Heat dissipation and thermopower in atomic-scale junctions

Fabian Pauly
Department of Physics, University of Konstanz, D-78457 Konstanz, Germany
*e-mail: Fabian.Pauly@uni-konstanz.de

Single-atom and single-molecule junctions represent the ultimate limit to the miniaturization of electrical circuits. They are also ideal platforms for testing quantum transport theories that are required to describe charge and energy transfer in novel functional nanometer-scale devices. Recent work has successfully probed electric and thermoelectric phenomena in atomic-scale junctions. However, heat dissipation and transport in atomic-scale devices remain poorly characterized owing to experimental challenges. In this talk, I will present our recent combined experimental and theoretical efforts to understand the heat dissipation in atomic-scale junctions [1,2]. Using custom-fabricated scanning probes with integrated nanoscale thermocouples, we find that if the junctions have transmission characteristics that are strongly energy dependent, this heat dissipation is asymmetric – that is, unequal between the electrodes – and also dependent on both the bias polarity and the identity of the majority charge carriers (electrons versus holes). In contrast, junctions consisting of only a few gold atoms ('atomic junctions') whose transmission characteristics show weak energy dependence do not exhibit appreciable asymmetry. Our results unambiguously relate the electronic transmission characteristics of atomic-scale junctions to their heat dissipation properties, establishing a framework for understanding heat dissipation in a range of mesoscopic systems where transport is elastic – that is, without exchange of energy in the contact region. The close relation between heat dissipation and thermopower provides general strategies for exploring fundamental phenomena such as the Peltier effect or the impact of quantum interference on the Joule heating of molecular junctions [2].

[1] W. Lee, K. Kim, W. Jeong, L. A. Zotti, F. Pauly, J. C. Cuevas, and P. Reddy, Nature **498**, 209 (2013).
[2] L. A. Zotti, M. Bürkle, F. Pauly, W. Lee, K. Kim, W. Jeong, Y. Asai, P. Reddy, and J. C. Cuevas, submitted.