Cryogenic temperatures

Time until creation of first contaminant atom is [300]

$$\tau = \frac{\tau_s}{bN_0} = \frac{4\delta^2}{\Omega^2}\frac{\tau_{\rm eff}}{bN_0},$$

where b is the branching ratio to contaminant states and N_0 is the total number of atoms. Using the estimates from [302] and the quasiclassical formulas in [303] we calculate how b, $\tau_{\rm eff}$ *and their relevant combinations* depend on the *ambient* temperature.

Figure 1 indicates how the branching ratio decreases when the temperature is reduced from 300 K to 1 K. It goes down by about 1 order of magnitude for temperatures between 10 K and 30 K, and about 2 orders of magnitude for T between 1 and 5 K. (At 77 K the branching ratio is roughly 2-4 times smaller).

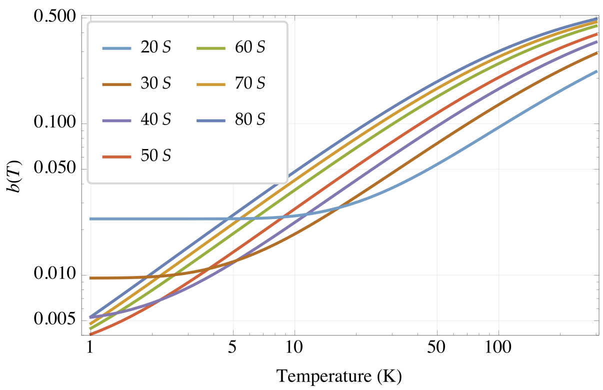

Figure 1: $b(T)$ vs T for different nS levels of ^{87}Rb.

In figure 2 the

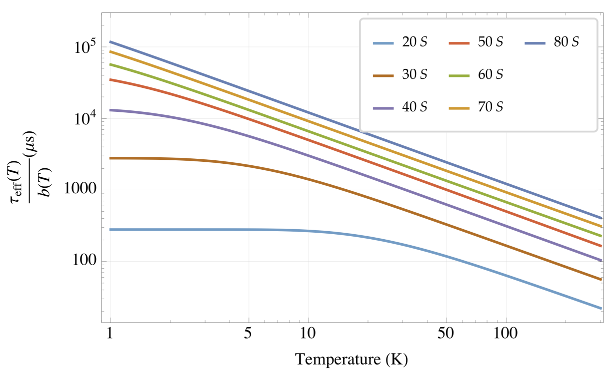

Figure 2: $\frac{\tau_{\rm eff}(T)}{b(T)}$ vs T for different nS levels of ^{87}Rb.

Figure 3 shows the *coherence* time reduction due to AB (proportional to N^{-1}) can only be *fully* compensated for atom number less than

- 600 for $T \gtrsim 1$ K.
- 100 for $T \gtrsim 5$ K.
- 15 for $T \gtrsim 50$ K.

From 1 K to 5 K one can *expect to fully neutralize* the AB effect for a system between 100 and 500 atoms. From 50K to 100 K this would occur only with less than 15 atoms.

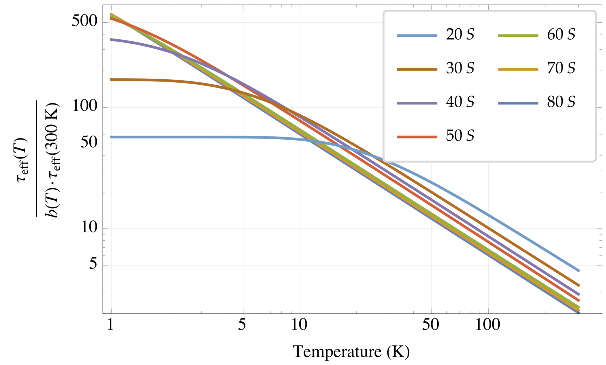

Figure 3: $\frac{\tau_{\rm eff}(T)}{\tau_{\rm eff}(300{\rm K})}\cdot\frac{1}{b(T)}$ vs T for different nS levels of ^{87}Rb. *The y axis can be interpreted as the atom number at which the $\frac{\tau_{eff}}{bN_0}$ factor becomes larger than $\tau_{eff}(300K)$.*

How would this help certain proposals? ...

- Reference [304, Pupillo] proposes a $N \lesssim 40$ atoms system to observe supersolid phases (This 2D system is purely repulsive, which makes me doubt is worth considering.). The AB effect would be compensated for temperatures arond 20 K.
- Ref [305, Glaetzle] proposes ealizing quantum spin ice in two dimensions using $16 \geq N_0 \leq 72$. Reducing the black-body radiation temperature between 50 K and 10 K would make up for the AB decoherence effect.
- Bloch Paper using 200 atoms would require temperatures between 3 K and 5 K. (Not entirely sure since I need to check the vdW radius).

References

[1] AB paper.

[2] I. I. Beterov, I. I. Ryabtsev, D. B. Tretyakov, and V. M. Entin, Phys. Rev. A 79, 052504 (2009).

[3] L. G. Dyachkov and P. M. Pankratov, J. Phys. B 27, 461 (1994).

[4] G. Pupillo, A. Micheli, M. Boninsegni, I. Lesanovsky, and P. Zoller, Phys. Rev. Lett. 104, 223002 (2010).

[5] A. W. Glaetzle, M. Dalmonte, R. Nath, C. Gross, I. Bloch, and P. Zoller, Phys. Rev. Lett. 114, 173002 (2015)