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INVESTIGATION OF POWER INFRARED RADIATION FROM THE LASER FREQUENCY

In this paper, we have studied the dependence of Raman scattering radiation from the laser intensity and the concentration of atoms. Power stimulated Raman scattering radiation is explored in two modes: with a strong depopulation of the resonant level and as the undeleted. In the first case, the dependence of stimulated Raman scattering on the laser intensity is linear, and the concentration of atoms is quadratic, while in the second case it is exponential.

Keywords: infrared radiation, stepwise settlement, laser energy, laser pulse, laser intensity, transmission of laser energy, kinetic energy.

Ключевые слова: инфракрасное излучение, пошаговое урегулирование, лазерная энергия, лазерный пульс, лазерная интенсивность, передача лазерной энергии, кинетическая энергия.

In [1], [2] there has been researched internally infrared radiation in a stepwise optico — collisinal (OC) settling baseline. Within the stepwise settlement level 2 and then level 3 are firstly settled (Figure 1). Optico — collisional — absorption (emission) of the light quantum in the collision of atoms, can s how the transition of an atom from one level to another.

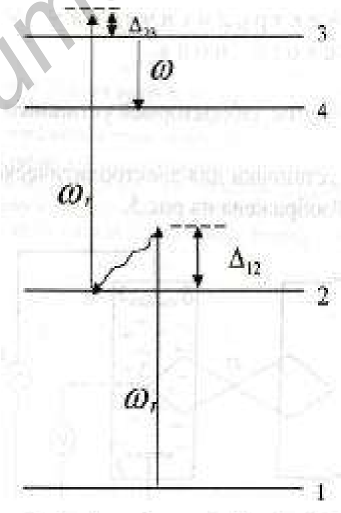

Figure 1 – Excitation scheme of stimulated IR radiation

In this paper, the theoretical calculations have been made and concern the power infrared radiation depending on the intensity and duration of the laser pulse and the concentration of atoms. Excited by infrared radiation at a ω frequency of one laser there was carried out with the settlement of the initial level of stepwise, where ω_L — angular frequency of laser light, Δ_{12}, Δ_{23} — the laser frequency detuning from atomic level 1—2 and 2—3 respectively. The values of detuning frequency the $\Delta_{12} >> \Delta_{23}$. The concentration of atoms at level 1 is approximately equal to the concentration of atoms suitable under this temperature. In their assessment, we assume that the lower level of the IR transitions 4 is effectively depleted by the stimulated emission of cascade to downstream levels of the atom (not shown), and we neglect the population of this level. A tiny difference between the populations is enough for the development of stimulated IR radiation. The wavy line in the figure shows the transmission of laser energy into kinetic energy of the atom. The dependence of infrared radiation from time to time in a stepwise OS occupancy is defined [1]

$$W(t) = W^{lim}(t)(1 - \frac{1 - e^{-w_{23}t}}{w_{23}t}). \qquad (1)$$

Where W^{lim} — limiting energy (energy at $t \to \infty$), w_{12} — the probability of electron transition from level 2—3. $W^{lim} = \hbar\omega\sigma l N_1 w_{12} t$ .The probability of electron transition from 1—2 is determined with $w_{12}=mI_LN_1$, where $m = const$, s -cross-sectional area of the beam of infrared radiation l- the length of active medium, ω- frequency of infrared radiation, N_1 — the concentration of atoms at level 1 $N_1=N$,

$$W^{lim} = \hbar\omega\sigma l m I_L N^2 t \qquad (2)$$

W versus detuning is determined by the dependence on the form $w_{23} \sim 1/\Delta_{23}^2$, put

$$w_{23} = \xi I_L \frac{1}{\Delta_{23}^2}, \ \xi = const \qquad (3)$$

From (1) considering (2,3) we obtain

$$W = \mathbf{h}\omega\sigma lmN^2 I_L t\left(1 - \frac{1-\exp(-\xi I_L Nt/\Delta_{23}^2)}{\xi I_L Nt/\Delta_{23}^2}\right) \quad (4)$$

Power IR radiation

$$P = \mathbf{h}\omega\sigma lmN^2 I_L\left(1 - \frac{1-\exp(-\xi I_L Nt/\Delta_{23}^2)}{\xi I_L Nt/\Delta_{23}^2}\right) \quad (5)$$

The results of theoretical calculations. To calculate the power of infrared radiation, the parameters will take close to the experimental data [2], the frequency of infrared radiation = 4,75 $^*10^{14}$ Hz, laser pulse duration τ_L = 15 ns, σ = 0,0314 sm^2, l=20 sm, the constant value m = 0,2$^*10^{16}$ sm^5/ Dzh, ζ = 28$^*10^{-14}$ sm^3/Dzh.

1. The dependence of the relative power of infrared radiation from the laser intensity.The dependence of the relative power of infrared radiation on the laser intensity has been studiet under various frequency detuning the laser radiation Δ_{23} and the concentration of atoms are calculated by formula (5). Figure 2 shows the dependence of the relative power of the infrared radiation of company commander on the intensity of the laser at proving 2, 5, 10 and 20 sm^{-1} and the concentrations of 5$^*10^{15}$, 10* 10^{15} sm^{-3}. When deviations of 1 sm^{-} and 5 sm^{-1} dependence P of company commander on the intensity at the given concentration of atoms is linear, and - 10 and 20 sm^{-1} square. This is due to the fact that the probability of transition of 2—3 w_{23} at small detuning is very large and does not depend on laser intensity.

