_2L_1}(\Omega) - C_{4,k}^{L_2L_1}(\Omega) -$$
$$- C_{5,k}^{L_2L_1}(\Omega) - C_{6,k}^{L_2L_1}(\Omega), \qquad C_{2,k}^{L_2L_1}(\Omega) = 0, \tag{11}$$

$$C_{3,k}^{L_2L_1}(\Omega) = \frac{A_{6,k}(x)}{i\Delta\Omega_{L_2L_1} + \Gamma(2(M-k) - L_1 - L_2) + \gamma/2},$$

$$C_{4,k}^{L_2L_1}(\Omega) = \frac{A_{4,k}^*(x)}{i(\Delta\Omega_{L_2L_1} - x) - \Gamma(L_1+L_2-M) + \Delta},$$

$$C_{5,k}^{L_2L_1}(\Omega) = \frac{A_{4,k}(x)}{i(\Delta\Omega_{L_2L_1} + x) - \Gamma(L_1+L_2-M) + \Delta},$$

$$C_{6,k}^{L_2L_1}(\Omega) = \frac{A_{2,k}(x)}{i\Delta\Omega_{L_2L_1} - \Gamma(L_1+L_2) - \gamma/2 + 2\Delta},$$

$$C_{7,k}^{L_2L_1}(\Omega) = \frac{-A_{3,k}(x)}{i\Delta\Omega_{L_2L_1} - \Gamma(L_1+L_2) - \gamma/2 - 2\Delta},$$

$$C_{1,0}^{ML_1}(\Omega) = \frac{A_{1,0}(x)}{i(\Delta\Omega_{ML_1} + x) - \Gamma L_1 - \Delta} - C_{3,0}^{ML_1}(\Omega) - C_{5,0}^{ML_1}(\Omega), \tag{12}$$

$$C_{2,0}^{ML_1}(\Omega) = \frac{A_{5,0}(x)}{i(\Delta\Omega_{ML_1} + x) - \Gamma L_1 - \Delta} - C_{4,0}^{ML_1}(\Omega) - C_{6,0}^{ML_1}(\Omega),$$

$$C_{3,0}^{ML_1}(\Omega) \equiv \left[C_{3,k}^{L_2L_1}(\Omega)\right]_{\substack{k=0\\ L_2=M}}, \quad C_{4,0}^{ML_1}(\Omega) = \frac{A_{4,0}^*(x)}{i\Delta\Omega_{ML_1} + \Gamma(M-L_1) + \gamma/2},$$

$$C_{5,0}^{ML_1}(\Omega) \equiv \left[C_{5,k}^{L_2L_1}(\Omega)\right]_{\substack{L_2=M\\ k=0}},$$

$$C_{6,0}^{ML_1}(\Omega) = \frac{A_{2,0}(x)}{i(\Delta\Omega_{ML_1} + x) - \Gamma L_1 + \Delta},$$

$$C_{7,0}^{ML_1}(\Omega)=\frac{-A_{3,0}(x)}{i(\Delta\Omega_{ML_1}+x)-\Gamma L_1-\Delta}.$$

The factors $A_{i,k}(x)$ depend only on the absorption conditions:

$$\begin{aligned}
A_{1,k}(x)&=\frac{2\Delta}{(ix-\Gamma M-\gamma/2-\Delta)\cdot[(ix+\Gamma M+\gamma/2)^2-\Delta^2]},\\
A_{2,k}(x)&=\frac{2(\Gamma M+\gamma/2-\Delta)}{(2\Gamma(M-k)+\gamma-2\Delta)(x^2+(\Gamma M+\gamma/2-\Delta)^2)},\\
A_{3,k}(x)&=\frac{2(\Gamma M+\gamma/2+\Delta)}{(2\Gamma(M-k)+\gamma+2\Delta)(x^2+(\Gamma M+\gamma/2+\Delta)^2)},\\
A_{4,k}(x)&=\frac{2\Delta}{(ix-\Gamma(M-2k)-\gamma/2+\Delta)((ix+\Gamma M+\gamma/2)^2-\Delta^2)},\\
A_{5,k}(x)&=\frac{1}{(ix-\Gamma M-\gamma/2-\Delta)(-ix-\Gamma M-\gamma/2+\Delta)},\\
A_{6,k}(x)&=A_{3,k}(x)-A_{2,k}(x)-A_{4,k}(x)-A_{4,k}^*(x).
\end{aligned}\tag{13}$$

