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From dissipation-induced instability to the dynamics of engines

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Abstract: In the 1930s, Philippe Le Corbeiller proposed connecting the mathematical theory of Lyapunov stability with the thermodynamics of engines (understood as devices capable of generating and maintaining a cyclic motion at the expense of an external disequilibrium without any corresponding periodicity). Unfortunately, this had little impact in the scientific community and was not developed very far by Le Corbeiller himself. I will argue that Le Corbeiller's program is still a promising way forward in the theory of non-equilibrium thermodynamics, which until now has, for the most part, failed to capture the detailed dynamics of work extraction by engines. In classical physics, such work extraction requires an active, non-conservative force, something that has been studied almost exclusively in the context of mechanical instabilities. I will treat three separate problems: the generation of waves on the surface of the water by the action of the wind, the hunting oscillation of a train, and the tidal acceleration of the Moon. I will show how the dialogue between dynamical systems theory and thermodynamics simplifies the solutions to these problems while revealing surprising commonalities among them. Finally, I will also argue that a similar approach can throw light on the thermodynamics of non-conservative chaotic systems, including Chua's circuit and the Lorenzian waterwheel.

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