

Ratio measurements of atom-surface potentials reveal effect of core electrons

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Abstract

Van der Waals (vdW) and Casimir-Polder potentials are the dominant interactions between charge-neutral objects at nano- to micrometer length scales. Understanding these potentials is important for designing atom-chips and nanotechnology devices as well as searches for vacuum friction and non-Newtonian gravitational potentials at short length scales.

The contribution of atomic core electrons to vdW potentials is surprisingly large. While core electrons only contribute 3% to the DC-polarizability of Rb atoms, they are predicted to contribute 35% to the vdW potential (C_3) for Rb near an ideal surface [1]. For a silicon nitride surface, the importance of core electrons is still predicted to be about 17%. Until now, no measurements have verified this prediction.

Our data confirm that core electrons are significant for C_3 of Rb atoms and a silicon nitride surface. We measured ratios of C_3 for several different atoms (Li, Na, K, and Rb) and the same surface to highlight the role of core electrons. In absolute measurements of C_3 , the effect of core electrons can be masked by other effects such as variation in surface response, contaminations, and edge effects.

By diffracting different species of atoms from the same nano-grating we measured ratios, e.g. $C_3(\text{Rb})/C_3(\text{Na})$, with a precision better than 3%. These ratio measurements are insensitive to surface contaminations and impurities. In addition, no knowledge of the grating geometry or the shape of the potential is required to interpret the diffraction data. Figure 1 shows the measured ratios as well as

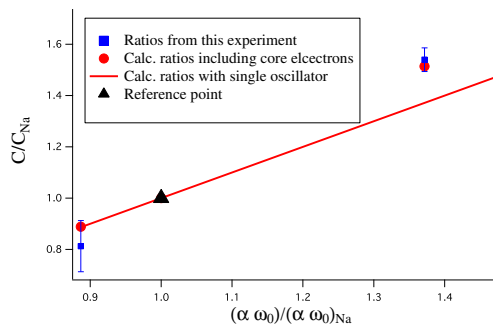


Figure 1: Experimentally determined ratios of potential strength relative to Na (C/C_{Na}) compared to model predictions. For the heavier atoms there is a clear deviation from the single oscillator model and core electrons have to be taken into account.

predictions based on a single oscillator model and a model that includes core electrons.

Keywords: VAN DER WAALS, ATOM-SURFACE POTENTIALS, CORE ELECTRONS, DIFFRACTION

References

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