Probing near field thermal emission with atoms

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In the electrostatic or van der Waals (vdW) regime, the Casimir-Polder interaction is usually described as the classical interaction between a fluctuating dipole and its image. This shifts the atomic energy levels by $-C_3/z^3$, C_3 being the vdW coefficient and z the atom-surface distance. The above picture fails to account for thermal effects. Contrary to the far field regime [1], near field thermal effects are intricately linked to the dielectric properties of the surface. Dielectrics support evanescent surface modes whose density peaks around the surface polariton resonance frequency. As a result the thermal excitation of the surface modes creates intense nearly monochromatic electromagnetic fields [2] that evanescently decay away from the surface of the dielectric.

Here we show that excited state atoms are sensitive to the near field emission of hot surfaces. By means of selective reflection spectroscopy we probe $Cs(7D_{3/2})$ atoms next to a sapphire surface ($\approx 100nm$) and measure the C_3 (vdW) coefficient of the atom-surface interaction [3]. Using a high temperature all sapphire vapour cell, we explore temperatures ranging from $500K$ to $1000K$. The evanescent thermal fields at the sapphire surface resonance at $12.1\mu m$ couple with the $7D_{3/2} \rightarrow 5F_{5/2}$ virtual atomic transition at $10.8\mu m$. As a consequence the surface induced red shift of the $7D_{3/2}$ level is increased by a factor of 2. Our findings are summarised in Fig.1 which shows the measured temperature dependence of the C_3 coefficient (red dots) as a function of temperature along with the theoretical predictions (dashed line). A very good agreement between theory and experiment is observed.

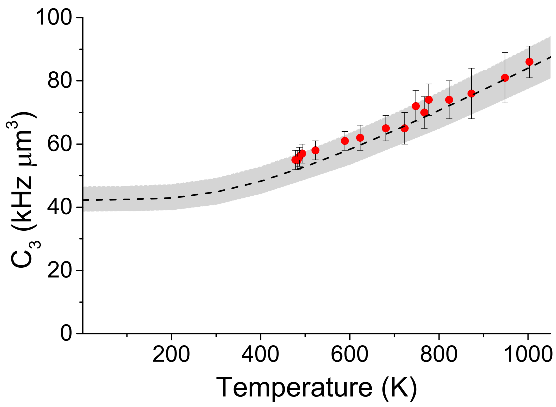

Figure 1: *The temperature dependence of the C_3 coefficient. The grey shaded area represents the uncertainty on the theoretical predictions.*

The influence of temperature reveals the QED nature of the van der Waals interaction and may provide a way to control forces between neutral atoms and surfaces including their complete cancellation or change of sign. This could have important implications on fundamental measurements or technological applications, such as atom trapping close to nanofibers [4] or atom chips. This work was partly supported by Capes-Cofecub Ph 740/12

References

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