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Attosecond clocking of scattering dynamics in dielectrics

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In the past few years electronic-device scaling has progressed rapidly and miniaturization has reached physical gate lengths below 100 nm, heralding the age of nanoelectronics. Besides the effort in size scaling of integrated circuits, tremendous progress has recently been made in increasing the switching speed where strong-field-based "dielectric-electronics" may push it towards the petahertz frontier. In this contest, the investigation of the electronic collisional dynamics occurring in a dielectric material is of primary importance to fully understand the transport properties of such future devices. Here, we demonstrate attosecond chronoscopy of electron collisions in SiO_2. In our experiment, a stream of isolated aerodynamically focused SiO_2 nanoparticles of 50 nm diameter was delivered into the laser interaction region. Photoemission is initiated by an isolated 250 as pulse at 35 eV and the electron dynamics is traced by attosecond streaking using a delayed few-cycle laser pulse at 700 nm. Electrons were detected by a kilohertz, single-shot velocity-map imaging spectrometer, permitting to separate frames containing nanoparticle signals from frames containing the response of the reference gas only. We find that the nanoparticle photoemission exhibits a positive temporal shift with respect to the reference. In order to understand the physical origin of the shift we performed semi-classical Monte-Carlo trajectory simulations taking into account the near-field distributions in- and outside the nanoparticles as obtained from Mie theory. The simulations indicate a pronounced dependence of the streaking time shift near the highest measured electron energies on the inelastic scattering time, while elastic scattering only shows a small influence on the streaking time shift for typical dielectric materials. We envision our approach to provide direct time-domain access to inelastic scattering for a wide range of dielectrics.