Prominence of Terahertz Acoustic Surface Plasmon excitation in Gas-Surface interaction with Metals

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Understanding the dynamics of gas-surface interaction has been at the focus of research for the last decades. One reason for this interest is the modelling of the energy transfer to solid surfaces which dictates the drag force on aerospace shuttles. For telecommunication satellites orbiting the Earth typically below 600 km, this process represents the main source of orbital perturbation [1-3]. Another main application is heterogeneous catalysis, since the rate of the processes is often limited by the energy accommodation of the gas phase reactants [4]. In both cases, the interaction of gases up to mild hyperthermal kinetic energies (0.1 to 1 eV) with metal surfaces is of pivotal importance.

The classical understanding of gas-surface dynamics based on direct collisions with the surface atoms is that the excess kinetic energy of the colliding particles is transferred to the vibrational degrees of freedom of the target [5,6]. This process was demonstrated to dominate, e.g., for H_2 dissociation on Cu(111) [7] and Ru(0001) [8], methane on Ni(100) [9], and water on Ni(111) [10]. Energy transfer to the electronic degrees of freedom (electron hole (*e*-*h*) pair excitations) was observed only for much higher energies: impact energies of several eV for H [11] and HCl [12] scattering off Au(111), and high vibrational excitation for NO dissociation on Au(111) [13]. In all these cases, as well as in the interpretation of friction phenomena,[16] only *e*-*h* pair generation was considered.

Here we show that this picture does not hold for metal surfaces supporting acoustic surface plasmons [14-16]. Such loss, dressed with a vibronic structure, is shown to make up a prominent energy transfer route down to the terahertz region for Ne atoms scattering off Cu(111) and is expected to dominate for most metals [17]. This mechanism determines, e.g., the drag force acting on telecommunication satellites which are typically gold plated to reduce

overheating by sunshine. The electronic excitations can be unambiguously discerned from the vibrational ones under mild hyperthermal impact conditions.

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