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Probing stray electric fields at surfaces with Rydberg atoms

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While the surfaces of conductors are often viewed as an equipotential, in reality surface microstructure and adsorbates lead to local potential variations. These produce surface patch fields that can affect the behavior of ions or atoms trapped near a surface and can influence the outcome of atom-surface interactions. Measurement of such fields is therefore important to assess their likely impact and to explore means to reduce them. Because of their large physical size, Rydberg atoms are strongly perturbed by electric fields and thus provide a powerful probe of surface fields. For example, Rydberg atoms display pronounced Stark shifts and their measurement has been used to map stray fields above an atom chip and fields resulting from alkali deposition on a surface. Stray fields nearer the surface can be explored by studying the ionization of Rydberg atoms incident at near grazing angle in the presence of an ion collection field. Close to the surface ionization can occur through resonant tunneling of the excited electron into the surface. Stray fields (and the ion collection field) modify the potential barrier between the atom and surface and thus the atom-surface separation at which ionization occurs. (If sufficient, they might even induce field ionization in vacuum well above the surface.) Once formed, an ion experiences forces from its image charge and the local stray field that must be overcome by the ion collection field to detect the ion. Thus measurements of the ion signal versus collection field provide a measure of the stray fields present. Strong surface fields can also be generated using micrometer-scale electrode arrays providing a new approach to studying their effects. Research conducted in conjunction with Y. Pu and D. D. Neufeld and supported by the NSF and the Robert A. Welch Foundation.