3. Discussion

Let us examine the probability $W^{L_2L_1}(\Omega,t)$ at $t=\infty$, which describes the whole secondary emission of the $L_2\to L_1$ lines. The results are essentially different for the lines to which the transitions from the excitation level $L_2=M$ correspond, and for the lines to which the transitions from lower levels $L_2<M$ correspond.

$$W^{L_2L_1}(\Omega)=\frac{BS_0}{2\pi}|\langle 0|M\rangle|^2\cdot|\langle L_2|L_1\rangle|^2\binom{M}{L_2}\times \tag{14}$$

$$\times\sum_{k=0}^{M-L_2}(-1)^{M-L_2+k}\binom{M-L_2}{k}\Big[\frac{1}{i\Delta\Omega_{L_2L_1}-\Gamma(L_1+L_2)-\gamma/2}\Big(-\frac{A_{6,k}(x)}{2\Gamma(M-k)+\gamma}-$$

$$-\frac{A_{4,k}(x)}{ix+\Gamma M+\gamma/2+\Delta}-\frac{A_{4,k}^*(x)}{-ix+\Gamma M+\gamma/2+\Delta}-\frac{A_{2,k}(x)+A_{3,k}(x)}{2\Delta}\Big)+c.c.\Big],$$

$$W^{ML_1}(\Omega)=\frac{BS_0}{2\pi}|\langle 0|M\rangle|^2|\langle M|L_1\rangle|^2\times \tag{15}$$

$$\times\Big[\frac{1}{i\Delta\Omega_{ML_1}-\Gamma(L_1+M)-\gamma/2}\Big(\frac{A_{1,0}(x)}{ix+\Gamma M+\gamma/2-\Delta}-\frac{A_{4,0}(x)}{ix+\Gamma M+\gamma/2+\Delta}-$$

$$-\frac{A_{6,0}(x)}{2\Gamma M+\gamma}\Big)+\frac{1}{i(\Delta\Omega_{ML_1}+x)-\Gamma L_1-\Delta}\Big(-\frac{A_{1,0}(x)}{ix+\Gamma M+\gamma/2-\Delta}-$$

$$-\frac{A_{2,0}(x)+A_{3,0}(x)}{2\Delta}-\frac{A_{4,0}^*(x)}{-ix+\Gamma M+\gamma/2+\Delta}+\frac{A_{5,0}(x)}{i(\Delta\Omega_{ML_1}+x)-\Gamma L_1-\Delta}\Big)+$$

$$+c.c.\Big].$$

In case $L_2 < M$ the spectrum has a maximum at $\Delta\Omega_{L_2L_1}=0$ and the width $\Gamma(L_1+L_2)+\gamma/2$, i. e., here we have the hot luminescence (HL) at $L_2>0$

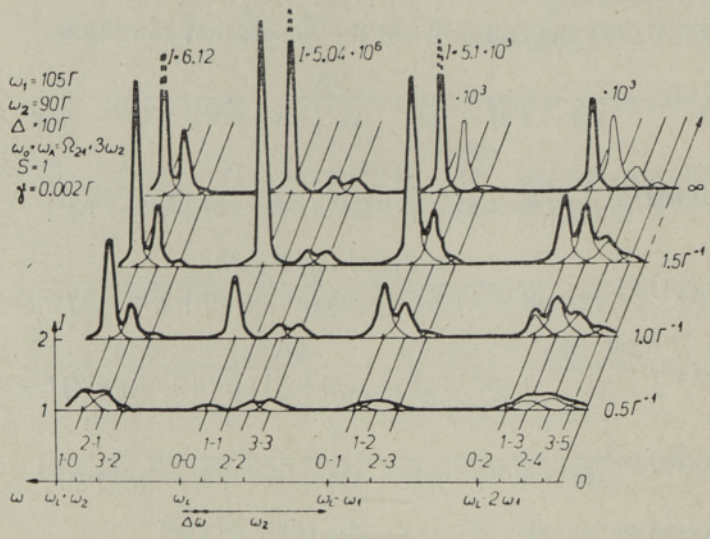

Fig. 1. Time dependence of the probability $W(\Omega, t)$. Model (1).

