Abstract Submitted
for the TSF16 Meeting of
The American Physical Society

Persistent entropy current? A third-law paradox[1] YIHENG XU, ABHAY SHASTRY, CHARLES STAFFORD, University of Arizona — We consider persistent currents at finite temperature induced by the Aharonov-Bohm effect in a multiply connected quantum system threaded by a magnetic flux. In general, both the energy current I_E and the particle current I_N are nonzero in the limit $T \to 0$, while the entropy of the system $S(T) \to 0$ as $T \to 0$, consistent with the third law of thermodynamics. The conventional definition of the heat current is $I_Q = I_E - \mu I_N$, with the entropy current defined as $I_S = I_Q/T$. We show that generically the persistent heat current defined in this way is nonzero in the limit $T \to 0$, leading to the paradoxical result that $I_S \to \infty$ as $T \to 0$ despite the fact that $S(T) \to 0$ and I_N is finite. This suggests that the conventional definition of heat current is problematic for a quantum system in thermal equilibrium. A curl-free formula for the entropy current is proposed as a possible way out of this paradox.

[1]Work supported by the US Department of Energy, Office of Science, under Award No. DE-SC0006699.

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Date submitted: 08 Sep 2016 Electronic form version 1.4