```
ClearAll["Global`*"]
```

The energies of the states |1>, |2>, as well as the energy of the interaction are

```
E1, E2, Eint = ℏ Ω Cos[ω t - ϕ];
```

The matrix with the ground state energies is

```
MatrixForm[{{E1, 0}, {0, E2}}]
```

$$\begin{pmatrix} e_1 & 0 \\ 0 & e_2 \end{pmatrix}$$

These are associated with the states c_1 and c_2 whose phases are ξ_1 and ξ_2. We choose these phases in interaction picture so that

```
ξ1 = E1 t / ℏ
ξ2 = E1 t / ℏ + ωt
```

$$\frac{t\, e_1}{\hbar}$$

$$\omega t + \frac{t\, e_1}{\hbar}$$

Where ω is the frequency of the laser and $\omega_0$is the difference in frequency between the two energy levels that help us define the detuning Δ

```
Δ = ℏ (ω0 - ω)
```

$$\hbar\,(-\omega + \omega_0)$$

which give a hamiltonian such as

```
H = MatrixForm[{{0, Ω (1 + e^(2 iωt)) / 2}, {Ω (1 + e^(2 iωt)) / 2, Δ}}]
```

$$\begin{pmatrix} 0 & \frac{1}{2}\left(1 + e^{2\, i\omega t}\right)\Omega \\ \frac{1}{2}\left(1 + e^{2\, i\omega t}\right)\Omega & \hbar\,(-\omega + \omega_0) \end{pmatrix}$$

In Rotating Wave Approximation RWA $1 + e^{2\, i\omega t} \simeq 1$ when averaged over time

```
H = MatrixForm[{{0, Ω/2}, {Ω/2, Δ}}]
```

$$\begin{pmatrix} 0 & \frac{\Omega}{2} \\ \frac{\Omega}{2} & \hbar\,(-\omega + \omega_0) \end{pmatrix}$$

So the Schrödinger equation $c_i' = H * c_i$ gives the following system of equations where we suppose the laser is in resonance with the difference in frequencies of the two levels (Δ=0)

```
c1'[t] == -i Ω[t] * c2[t] / 2;
c2'[t] == -i Ω[t] * c1[t] / 2 - i Δ c2[t];
```

Value of the bandwidth(τ) and its inverse at half the amplitude are

```
τ = 5;
1 / τ
```

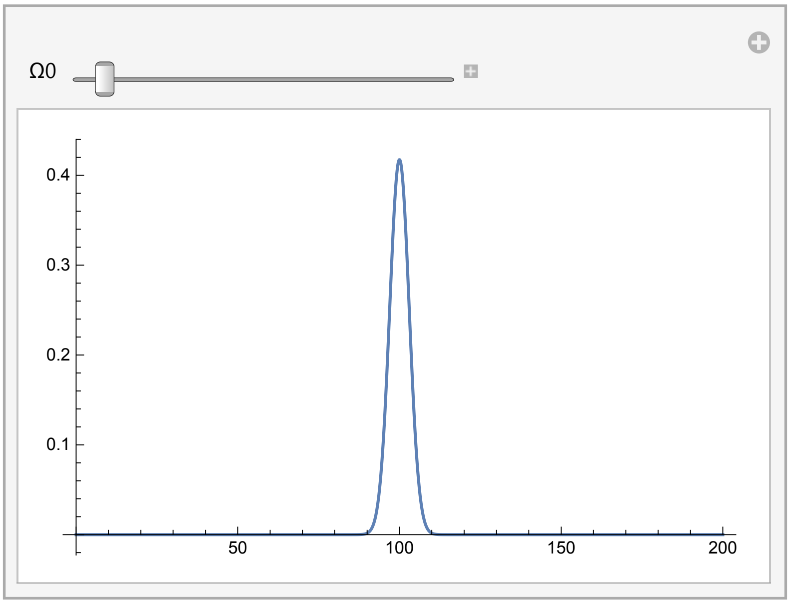
$$\frac{1}{5}$$

Now we plot these values to find the shape of the gaussian in the time span that goes between(all constatnts and variables are in nanoseconds):

```
ti = 0;
tf = 200;
```

