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Dynamics of rotating nanoparticles mediated by the Casimir torque

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The vacuum and thermal fluctuations of the electromagnetic field give rise to important phenomena, such as Casimir forces and torques, which can dominate the dynamics of nanoscale particles. Although these interactions have hindered the design of early nanomechanical devices by causing their moving parts to stall due to friction and stiction, they also present a unique opportunity to achieve efficient momentum and energy transfer at the nanoscale, when properly controlled. In that context, we study how the Casimir torque can mediate the transfer of angular momentum in chains of rotating nanoparticles. To that end, we derive an analytic expression describing the Casimir torque experienced by each particle in the chain, which we use to calculate the rotational dynamics of the chain and, thereby, analyze the angular momentum transfer. We show that these dynamics are fully determined by a set of natural modes and corresponding decay rates. With this paradigm, we investigate examples of exotic and driven dynamics. These results show that the Casimir torque can play a dominant role in angular momentum transfer at the nanoscale and, therefore, holds important possibilities for the design of nanomechanical devices.