Study of heteronuclear trap loss: the contribution of double excited states channel

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Recently our group have measured the intensity and frequency dependence of the trap loss rates for mixtures of alkalis: Na−K [1], Na−Rb [2], K−Rb [3], Rb−Cs [4], and K−Cs [5]. Our main goal is to detect heteronuclear molecular bound states that will help us to understand the coexistence of the two samples for future investigations in mixed BEC systems. The mechanisms involved in mixed species trap loss are similar to those in one species. Still, the radiative escape (RE) remains as the main channel for losses at higher trap laser intensities. The attractive long range potentials are due to van der Waals interactions ($-C_6/R^6$) between the two different colliding atoms. This means that in these cases the amount of shared energy it is not equal anymore, then the velocity acquired by the atoms must be weighted according to the mass ratio (or the reduced mass). We have observed that each combination presents its own particular behavior with the trap laser intensity for the heteronuclear trap loss rate (β').

On the other hand, the investigation of the loss rate with the laser frequency presented an interesting dependence. For the homonuclear system, it is well established that the $\beta \propto \Delta^{-7/6}$, at large detunings [6]; this is easily explained using the GP model [7] for single excited state collisions. If one apply the same idea for the heteronuclear case a $\beta' \propto \Delta^{-5/6}$ dependence is obtained at similar conditions. Although, for a particular combination (Na−Rb) we observed experimentally that $\beta' \propto \Delta^{-2.0\pm0.2}$. More recently we discovered that such dependence can be reproduced using an adapted GP model, and the explanation relies on the double excited (or excited-excited) potential interactions. We found that this alternative loss channel produces much higher losses (almost 100 times bigger), and it agrees well with the experimental data. The point is, the kinetic energy gained can take place in either the single excited or the double excited potentials. This result is quite surprising if one compares with the homonuclear traditional case, where the single excited states produces major contributions in the losses.

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