Nanorotor driven by single-electron tunneling

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Much effort has been devoted to investigate the coupling of electrical and mechanical degrees of freedom on the nano-meter scale in order to design novel electronic devices. An example is the nano-mechanical single-electron transistor (NEMSET), where electrons are transported from a source to a drain electrode via a movable nano-object which can be occupied by exactly one electron. The charged object experiences a force caused by the electric field between source and drain. The interplay of vibrational motion of the particle and the strong distance dependence of tunneling (which is responsible for charging/decharging) gives rise to mechanically assisted electron transport, called electron shuttling.

Recently, we investigated a nano-rotor based on the same mechanism as the electron shuttle described above [1]. This rotor exhibits novel effects, which could be used for various applications, like sensors or charge pumps. The coupling of mechanical motion and tunneling leads to the self-excitation of oscillatory motion and for large bias voltage to rotational motion even in the presence of damping.

A rotor with tilted and unequal arms can rotate preferably in one direction independently on the initial condition [2]. This can be an advantage compared to some previous proposals of nano-motors driven by single electron tunneling because control over the initial condition may be difficult or even impossible, depending on the specific experimental setup. We show which geometries lead to a preferred rotational direction and how stable they are under fabrication imperfections.

References

[1] A Croy and A Eisfeld, Europhys. Lett. 98, 68004 (2012).
[2] A Celestino, A Croy, M W Beims and A Eisfeld, New J. Phys. 18, 063001 (2016).

Figures

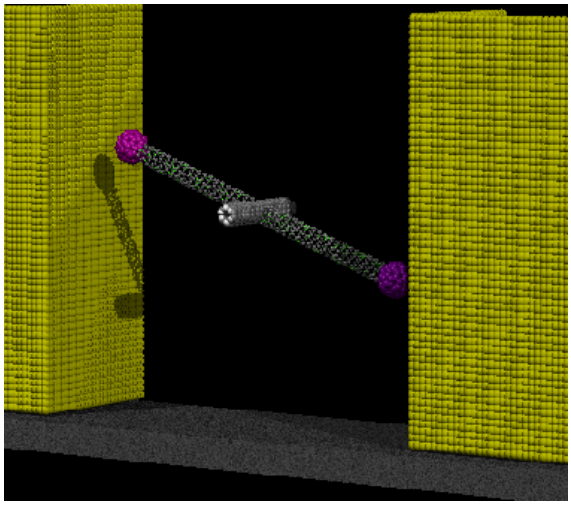

Figure 1. Sketch of a nano-motor realized by a carbon-nanotube.