The frequency when detuned by one peak Rabi is(multiplied by ln(2) for the BW we choose)

```
Manipulate[
 Plot[Ω0 * Exp[-2 Log[2] (t - (tf - ti) / 2)^2 / τ^2], {t, ti, tf}, PlotRange → All],
 {{Ω0, Sqrt[π Log[4]] / τ}, 0, 10, 2 * Sqrt[π Log[4]] / τ}]
```



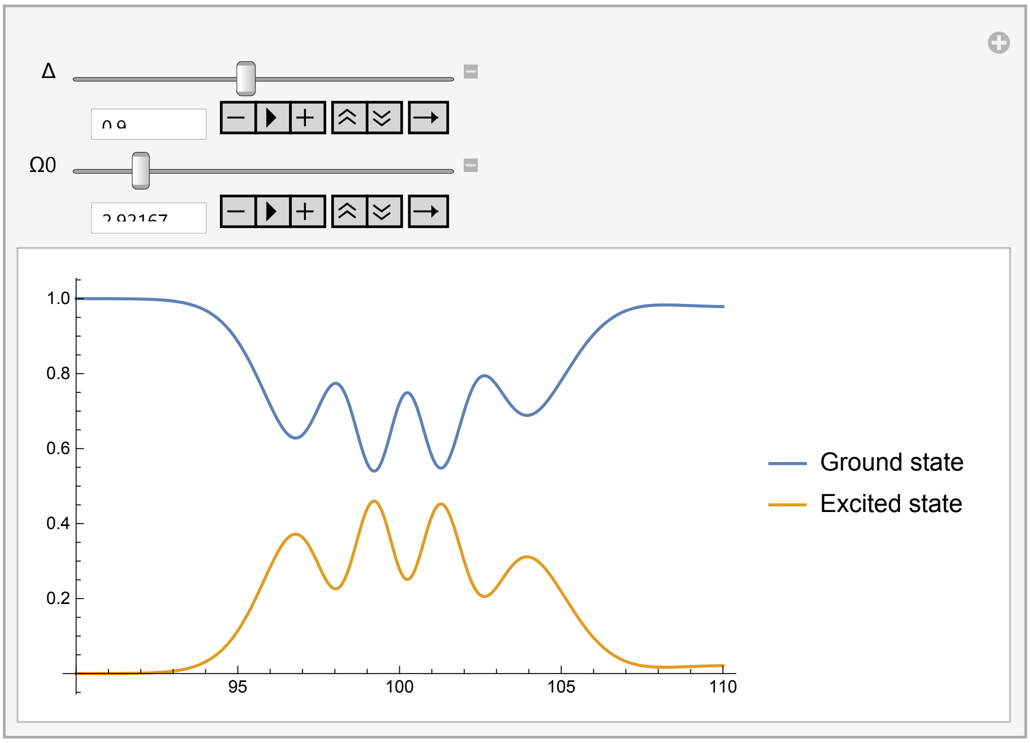
For operating purposes we write down the Rabi frequency relative to its peak

```
Ωrel[t_] := Exp[-2 Log[2] (t - (tf - ti) / 2)^2 / τ^2];
```

As well as the representation of the population for varying detuning Δ and peak Rabi Ω_0

```
Manipulate[Block[{c1Solved, sc2Solved, c1, c2, t, s},

  s = NDSolve[{c1'[t] == -ⅈ Ω0 * Ωrel[t] * c2[t] / 2,
     c2'[t] == -ⅈ Ω0 * Ωrel[t] * c1[t] / 2 - ⅈ Δ c2[t],
     c1[ti] == 1, c2[ti] == 0}, {c1[t], c2[t]}, {t, ti, tf}];
  c1Solved = c1[t] /. s[[1, 1]];
  c2Solved = c2[t] /. s[[1, 2]];
  Plot[{c1Solved * Conjugate[c1Solved], c2Solved * Conjugate[c2Solved]}, {t, 90,
    110}, PlotRange → All, PlotLegends → {"Ground state", "Excited state"}]]
 , {{Δ, 0}, 0, 2, 0.1}, {{Ω0, Sqrt[π Log[4]] / τ}, 0, 20, Sqrt[π Log[4]] / τ}]
```



The effective Rabi frequency is Ω_{eff}

```
Manipulate[{Ω0² / Sqrt[Ω0² + Δ²]}, {{Δ, 0}, 0, 100, 5}, {{Ω0, 1}, 0, 10, 0.5}]
```