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## Study on A Cascade Pulse Tube Cooler with Energy Recovery: New Method for Approaching Carnot

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A pulse tube cryocooler can not reach the Carnot efficiency basically because the expansion work must be dissipated at the warm end of the pulse tube, thus the ideal efficiency of a PTC is only  $T_c/T_h$ , which is less than the Carnot efficiency  $T_c/(T_h - T_c)$ . How to recover this amount of dissipated work is a key to improve the PTC efficiency. A cascade PTC is consisted of PTCs those are staged by transmission tubes in between, it can be a two-stages or even more stages, each stage is driven by the recovered work from the last stage by a well-designed long transmission tube. It's shown that the more stages it has, the closer the efficiency will approach the Carnot efficiency. A two-stages cascade pulse tube cooler working at 233 K is designed, fabricated and tested in our lab, and experimental results show that the efficiency can be improved by 33%.

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