Atom in front of a hot surface: Temperature-dependence of the Casimir-Polder interaction and thermal energy transfer

A. Laliotis[1], J. C. de Aquino Carvalho[1], T. Passerat de Silans[1,2], P. Chaves de Souza Segundo[1,3], I. Maurin[1], M. Ducloy[1], and D. Bloch[1]

[1]*LPL, CNRS-UMR 7538, Université Paris13 - Sorbonne Paris Cité, 93430 Villetaneuse, France*
[2]*also at Universidade Federal de Paraiba, João Pessoa, Brazil*
[3]*now at Universidade Federal de Campina Grande, Cuité, Brazil*

Presenting Author: daniel.bloch@univ-paris13.fr

The temperature dependence of the Casimir-Polder (CP) atom-surface interaction addresses fundamental issues for understanding vacuum and thermal fluctuations. Recently, we have shown that the CP interaction can be strongly modified by the temperature effects [1]. In our regime of short distances ($\sim 100nm$, i.e. electrostatic limit), the atom becomes a probe, with a high-frequency selectivity, of the near-field thermal emission, which strongly differs from the long-distance (material-independent) black-body emission. The observed increase of the interaction with temperature (fig. 1), by up to 50%, relies on the coupling between atomic virtual transitions — located in the *thermal* infrared range — and thermally excited surface-polariton modes. The experiments were performed on $Cs(7D_{3/2})$, through a selective reflection spectroscopy technique on a vapour at the interface of a hot superpolished sapphire window. The measurements rely on an elaborate fitting of the data to a catalogue of universal lineshapes.

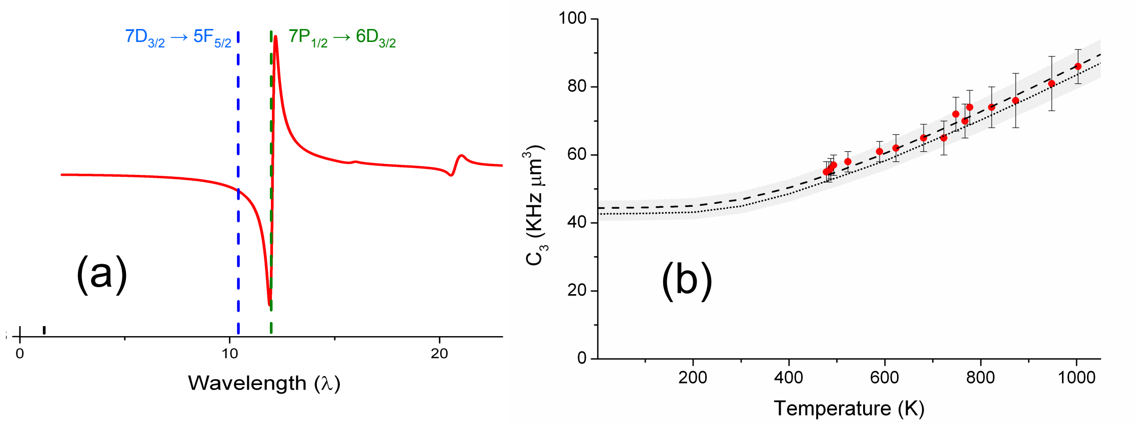

Figure 1: *(a) the sapphire surface resonance around* $12\mu m$*, and (b) the temperature dependence of the CP interaction for* $Cs(7D_{3/2})$ *(see [1]), mostly related to the* $10.8\mu m$ *coupling [see (a)].*

We are now extending these experiments to $Cs(7P_{1/2})$ and $Cs(7P_{3/2})$, at the same interface (superpolished sapphire). For $Cs(7P_{1/2})$, the dominant coupling (to $6D_{3/2}$) at $12.15\mu m$ falls in a strong coincidence with the sapphire surface resonance (fig.1a), yielding the reverse effect of the resonant repulsion previously observed on $Cs(6D_{3/2})$ at a sapphire interface [2]. Conversely, the couplings from $Cs(7P_{3/2})$, at $14-15\mu m$, are far away from this sapphire resonance, and major differences are predicted for the temperature dependence. At stake is the possibility of an original and precise way to probe surface resonances, predicted to soften and shift with temperature, which are commonly extrapolated from broadband data on the entire spectrum (e.g. through Kramers-Kronig relation). The thermal emission of sapphire may also induce a transfer $Cs(7P_{1/2}) \rightarrow 6D_{3/2}$, involving a real transition where the thermal energy is selectively absorbed by the neighbouring atom. A refined analysis of the spectrum on the $459nm$ line may be able to provide an evidence of the corresponding temperature-modification of the atomic lifetime of $Cs(7P_{1/2})$.

One of us (J.C.A.C.) thanks the "Ciencîas sem fronteiras" programme. The France-Brazil cooperation is supported by CAPES-COFECUB programme Ph 740-12.

References

[1] A. Laliotis et al., Nature Comm. **5**, 5634 (2014) doi:10.1038/ncomms5364
[2] H. Failache et al., Phys. Rev. Lett., **83**, 5467 (1999)