# The Thomson cooler derived from the Compatibility Factor Approach to the analysis of Thermoelectric Devices

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Traditional thermoelectric Peltier coolers exhibit a cooling limit which is primarily determined by the figure of merit, zT. Rather than a fundamental thermodynamic limit, this bound can be traced to the difficulty of maintaining thermoelectric compatibility. Self-compatibility locally maximizes the cooler's coefficient of performance for a given zT and can be achieved by adjusting the relative ratio of the thermoelectric transport properties that make up zT . In this study, we investigate the theoretical performance of thermoelectric coolers that maintain self-compatibility across the device. We find that such a device behaves very differently from a Peltier cooler, and we term self-compatible coolers "Thomson coolers" when the Fourier heat divergence is dominated by the Thomson, as opposed to the Joule, term. A Thomson cooler requires an exponentially rising Seebeck coefficient with increasing temperature, while traditional Peltier coolers, such as those used commercially, have comparatively minimal change in Seebeck coefficient with temperature. When reasonable material property bounds are placed on the thermoelectric leg, the Thomson cooler is predicted to achieve approximately twice the maximum temperature drop of a traditional Peltier cooler with equivalent figure of merit (zT ).We anticipate that the development of Thomson coolers will ultimately lead to solid-state cooling to cryogenic temperatures.

**References** :

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