History-dependent fluctuations control static electricity

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Statistical descriptions of same-material contact electrification, or "static electricity", generally assume that charge exchange arises from fluctuating surface properties. In such models, charge-transfer distributions for repeated contacts between two samples should be centered on zero, with net charging emerging only from statistical fluctuations. I this talk, I will discuss how we perform experiments to determine that nominally identical SiO_2 samples instead possess a hidden global symmetry-breaking parameter that is random across an ensemble but consistent within a given sample pair, and identify the physical origin of this parameter. Using acoustic levitation, we measure charge exchange between an amorphous SiO_2 particle and plate (Fig. 1). Although charging polarity is random for co-prepared samples [1], it can be systematically controlled through baking or plasma treatment. Combining time-of-flight mass spectrometry, low-energy ion scattering, and infrared spectroscopy, we show that the resulting evolution in charging is governed by the removal and re-adsorption of primarily carbon-based atmospheric adsorbates [2]. These results reveal that the symmetry breaking parameter in oxide contact electrification arises from history-dependent fluctuations, not material fluctuations, and identifies adventitious carbon as the physical origin.

[1] Grosjean G & Waitukaitis SR. PRL 130 (2023) 098202. DOI: 10.1103/PhysRevLett.130.098202.

[2] Grosjean G, Ostermann M, Sauer M, Hahn M, Pichler CM, Fahrnberger F, Pertl F, Balazs DM, Link MM, Kim SH, Schrader DL, Blanco A, Gracia F, Mujica N & Waitukaitis S. Nature 651 (2026) 626-631. DOI: 10.1038/s41586-025-10088-w

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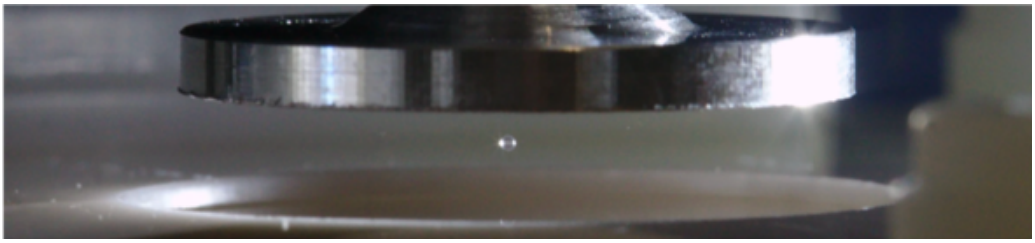

Figure 1. We use acoustic levitation to study charge exchange of a particle colliding with a plate of the same material. In results recently published in Nature, we find that airborne molecular adsorbates control the charging.