Q3: Installation & Quick Start

```
In[•]:= << Q3`
```

Elementary Example: General

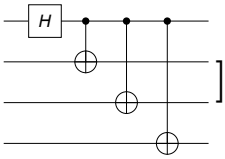
```
In[•]:= ∫ 1/(a + b x^2) dx
```

```
In[•]:= sol = DSolve[{f'[t] == -f[t] + t, f[0] == 1}, f[t], t]

In[•]:= Plot[f[t] /. sol, {t, 0, 3},
         FrameLabel → {"t", f[t]}]
```

Elementary Example: Q3

```
In[•]:= << Q3`

In[•]:= Let[Qubit, S]
        Let[Real, ϕ]

In[•]:= U = MultiplyExp[-I * S[3] * ϕ / 2];
        expr = U ** S[1] ** Dagger[U]

In[•]:= new = Elaborate[expr]

In[•]:= new // ExpToTrig // Garner
```

```
In[•]:= ExpressionFor[
```

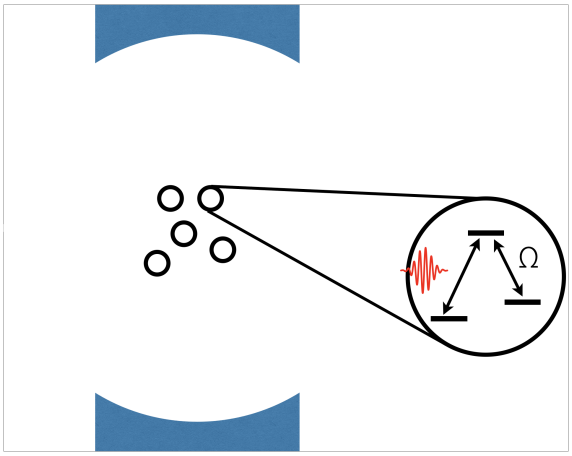



```
]
```

Installation of Q3

```
Module[
 {ps},
 ps =
  PacletSiteRegister["https://github.com/quantum-mob/PacletServer/raw/main",
   "Quantum Mob Paclet Server"];
 PacletSiteUpdate[ps];
 PacletInstall["Q3"]
]
```

Λ-Matter in a Cavity



In this example, we consider a system of Λ-level (artificial) atoms in a single-mode cavity. Each atom has two ground-state levels $|0\rangle$ and $|1\rangle$ and a excited-state level $|2\rangle$, and no transition is allowed between 0 and 1; and hence Λ-level structure. Suppose that transition $0 \to 2$ is induced resonantly by photon in the cavity whereas transition $1 \to 2$ is driven classically by an external laser.

With different atoms interacting with each other by exchanging photons, the system is strongly correlated. Here we examine symmetries of the system to reveal the zero-energy subspace with decoherence-free feature. For more details of the system and the properties of the zero-energy subspace, see Chen et al. (arXiv/2103.07907).

In[•]:=
```
$p = 2;(*the total number of excitations*)
```

In[•]:=
```
Let[Boson, c, Top → $p]
Let[Qudit, A]
Let[Real, Ω]
```

In[•]:=
```
$n = 3; (* the number of atoms *)
kk = Range[$n];
AA = A[kk, None];
```

```
In[•]:= Hg = Total[Dagger[c] ** A[kk, 1 → 0]] // PlusDagger
        Hw = Ω * Total@A[kk, 1 → 2] // PlusDagger
        HH = Hg + Hw;
```

```
In[•]:= bs = Basis[AA];
        bs = KetPurge[bs, Hold[Count[A[kk], 0] < $n - $p]];
        bs = KetUpdate[bs, c → Hold[$p - $n + Count[A[kk], 0]]];

In[•]:= mat = MatrixIn[HH, bs];
        mat // MatrixForm
```

```
In[•]:= sbs = SchurBasis[AA];
        sbs = KetPurge[sbs, Hold[Count[A[kk], 0] < $n - $p]];
        sbs = KetUpdate[sbs, c → Hold[$p - $n + Count[A[kk], 0]]];
        sbs = KeyGroupBy[sbs, First, Values];
        Length /@ KeyMap[YoungForm@*ToYoungTableau, sbs]

In[•]:= new = MatrixIn[HH, sbs, sbs] // SimplifyThrough;
        new = Values@KeyGroupBy[new, First, Values];
        Map[MatrixForm, new, {2}] // MatrixForm
```