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A Leidenfrost Engine GARY WELLS, RIDRIGO LEDESMA-AGUILLAR, GLEN MCHALE, Northumbria University, Newcastle upon Tyne NE1 8ST, UK, KHELLIL SEFIANE, University of Edinburgh, Scotland EH9 3FB. — The Leidenfrost effect, the sustained levitation of evaporating liquid droplets by a cushion of their on vapour on very hot surfaces, has received increased attention over the past few years. On patterned surfaces, rectification of the vapour layer flow can lead to rich dynamics of evaporating drops or sublimating blocks of dry ice, including self-propulsion, orbiting and conjoint rotation. In this paper we show that the Leidenfrost effect can be exploited to drive the rotation of rigid objects, such as solid hydrophilic plates coupled to water droplets and blocks of dry ice, by using turbine-like substrates. Using a hydrodynamic model, we show that drag-based rotation is achieved at low-Reynolds number by a rectification mechanism of the flow in the vapour layer caused by the underlying turbine-like geometry. Our theoretical model determines the maximum weight of Leidenfrost rotors and the net torque driving their motion in terms of operational parameters, showing an excellent agreement with experiments using dry-ice blocks. We generalise the concept of rotation into a new concept for a heat engine capable of harvesting thermal energy using either thin-film boiling or sublimation as a phase-change mechanism. As a proof principle, we implement the new sublimation engine in the lab to create a simple electromagnetic generator. Our results support the feasibility of low-friction in situ energy harvesting from both liquids and ices in challenging situations such as deep drilling, outer space exploration or micro-mechanical manipulation.

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