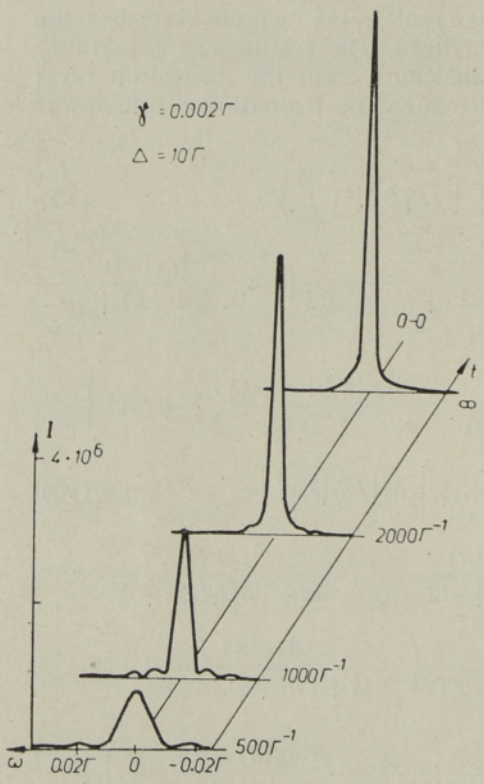

Fig. 2. Time dependence of the 0—0-lines. Note the quantum beats. Model (1).

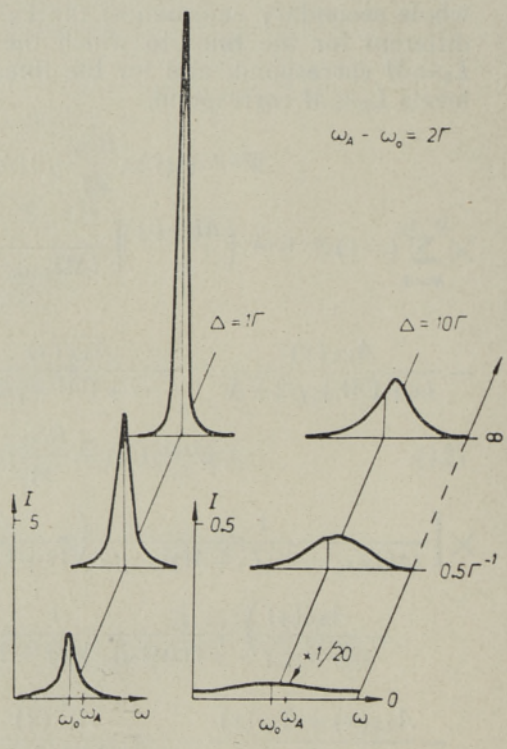

Fig. 3. Time dependence of the Rayleigh line at various exciting packet widths. Model (1).

and ordinary luminescence (OL) at $L_2=0$. In case $L_2=M$ the spectrum consists of two parts: one with the maximum at the frequency $\Delta\Omega_{ML_1}=0$ and width $\Gamma(L_1+M)+\gamma/2$, and the other one with the maximum at the frequency $\Delta\Omega_{ML_1}+x=0$ and width $\Gamma L_1+\Delta$. The first member discribes HL and the second one — resonant Raman scattering (RRS), where L_1 corresponds to the order of scattering. We can see that the widths of all lines correspond to the Weisskopf-Wigner theory [4]. The absence of RRS at $L_2<M$ shows that already in the first relaxational transition $M\to M-1$ the phase correlation between the exciting and emitted electromagnetic fields gets lost.

In the limit case of the steady excitation with monochromatic light of frequency ω_0

$$W(\Omega,\omega_0)=\lim_{\Delta\to 0}\frac{d}{dt}W(\Omega,t)$$

formulas (14) and (15) are transformed into those obtained earlier in [3].

Fig. 1 gives the time dependence of the most intensive lines in the RSE for the case $M=3$, $x=0$. The values of the parameters are given in the figure caption 1.

During the initial time interval comparable with the vibrational relaxation time $t\lesssim\Gamma^{-1}$ the intensities of all the lines are of the same order of magnitude. During the time $t>\Gamma^{-1}$ the intensities of hot lines ($L_2>0$) do not rise any more, since the vibrational relaxation is completed. But the intensities of OL lines ($L_2=0$) continue to grow during the whole optical lifetime $t\sim\gamma^{-1}$, and by the end of the emission process the intensity of OL lines exceeds that of HL lines by $\sim\Gamma/\gamma$ times.

