Experimental investigation of interactions between ultracold atoms and room-temperature surfaces

by

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Experimental investigation of interactions between
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Thesis directed by Dr. Eric A. Cornell

The initial experiments with dilute gas Bose-Einstein condensates have primarily focused on the study of the extremely non-trivial properties of the condensate itself. There remains a good deal of interesting work in this direction, but the field has progressed to the point where one might consider using the condensate as a probe to study physics phenomena "external" to the condensate. In the series of experiments described in this thesis, we utilize magnetically-trapped ultracold and condensed ^{87}Rb atoms to probe the interactions between atoms and room-temperature surfaces.

The first atom-surface interaction studied was magnetic trap-loss induced by Johnson noise in room-temperature conducting surfaces. Near-field radio-frequency noise emanating from the surface can drive the magnetically-trapped atoms to make Zeeman spin-flip transitions to untrapped states. Because this limits the trap lifetime near conducting surfaces, it is of great interest to cooling and trapping experiments working with miniaturized atom traps. Subsequently, we investigated the electric fields generated by small numbers (10^5–10^7) of partially ionized rubidium atoms adsorbed onto conducting and semiconducting surfaces. These electric fields, although small, can exhibit large potential energy gradients that in turn generate large, attractive surface forces. This is of concern for experiments intent on measuring small, fundamental atom-surface forces such as the Casimir-Polder force. The final, and most involved, experiment undertaken was a measurement of the Casimir-Polder force near a dielectric surface. Additionally, analysis of the results of our Casimir-Polder measurement provides a limit on the presence of hypothetical exotic short-range forces.

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