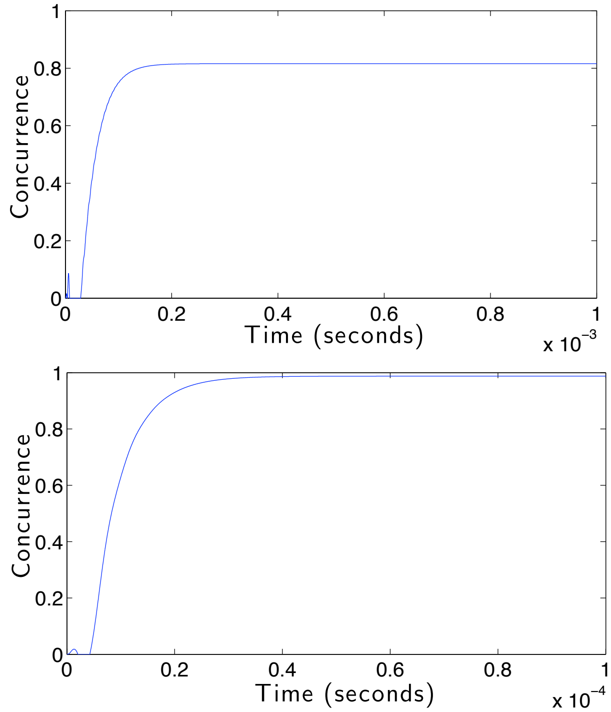

FIG. 5: (Color online) Entanglement unconditioned on either spontaneous emission or cavity decay. With no feedback the concurrence is zero, but with feedback concurrence is close to unity. These simulations use parameters taken from Russo [30](top) and Khudaverdyan [31](bottom), with a detuning big enough to be in the adiabatic regime.

jumps, and hence control, occur is fixed by the atom-cavity coupling and the cavity decay rate. If this jump rate is too low, entanglement takes longer to build, while if it is too fast, one could reach limitations in the bandwidth of either the photo-detector or the electronics controlling the feedback pulses. On the other hand, the feedback rate in the Raman scheme can be changed by the detuning or laser power, allowing full control over the speed of the process.

IV. EXPERIMENTAL LIMITATIONS

A. Delocalised Particles in a Cavity Standing Wave

Another issue with these schemes involves the coupling of the atoms to the optical mode of the cavity. These models require the coupling strengths of the two atoms to be equal, as this results in the antisymmetric state being a dark state of the system. The atoms are coupled to standing waves in the cavity, so the coupling strength is proportional to the amplitude of the standing wave (per photon) and as such, varies from maximum to zero in one quarter of a wavelength, typically a couple of hundred nanometres. The field strength varies more gradually in the transverse direction, with the waist of the beam usually being on the order of micrometres. Due to their strong interaction with electric fields, ions are a prime candidate for tight trapping, and current ion trapping techniques are able to trap an ion to a little less than an optical wavelength. In [32], $^{40}Ca^{+}$ ions are trapped to within 70nm. This is not a lot smaller than the distance between two nodes of the standing wave, so the change in coupling strength as the ion moves in the trap will be significant. A similar problem would be present in experiments with neutral atoms.

The reduced master equation when the coupling constants of the two atoms are allowed to vary is (without spontaneous emission for now),

$$\dot{\hat{\rho}} = \frac{\hbar V_M}{2}\left[\left(\hat{A}_{0,1}+\hat{A}_{1,0}\right),\hat{\rho}\right] + \frac{V_L^2}{\Delta^2\kappa}\mathcal{D}[\hat{U}_{fb}(g_1(t)\hat{\sigma}_1^- + g_2(t)\hat{\sigma}_2^-]\hat{\rho}, \qquad (14)$$

where $g_i(t)$ are the effective cavity coupling constant for each atom. They vary as $g_i(t) = g_{\max}cos(\frac{2\pi x_i(t)}{\lambda})$, with $x_i(t)$ being a Gaussian random position centred at zero with standard deviation of the trap. This corresponds to the centre of the distribution being at an antinode of the standing wave. Figure 6 shows the simulation of Eq.(14) with the random position re-rolled at each time step.

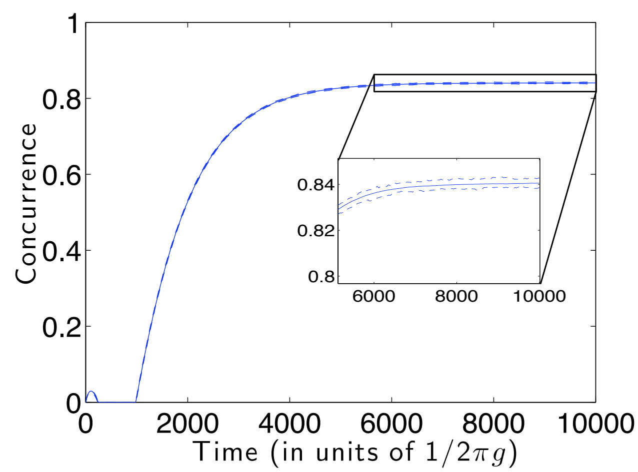

FIG. 6: (Color online) The concurrence of the two atom system with the atoms trapped in a Gaussian distribution with standard deviation of 0.08 λ, which approximately corresponds to the trapping of an ion in Reference [32]: a 70nm trap within a standing wave with wavelength $\lambda = 866$nm. The solid line shows the average concurrence over 100 runs, with the inset showing the maximum and minimum concurrence over these 100 runs with dashed lines.

The reduction in concurrence observed in Fig. 6 can be better understood in terms of the conditional dynamics based on the detection of photons leaving the cavity. As discussed in [20], the state $\frac{1}{\sqrt{2}}(|eg\rangle - |ge\rangle)$ is the steady state of the system when there is no spontaneous emission and the two coupling strengths are constant. When