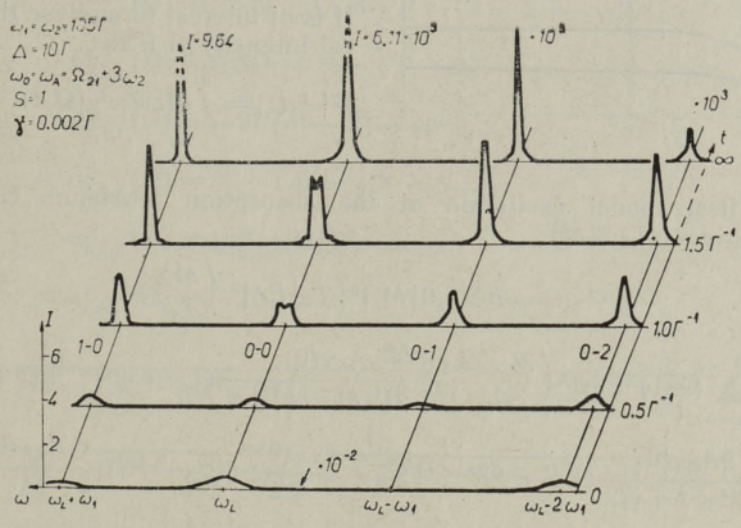

Fig. 4. Time dependence of the probability $W(\Omega,t)$ Model (2).

As a part of the damping constants $\alpha_{i,k}^{L_2L_1}(x)$ is complex, the time spectra may reveal quantum beats [5]. They may be especially pronounced for the pure electronic line (Fig. 2).

In Fig. 1 it is impossible to tell RRS lines by spectral characteristics

from the $L_2=M$ HL lines because $x=0$. However, as is shown in Fig. 3, on the example of the Rayleigh line, in the case of a sufficiently wide exciting packet ($\Delta=10\Gamma$), the intensity of RRS is small in comparison with HL. On the other hand, under spectrally narrow excitation $\Delta=1\Gamma$ (Fig. 3) RRS is much more intense than HL.

For the second model ($\omega_1=\omega_2$) the general formulas are analogous

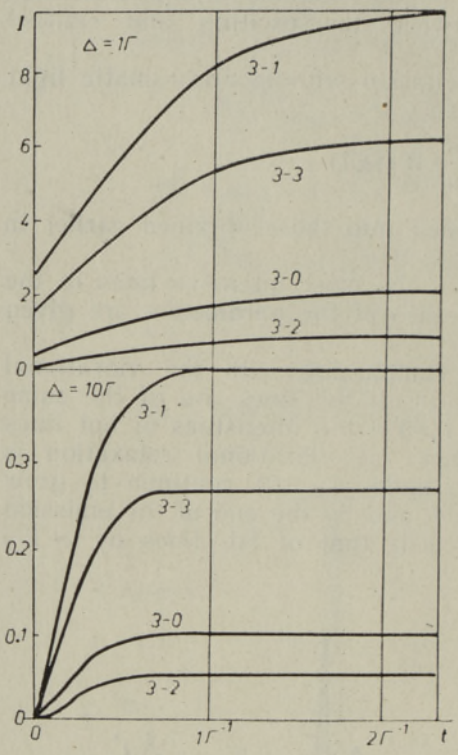

Fig. 5. Time dependence of the integral intensity of the lines 3—0, 3—1, 3—2 and 3—3 for two widths of the exciting packet. Model (1).

(see Appendix). In Fig. 4 the time dependences of RSE for $M=3$, $x=0$ and $\xi^2=1$ are presented. In this case all the lines with a given difference L_2-L_1 cannot be distinguished and, consequently, all the lines contain HL and RRS in an unseparable manner and it is impossible and meaningless to separate these components of RSE. This model displays strong interference effects.

4. Integral intensity

It is of interest to analyse the integral intensity of RSE:

$$W^{L_2L_1}(t)=\int_0^\infty d\Omega W^{L_2L_1}(\Omega,t). \qquad (16)$$

In the first model excitation at the absorption maximum frequency ($x=0$) gives ($L_2\leqslant M$):

$$W^{L_2L_1}(t)=BS_0|\langle 0|M\rangle|^2|\langle L_2|L_1\rangle|^2\binom{M}{L_2}\times$$

$$\times\sum_{k=0}^{M-L_2}(-1)^{M-L_2+k}\binom{M-L_2}{k}\Big[\frac{A_{6,k}(0)}{2\Gamma(M-k)+\gamma}(1-e^{-(2\Gamma(M-k)+\gamma)t})+$$

$$+\frac{2A_{4,k}(0)}{\Gamma M+\Delta+\gamma/2}(1-e^{-(\Gamma M+\Delta+\gamma/2)t})+\frac{A_{2,k}(0)}{2\Delta}(1-e^{-2\Delta t})+\frac{A_{3,k}(0)}{2\Delta}\Big]. \qquad (17)$$

We can see that there exist components gaining intensity at essentially different rates. However, only at $L_2=0$ there is a component whose intensity grows with the rate determined by the damping constant of the excited electronic state γ, i. e., the component corresponding to the ordinary luminescence.

