Heat transport study of $Dy_2Ti_2O_7$ single crystals in a [110] magnetic field

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$Dy_2Ti_2O_7$ is considered to be a model of spin ice materials which display a variety of fascinating magnetic behaviors due to the geometrical frustration. Magnetic Dy^{3+} ions on the vertexes of each tetrahedra process a strong Ising anisotropy along the local $< 111 >$ axis, and form the "2-in 2-out" ground state with sixfold degeneration at low temperature. Magnetic field can easily break the macroscopic degeneracy and the spin system will show up various types of magnetic order depending on the field directions. We report a particular study of the low temperature heat transport of a $Dy_2Ti_2O_7$ single crystals in the magnetic field applied along [110] crystallographic direction up to 14 T, in which case the spins along and perpendicular to the field will form long-range ferromagnetic α-chains and short-range antiferromagnetic β-chains, respectively (Q=X state) or a simplex long-range ferromagnetic order state (Q=0 state). The $\kappa(T)$ curves show a small and broad phonon peak extraordinarily. It is because of the serious scattering of phonons by the spin fluctuation. Also, the thermal conductivities exhibit obvious field dependencies. The over all behavior of $\kappa(H)$ is that the magnetic field strongly suppresses thermal conductivity, but with some drastic decreasing at some critical fields which are corresponded to the field induced magnetic order transitions from the spin ice state to Q=X and Q=0 states.