Atomic beam

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Solution: *a. The Rabi frequency follows from,*

$$\Omega = \sqrt{\frac{\sigma_0 \Gamma I}{\hbar\omega}} \ .$$

With $\sigma_0 = 3\frac{\lambda^2}{2\pi}$ *we obtain* $\Omega/2\pi = 104$ *MHz. The Rabi frequency is therefore much larger than the decay rate, such that the decay can be neglected at initial times. The solution of the Bloch equations is, therefore,*

$$\rho_{22} = \frac{\Omega^2}{\Delta^2+\Omega^2} \sin^2 \frac{\sqrt{\Delta^2+\Omega^2}}{2} t \ ,$$

that is, at the beginning, the atom is in the ground state, then the population inversion makes some rapid oscillations with maximum amplitude, which relax after a while. The stationary population finally stabilizes to,

$$\rho_{22}(\infty) = \frac{\Omega^2}{4\Delta^2+2\Omega^2+\Gamma^2} \to \frac{1}{2} \ .$$

When the pulse ends after 200 *ns, the population relaxes exponentially.*
b. When the light frequency is detuned, the generalized Rabi frequency drops to $G = \sqrt{\Delta^2+\Omega^2} = 2\pi \times 144$ *MHz, the amplitude of the Rabi oscillations decreases by half and the average stationary population drops to* $\rho_{22}(\infty) = 0.17$.

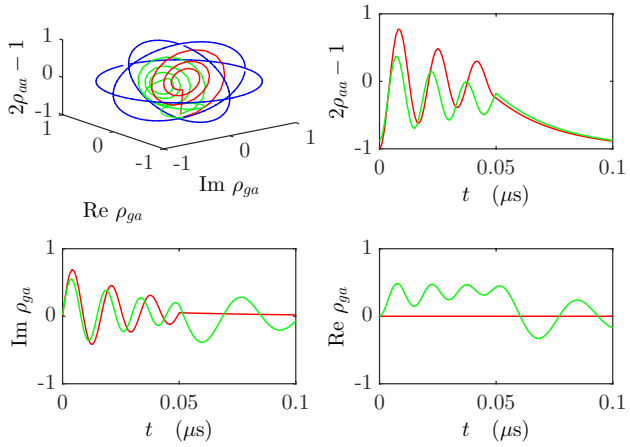

Figure 2.8: (code for download) Evolution on the sphere of Bloch.