The ratio of the integral intensities of the lines emitted from a given level L_2 is determined by the ratio of the Franck-Condon factors:

$$\frac{W^{L_2L_1^A}(t)}{W^{L_2L_1^B}(t)}=\frac{|\langle L_2|L_1^A\rangle|^2}{|\langle L_2|L_1^B\rangle|^2}. \tag{18}$$

That is a very reasonable result, which can serve as an additional confirmation of the correctness of the theory.

Fig. 5 shows the time dependence of the intensity of the lines with $M=L_2=3$ and $L_1=0,1,2,3$ for two width values of the exciting packet: $\Delta=1\Gamma$ and $\Delta=10\Gamma$.

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APPENDIX

Here $P=L_1-L_2+M$ and $\Delta\Omega_P=\Omega-\Omega_{21}+\omega(L_1-L_2)$.

$$W^P(\Omega,t)=\frac{BS_0}{2\pi}\sum_{k=0}^{P}\sum_{l=0}^{P-k}F_{k,l}^P\Big[\frac{1}{2\Delta}C_{7,k,l}^P(\Omega)+$$

$$+\sum_{i=1}^{6}\frac{C_{i,k,l}^P(\Omega)}{\alpha_{i,k,l}^P(\Omega)}(1-\exp(\alpha_{i,k,l}^P(\Omega)t))+c.c.\Big],$$

$$F_{k,l}^P=\sum_{l'=0}^{P-k-l}(-1)^{l+l'}\frac{e^{-2\xi^2}\cdot\xi^{2(P+2M-2k-l-l')}}{k!l!l'!(M-k-l)!(M-k-l')!(P-k-l-l')!},$$

$$\alpha_{1,k,l}^P(\Omega)=i\Delta\Omega_P-\Gamma(M+P-2k-2l)-\gamma/2,$$

$$\alpha_{2,k,l}^P(\Omega)=i(\Delta\Omega_P+x)-\Gamma P-\Delta,$$

$$\alpha_{3,k,l}^P(\Omega)=-2\Gamma(M-k)-\gamma,$$

$$\alpha_{4,k,l}^P(\Omega)=ix-\Gamma M-\gamma/2-\Delta,$$

$$\alpha_{5,k,l}^P(\Omega)=(\alpha_{4,k,l}^P(\Omega))^*,$$

$$\alpha_{6,k,l}^P(\Omega)=-2\Delta;$$

$$A_{1,k,l}(x)=\frac{2\Delta}{(ix-\Gamma M-\gamma/2-\Delta)((-ix-\Gamma(M-2k-2l)-\gamma/2)^2-\Delta^2)},$$

$$A_{2,k,l}(x)=\frac{1}{(ix-\Gamma M-\gamma/2+\Delta)(-ix-\Gamma(M-2k-2l)-\gamma/2+\Delta)},$$

$$A_{3,k,l}(x)=\frac{1}{(ix-\Gamma M-\gamma/2-\Delta)(-ix-\Gamma(M-2k-2l)-\gamma/2-\Delta)},$$

$$A_{4,k,l}(x)=\frac{2\Delta}{(-ix-\Gamma(M-2k-2l)-\gamma/2+\Delta)((ix-\Gamma M-\gamma/2)^2-\Delta^2)},$$

$$A_{5,k,l}(x)=\frac{1}{(ix-\Gamma M-\gamma/2-\Delta)(-ix-\Gamma(M-2k-2l)-\gamma/2+\Delta)},$$

$$A_{6,k,l}(x)=\frac{2\Delta}{(ix-\Gamma(M-2k)-\gamma/2+\Delta)\,((-ix-\Gamma M-\gamma/2)^2-\Delta^2)},$$

$$A_{7,k,l}(x)=\frac{-2(\Gamma M+\gamma/2-\Delta)}{(-2\Gamma(M-k)-\gamma+2\Delta)\,(x^2+(\Gamma M+\gamma/2-\Delta)^2)},$$

