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O. V. Alifanov (Moscow, MISiS). **Thermal conductivity reduction in metal by ununiform excitation of electronic subsystem.**

Ultra short laser pulse create in crystal locally ununiform two-temperature media which consists of excited electrons with temperature T_{el} and lattice vibrations with temperature T. Investigation of such systems attract unflagging interest both in the case of bulk specimens [1] and for nanosized structures [2–5].

In this report we examine the possible mechanism for this effect, which is based on the calculation of heat capacity for the model system of boson- and fermion- type elementary excitations. The energy of the system represented in the form:

$$U = \hbar\omega\Big[\exp\Big(\frac{\hbar\omega}{kT}\Big) - 1\Big]^{-1} + \varepsilon\Big[\exp\Big(\frac{\varepsilon}{kT_{\text{el}}}\Big) + 1\Big]^{-1}. \tag{1}$$

Here ω is phonon frequency, ε — electronic elementary excitation energy, k, $\hbar$ — Boltzman and Plank constants respectively. By introducing the notations:

$$a = \frac{\varepsilon}{\hbar\omega}, \quad n = \frac{T_{\text{el}}}{T}, \quad x = \frac{\hbar\omega}{kT}, \tag{2}$$

the energy (1) takes the form:

$$U = kT\Big[\frac{x}{\exp(x) - 1} + \frac{ax}{\exp(ax/n) + 1}\Big]. \tag{3}$$

In this expression the factor kT represents the system energy U at high temperatures ($x = 0$), a characterizes relational value of electronic and vibrational energy.

Taking into account expressions (1)–(3) and assuming that $n = \text{const}$ we find for heat capacity C (after differentiation with respect to lattice temperature T):

$$\frac{C}{k} = \Big(\frac{\hbar\omega}{kT}\Big)^2\Big\{\exp\Big(\frac{\hbar\omega}{kT}\Big)\Big[\exp\Big(\frac{\hbar\omega}{kT}\Big) - 1\Big]^{-2} + \frac{a^2}{n}\exp\Big(\frac{a\hbar\omega}{kTn}\Big)\Big[\exp\Big(\frac{a\hbar\omega}{kTn}\Big) + 1\Big]^{-2}\Big\}. \tag{4}$$

The results of numerical calculations according the formula (4) are represented at the figure. The plots demonstrate strong dependence of heat capacity on excitation degree n of crystal electronic subsystem. It may be expected, therefore, the same behavior for thermal conductivity, because the latter is proportional to heat capacity C. For example, as it can be seen from the picture (left-edge curve) heat capacity reduction between maximal and minimal values is more than one order of magnitude (difference 13 times). Besides it can be marked that for some parameters values there are the curves with minima of different depths. Such behavior of thermal conductivity takes place in the case of metal excitation by short laser pulse [1].

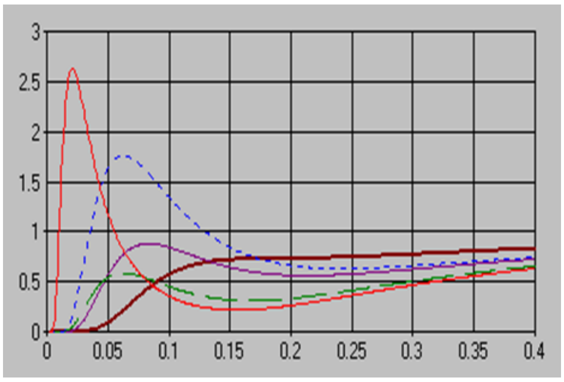

Fig. Heat capacity C (in k units) versus relational temperature T/T_0 $(T_0 = \hbar/k)$ at various values n and $a:$ $n = 6$, $a = 0.3$ — left edge curve; $n = 4$, $a = 0.6$ — upper pointed line; $n = 2$, $a = 0.4$ — middle splash curve; $n = 1.33$, $a = 0.2$ — lower dashed line; $n = 1.5$, $a = 0.5$ — lower splash curve

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