Cryogenic temperatures

- Purple: statements/words that don't seem so necessary or that should be clearly modified/expanded.
- Green: my comments.

As pointed out in the previous (sub-)section, for a sufficiently large atom density[1] the time until the creation of the first contaminant atom is [301]

$$\tau_c = \frac{4\delta^2}{\Omega^2}\frac{\tau_0}{b_{nL}N_\beta} \quad \text{(or } \sim \text{ instead of } =\text{)},$$

where N_β is the number of atoms per effective interaction volume β, and b_{nL} is the sum of the branching ratios from the nL Rydberg state to the relevant[2] contaminant states. τ_0 is the natural lifetime of the nL state. If β is much larger than the size of the sample, N_β is simply the total number of atoms N_0.

The time τ_c depends on the ambient temperature[3] T through τ_0 and b_{nL}. Using the estimates from [302] and the quasiclassical formulas in [303], we *roughly*[4] estimate the largest value T_N^* of the ambient temperature T needed to compensate for the avalanche dephasing effect as a function of N_β.

In figure 2 we plot τ_0, b_{nL} and T_N^* as a function of T for different ^{87}Rb nS Rydberg states.

Rydberg-dressing proposals like [304,305] and previous experimental setups [306] making use of systems with an *effective* $N_\beta \lesssim 40$ would need an ambient temperature between 10 K and 30 K to make up for the dephasing effect. The effects on those with a low atom number $N \sim 10$ [309] should be negligible for cryogenic temperatures around 70 K.

Proposals like [307] and [308] where the atom number is 100-1000 atoms but the van der Waals blockade radius is larger than or comparable to the sample dimensions will not be considerably affected by this dephasing process (even if not working in a cryogenic environment).

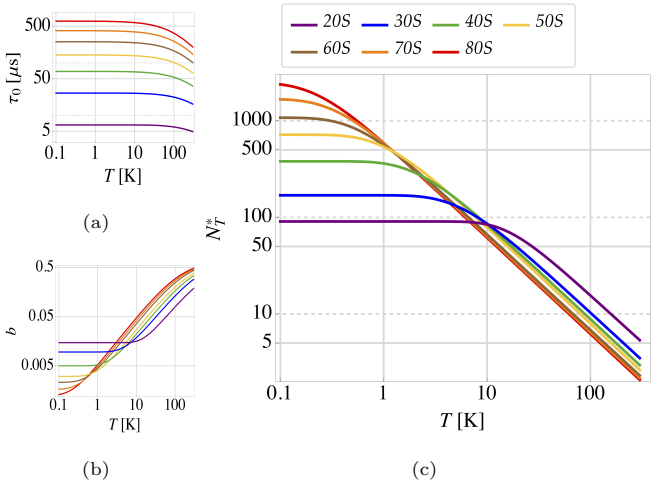

Figure 1: (a). (b). (c)

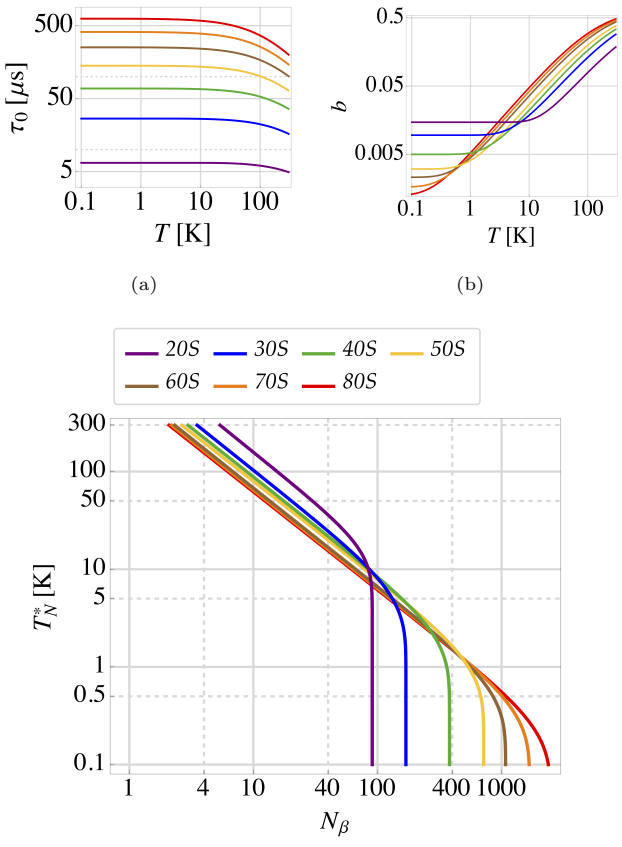

Figure 2: (a). (b). (c).

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).

[1] ... because $1/b_{nL}N_b$ might not be the right scaling when the atom density is small. The right scaling could be, for example, $1/\sqrt{1+(b_{nL}N_b)^2}$.

[2] We've made the slightly arbitrary choice that the relevant ones are those that contribute the most to the value of β.

[3] this is the temperature defining the spectrum of black-body radiation surrounding the sample.

[4] I think it should be "roughly" if $\tau_c \sim$ and not $\tau_c =$.

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

[6] Zeiher-Bloch Paper. J. Zeiher, R. van Bijnen, P. Schau, S. Hild, J.-y. Choi, T. Pohl, I. Bloch, and C. Gross, Nature Physics (2016).

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