Huge magnetothermal conductivity in a spin liquid material $Tb_2Ti_2O_7$

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Low-temperature magnetic states of the pyrochlore compound $Tb_2Ti_2O_7$ with geometrical frustration have attracted much interest because of a variety of exotic behaviors at low temperature, such as the Tb^{3+} moments remaining in a collective paramagnetic or spin-liquid state down to 70 mK. In order to study the nature of spin liquid, we have measured the low-temperature thermal conductivity (κ) of the high-quality single crystal of $Tb_2Ti_2O_7$. It is found that the low-temperature thermal conductivity is extremely small, about 10^{-4} W/Km at 300 mK, which is comparable to the thermal conductivity of some amorphous solids. When applying the field along the [111] direction or perpendicular to it, κ show very large enhancements, for example, up to 35 times at 9 T along [111] and 30 times at 14 T perpendicular [111], (at 0.36 K) respectively. This indicates that phonons are scattered by the magnetic fluctuations strongly in zero field, which can be strongly suppressed by magnetic field. A remarkable phenomenon is that $\kappa(H)$ for two field directions show striking differences, showing three peaks with H $\parallel$ [111] while monotonously increasing with H $\perp$ [111] till 14 T, which may be related to the low temperature anisotropic magnetic properties of Tb^{3+} induced by crystal field effect. The result with field along [111] suggests that a polarized paramagnetic or a short-range magnetically ordered phase is induced.