$$A_{8,k,l}(x)=\frac{-2(\Gamma M+\gamma/2+\Delta)}{(-2\Gamma(M-k)-\gamma-2\Delta)\,(x^2+(\Gamma M+\gamma/2+\Delta)^2)},$$

$$A_{9,k,l}(x)=A_{8,k,l}(x)-A_{6,k,l}(x)-A^*_{6,k,l}(x)-A_{7,k,l}(x);$$

$$C^P_{1,k,l}(\Omega)=\frac{A_{1,k,l}(x)}{i(\Delta\Omega_P+x)-\Gamma P-\Delta}+\frac{-A_{3,k,l}(x)+A_{8,k,l}(x)}{i\Delta\Omega_P-\Gamma(P+M-2k-2l)-\gamma/2-2\Delta}+$$

$$+\frac{A_{4,k,l}(x)}{i(\Delta\Omega_P-x)-\Gamma(P-2k-2l)+\Delta}-C^P_{3,k,l}(\Omega)+C^P_{5,k,l}(\Omega),$$

$$C^P_{2,k,l}(\Omega)=-\frac{A_{2,k,l}(x)}{i(\Delta\Omega_P+x)-\Gamma P+\Delta}-\frac{A_{4,k,l}(x)}{i\Delta\Omega_P-\Gamma(P-M)+\gamma/2}+$$

$$+\frac{A_{5,k,l}(x)}{i(\Delta\Omega_P+x)-\Gamma P-\Delta},$$

$$C^P_{3,k,l}(\Omega)=\frac{A_{9,k,l}(x)}{i\Delta\Omega_P-\Gamma(P-M-2l)+\gamma/2},$$

$$C^P_{4,k,l}(\Omega)=\frac{A_{4,k,l}(x)}{i\Delta\Omega_P-\Gamma(P-M)+\gamma/2}-\frac{A_{4,k,l}(x)}{i(\Delta\Omega_P-x)-\Gamma(P-2k-2l)+\Delta}+$$

$$+\frac{A^*_{6,k,l}(x)}{i(\Delta\Omega_P-x)-\Gamma(P-2k-2l)+\Delta},$$

$$C^P_{5,k,l}(\Omega)=\frac{A_{6,k,l}(x)}{i(\Delta\Omega_P+x)-\Gamma(P-2k-2l)+\Delta},$$

$$C^P_{6,k,l}(\Omega)=\frac{A_{2,k,l}(x)}{i(\Delta\Omega_P+x)-\Gamma P+\Delta}+\frac{-A_{2,k,l}(x)+A_{7,k,l}(x)}{i\Delta\Omega_P-\Gamma(P+M-2k-2l)-\gamma/2+2\Delta},$$

$$C^P_{7,k,l}(\Omega)=\frac{A_{3,k,l}(x)-A_{8,k,l}(x)}{i\Delta\Omega_P-\Gamma(P+M-2k-2l)-\gamma/2-2\Delta}-\frac{A_{3,k,l}(x)}{i(\Delta\Omega_P+x)-\Gamma P-\Delta}.$$

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Academy of Sciences of the Estonian SSR,
Institute of Physics

Received
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Inna REBANE

LISANDITSENTRITE RESONANTS-SEKUNDAARKIIRGUSE AJAST SÕLTUVATE SPEKTRITE TEOORIAST

On leitud kristalli lisanditsentri kahe mudeli ajast sõltuvad resonants-sekundaarkiirguse (RSK) spektrid ning näidatud spektrijoonte kuju ja integraalse intensiivsuse muutumist sõltuvalt ergastava impulsi pikkusest. Spektreid on analüüsitud RSK klassifikatsiooni seisukohast. Saadud tulemused kinnitavad ja illustreerivad sekundaarkiirguse teooria üldisi järeldusi [1].

Инна РЕБАНЕ

К ТЕОРИИ ВРЕМЕННОЙ ЗАВИСИМОСТИ СПЕКТРОВ РЕЗОНАНСНОГО ВТОРИЧНОГО СВЕЧЕНИЯ ПРИМЕСНЫХ СПЕКТРОВ

Вычислены временные зависимости спектров резонансного вторичного свечения (РВС) для двух моделей примесного центра кристалла. Показано, как изменяются во времени форма и интегральная интенсивность линии в зависимости от длительности возбуждающего импульса. Спектры проанализированы с точки зрения классификации РВС. Полученные результаты подтверждают и иллюстрируют общие заключения теории вторичного свечения [1].