Suppression of Penning ionisation in a spin polarised mixture of Rubidium and He*

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Ultracold mixtures of atoms have been widely studied, due to their interesting collisional properties as well as their appropriateness for sympathetic cooling e.g. of fermions. However, there has only been one previous investigation of a cold alkali-noble gas mixture in which metastable argon (Ar*) atoms were simultaneously trapped with Rb atoms. This study was conducted in a magneto-optic trap (MOT) where the atoms are essentially unpolarised and an unpolarised Penning rate was measured. The additional step of determining the polarised rate by implementing magnetic trapping was not pursued, presumably because the production of an Ar* BEC is not feasible due to the large inelastic loss rates still present in spin polarised Ar* [1].

Here we present the results of experiments in which we probe the Penning ionisation rates of a mixture of ultracold He*-^{87}Rb atoms. We are able to demonstrate that a high degree of suppression exists for the polarised case and put an upper limit on the polarised Penning rate constant at 5×10^{-12} cm^3/s. Such a low rate constant might make possible a dual He*-^{87}Rb BEC, which would be an interesting environment to create exotic He*-^{87}Rb molecules in a similiar manner that long range He* dimers have been previously demonstrated.

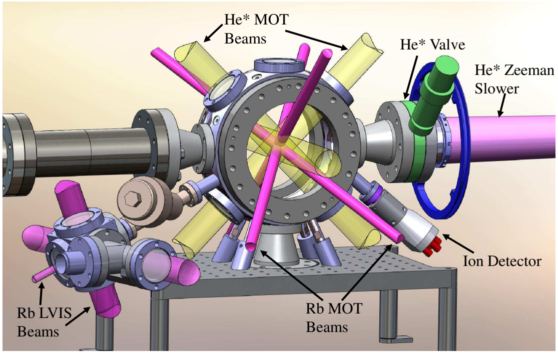

Fig. 1: Experimental setup used to produce dual He*-^{87}Rb MOTs. He* MOT beams are shown as transparent (yellow) beams while the solid (pink) beams represent the ^{87}Rb laser beams.

Suppression of Penning ions should occur in the case of a spin polarised mixture. We probe this suppression by loading both clouds of atoms into a magnetic trap. In such case both the He* and ^{87}Rb atoms are spin polarised (He* in the m$_j$ =+1, and ^{87}Rb in the m$_f$ = +2). Within the noise levels of our experiment we observe no increase in ion production due to the presence of ^{87}Rb in the spin polarised mixture. While this means we can not determine a spin polarised Penning rate coefficient for the mixture it allows an upper limit to be determined. We determine the limit to the rate constant to be 5×10^{-12} cm^3/s, demonstrating a spin polarised suppression of at least a factor of $\sim$ 100.

This surprising result can be explained by the fact that in our mixture both species are in symmetric S states, while all other trappable noble gas atoms are in asymmetric metastable P states. In the case of a collision involving two metastable atoms both in a P state the atoms experience a mutual electrostatic interaction. In the case of metastable neon the asymmetric P-core generates an electric quadrupole-quadrupole potential which depolarises the atoms during their approach and thus Penning ionization is no longer forbidden by spin conservation. For a He*-^{87}Rb mixture the interaction of ground state atoms is purely Van der Waals and thus spin polarisation can lead to a large suppression of Penning ions.

References

[1] H. C. Busch, M. K. Shaffer, E. M. Ahmed, and C. I. Sukenik, Phys. Rev. A **73**, 023406 (2006).