Reply to Comment on ‘Species-selective lattice launch for precision atom interferometry’

This content has been downloaded from IOPscience. Please scroll down to see the full text.
2016 New J. Phys. 18 118002
(http://iopscience.iop.org/1367-2630/18/11/118002)

View the table of contents for this issue, or go to the journal homepage for more

Download details:

IP Address: 194.95.157.219
This content was downloaded on 19/05/2017 at 12:13

Please note that terms and conditions apply.

You may also be interested in:

Species-selective lattice launch for precision atom interferometry
R Chamakhi, H Ahlers, M Telmini et al.

Comment on ‘Species-selective lattice launch for precision atom interferometry’
Alexander D Cronin and Raisa Trubko

Recent developments in trapping and manipulation of atoms with adiabatic potentials
Barry M Garraway and Hélène Perrin

Coherence loss and revivals in atomic interferometry: a quantum-recoil analysis
M Davidovi, A S Sanz, M Boži et al.

Zitterbewegung with spin–orbit coupled ultracold atoms in a fluctuating optical lattice
V Yu Argonov and D V Makarov
In our paper [1], we based the calculation of $\lambda_{\text{tune-out}}$ of $^{39}$K on reference [2] and more specifically on the tabulated values in version 1.0, which reports the lifetimes as $\tau_{D1} = \tau_{D2} = 26.37(5)$ ns. This led to $\lambda_{\text{tune-out}} = 768.959$ nm. Assuming the corrected values (table 1) in a more recent version of [2] (v1.02) or the ones in the original paper [3], we find the $\lambda_{\text{tune-out}} = 768.9691(20)$ nm, which is the same result as Cronin et al [4] and explain the discrepancy of 9.4 nm. As suggested, we use in this reply a more accurate formula of the dipole potential accounting for the contribution of the off-resonant terms:

$$U_{\text{dip}}(F) = -\frac{\pi c^2}{2} \left[ \frac{\Gamma_1}{\omega_{D1}^2} \left( \frac{1}{\omega_{D1} - \omega_L} + \frac{1}{\omega_{D1} + \omega_L} \right) + \frac{2\Gamma_2}{\omega_{D2}^2} \left( \frac{1}{\omega_{D2} - \omega_L} + \frac{1}{\omega_{D2} + \omega_L} \right) \right] I(F)$$

with the $D_1, D_2$ atomic transition lines $\omega_{D1,2}$, the laser frequency $\omega_L$ and the speed of light $c$. This expression yields a small correction of 1.7 pm as pointed out by Cronin et al [4]. Contributions of core electrons and other atomic excitations to the residual static polarizability of alkalis can lead to further small corrections (less than 1 pm). We choose not to include them for the sake of simplicity. The interested reader is referred to table 5.5 in [5] for the considered isotopes.

We recalculate the tune-out wavelengths in table 1 with updated and referenced D lines data and give uncertainties throughout.

In order to verify that the results of our proposal remain valid despite the change in the numerical values of $\lambda_{\text{tune-out}}$, we recalculate the acceleration sequence that we introduced in our proposal. The new potential expression led to the need to choose a new couple of integers ($N1 = 2028$ and $N2 = 982$) for the momentum kicks of the two species (to initially minimize the differential velocity to 77 $\mu$m s$^{-1}$). The required detuning, following equation (8) in our paper, is of 4.99 pm instead of 2.9 pm previously. This leads to a slightly larger value of the depth of the parasitic lattice for Rb (5.38 nK instead of 3.12 nK). Figure 1 illustrates the main result of our paper with these new parameters. As the reader can appreciate, no changes are to be reported. In the Rb isotope case, the effect of the parasitic lattice leads to a velocity offset of about 1 $\mu$m s$^{-1}$ consistent with the results of our papers ($P = 4.8$ in figure 8). All conclusions drawn in our proposal remain, therefore, unaffected after the corrections proposed in the comment.

**Table 1.** Updated table 1 of [1], with the lifetime of the atomic excited level $\tau$ and the line transition frequency $\omega_L$, $\lambda_{\text{tune-out}}$ is calculated according to the dipole potential expression $U_{\text{dip}}$ stated above. The different lifetimes of K isotopes reflect different measurements and not an isotopic shift.

<table>
<thead>
<tr>
<th>Isotopes</th>
<th>$\tau_{D1}$ (ns)</th>
<th>$\tau_{D2}$ (ns)</th>
<th>$\omega_L^R/2\pi$ (THz)</th>
<th>$\omega_L^R/2\pi$ (THz)</th>
<th>$\lambda_{\text{tune-out}}$ (nm)</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cs</td>
<td>34.750(70)</td>
<td>30.462(46)</td>
<td>335.116048807(41)</td>
<td>351.72571850(11)</td>
<td>880.1549(33)</td>
<td>[8–8]</td>
</tr>
<tr>
<td>$^{87}$Rb</td>
<td>27.679(27)</td>
<td>26.2348(77)</td>
<td>377.107385690(46)</td>
<td>384.230406373(14)</td>
<td>790.0273(47)</td>
<td>[9]</td>
</tr>
<tr>
<td>$^{89}$Rb</td>
<td>27.679(27)</td>
<td>26.2348(77)</td>
<td>377.107443380(11)</td>
<td>384.230464685(62)</td>
<td>790.0274(47)</td>
<td>[10]</td>
</tr>
<tr>
<td>$^{89}$K</td>
<td>26.72(5)</td>
<td>26.37(5)</td>
<td>389.286038716(62)</td>
<td>391.01617003(12)</td>
<td>768.9708(28)</td>
<td>[11, 12]</td>
</tr>
<tr>
<td>$^{40}$K</td>
<td>26.76(5)</td>
<td>26.45(7)</td>
<td>389.286249205(62)</td>
<td>391.01640601(12)</td>
<td>768.9700(39)</td>
<td>[11, 12]</td>
</tr>
<tr>
<td>Na</td>
<td>16.299(21)</td>
<td>16.254(22)</td>
<td>508.331958(13)</td>
<td>508.8487162(13)</td>
<td>589.356500(35)</td>
<td>[13]</td>
</tr>
<tr>
<td>$^{6}$Li</td>
<td>27.102(9)</td>
<td>27.102(9)</td>
<td>446.798635(20)</td>
<td>446.796865(20)</td>
<td>670.987388(31)</td>
<td>[14, 15]</td>
</tr>
</tbody>
</table>
References

[9] Steck D A 2008 Rubidium 85 D line data v2.1.6 (http://steck.us/alkalidata/rubidium85numbers.pdf)

Figure 1. View of the central momentum class of the accelerated Bose–Einstein condensates. These results are obtained for very close ramping sequences to the ones of figure 5 of our proposal [1], slightly adapted to realize the new number of momentum kicks mentioned in the text.