Power infrared radiation is determined only by the transition probability of the atom 1—2, w_{12} we know the probability of an atom depends on the intensity linearly. With increasing detuning w_{23} decreases in the atoms concentration and also begins to depend on the intensity, which explains the quadratic dependence. With increasing concentration of atoms, this dependence remains (linear and quadratic), but shifts in the direction of increasing detuning. Due an increase in the concentrations of the increasing population of level 2, the probability of transition w_{23} increase will increase.

2. The dependence of the relative power of infrared radiation on the concentration of atoms. Figure 3 shows the relative power of infrared radiation over the concentration of atoms at different detunings and laser intensity. As can be seen at small detunings (1, 3) the relative power of infrared radiation depending on the concentration becomes quadratic, and at large ones.

It is cubic — (2, 4). As a central part of the mismatch power infrared radiation is determined only by the speed of the transition running 1—2 (binary

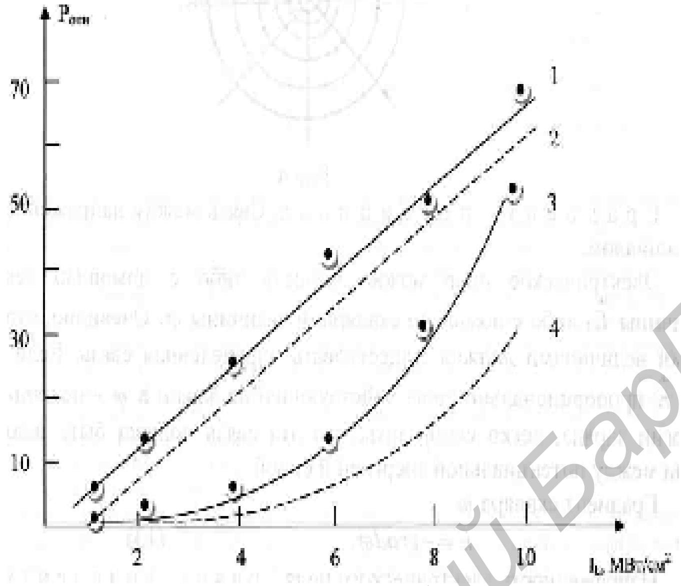

Figure 2 – The dependence of the relative power of infrared radiation on the laser intensity at detunings: Δ_{23} = 2 sm^{-1} (1), 5 sm^{-1} (2), 10 sm^{-1} (3) 20 sm^{-1} (4). Concentration of atoms $N = 5 \cdot 10^{15}$ sm^{-3} for 1,3 and $N = 10 \cdot 10^{15}$ sm^{-3} for 2,4.

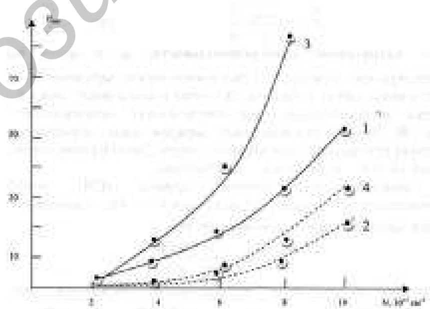

Figure 3 – The dependence of the relative power of infrared radiation from the atomic concentration at detuning: Δ_{23} = 2 sm^{-1} (1), 5 sm^{-1} (3), 10 sm^{-1} (2), 20 sm^{-1} (4). Laser intensity I_L = 2 MW/sm^2 for 1,2 and I_L = 5 MW/sm^2 to 3,4.

collisions of atoms — a quadratic dependence), at the same time for large deviations (greater than the shock region) is still on the operating speed of transition 2—3. The Cubic dependence indicates that excited atoms at level 2 faced mainly with unexcited atoms at 1 N_1. Theredore, the concentration of atoms is much greater than at level 2. However, we note that the collision cross section of excited atoms is not more than excited. Under experimental conditions in [2] N_2/N_1 ratio is about 1:100. With increasing laser intensity dependence of the relative power of the infrared radiation on the concentration shifts to larger mismatch. Along with the increasing intensity the population of level 2 increases, which would increase the probability of transition w_{23}.

3. The dependence of the relative power of infrared radiation over the duration of the laser pulse.

The dependence of the relative power of infrared radiation **over** the duration of the laser radiation obtained from different detuning and laser intensity. Atom concentration remained constant $N = 5*10^{15}$ sm^{-3}. With increasing pulse duration the relative power of infrared radiation increases linearly from the top and then saturates. With increasing detuning, this dependence shifts to the increase of the pulse duration. As it can be seen from the figure for large deviations (20 sm^{-1}) dependence of the infrared radiation from the laser radiation of this field is linear. To explain, we rewrite the equation (1) and (2) for the power of the radiation

$$P(t) = P^{lim}(t)\left(1 - \frac{1 - e^{-w_{23}t}}{w_{23}t}\right).$$

In the vicinity of the resonance transition 2—3 (with small deviations), the transition probability w_{23} is very large and $w_{23}t >> 1$ neglect the second term in brackets, this radiated power is independent of pulse duration. For large detunings $w_{23}t << 1$ and $P(t) = P^{lim}(t) w_{23} t / 2$ dependence is linear.

Conclusions. Thus, from the theoretical results, we can draw the following conclusions:

1) With the increase in the intensity of laser radiation power of infrared radiation depending on the detuning increases differently. For small detuning of the laser radiation from the atomic transition 1—2 dependence is linear, and at large it is square. With increasing the concentration of atoms leads to the tuning curve shifted upward mismatch.

2) At constant intensity the dependence of the infrared radiation from the concentration at small detunings is quadratic, and for the large ones it is cubic.

3) Power versus the pulse duration has a rich character. Also it depends on proving the frequency of laser radiation from atomic transition 2—3. In the central part it is saturated for a short period of time, at increasing frequency shifts to the pulse duration. Mostly detuning depends on the duration of the laser pulse linearly.

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