Glass-Like Heat Conduction in Materials With Disclination-Induced Topological Disorder

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The recent progress in a study of various topologically disordered materials shows clearly an importance of rotational defects: disclinations, disclination dipoles, and disclination loops. Surprisingly, the phonon scattering due to strain fields caused by biaxial wedge disclination dipoles (BWDDs) turned out to be rather unusual (the mean free path $l_D \sim q^{-1}$ at small q while $l_D \to const$ with q increasing) giving rise to a T^2 like behavior of the thermal conductivity at low temperatures. As is well-known, this behavior is typical for dielectric glasses and some disordered crystals. To reproduce all the important features of the thermal conductivity in glassy materials over a rather wide temperature range (including the characteristic plateau region), we consider a combination of two scattering processes: the first one comes from the sound waves scattering due to BWDDs while the second one is the Rayleigh type scattering which appears due to the local variations in structure. This approach introduces a new dimensional parameter, dipole separation $2L$, which can be used to characterize the microstructure of glasses, with BWDDs as important elements of disordered states. The model predictions are found to be in good agreement with some known experimental results in various amorphous dielectrics. In all cases, the best agreement is achieved for the density of defects $N = 2 \times 10^{15}\mathrm{m}^{-2}$ and $2L = 2\mathrm{nm}$ [1] .

At the same time, to study the dynamics of pinned disclination segments we suggest the concept of vibrating string and calculate the disclination-induced contribution to the specific heat of a crystal, C_v, which is found to depend linearly on the temperature and the disclination density. In particular, for $N = 2 \times 10^{15}\mathrm{m}^{-2}$ (and the parameter set for SiO_2) we obtain [2] $C_v/T = 4.7 \times 10^{-6}\mathrm{J/K^2mol}$ in good agreement with the experimental data on amorphous SiO_2. Some aspects of the disclination-induced contribution to the internal friction are briefly discussed as well.

[1] S.E. Krasavin and V.A. Osipov, J.Phys.: Cond.Mat. **13** 1023 (2001).

[2] V.A. Osipov and D.V. Churochkin, Phys.Lett. A (2001) in press.