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Surface friction investigated by neutron scattering

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The study of friction and diffusion processes on molecular length scales requires experimental methods that deliver sub-nanometer spatial resolution at nanosecond time resolution. After decades of research in friction the range of available spectrometers with these characteristics is still too limited. Although, neutron scattering is not a widely used for surfaces, neutron spectroscopy is able to cover the space and time domains that are of interest here. In addition, a wide choice of high surface density materials are available now that can serve as substrates for diffusion studies. These materials have the added benefit, that they are widely applied in energy storage, sensing and filtering. Hence, research on these materials has strong potential technical impact. In this presentation, we will show recent progress in friction research using neutron spectroscopy and diffraction.

Our research started with rather small and structurally simple molecules on carbon substrates, such as the aromatic molecule benzene adsorbed on the basal plane surface of graphite(0001) [1,2]. For benzene-graphite(0001) at sub-monolayer coverage, we now established the inter-molecular energy dissipation and the surface friction [2] using a range of neutron time-of-flight spectrometers, neutron spin-echo as well as neutron diffraction. The results led us to a surprisingly simple model: the inter-molecular friction can be quantitatively explained by a model of colliding cogwheels (or rough hard disks) that we had developed on the basis of the long established rough hard sphere model for molecular gases (the equivalent 3D model). The new model explains the collisional friction or viscosity based on universal constants only and makes almost no assumptions about the system.

[1] E. Bahn et al., Physical Chemistry Chemical Physics, 2014, 16, 22116.
[2] I. Calvo-Almazan, E. Bahn et al., Carbon, 2014, 79, 183.

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