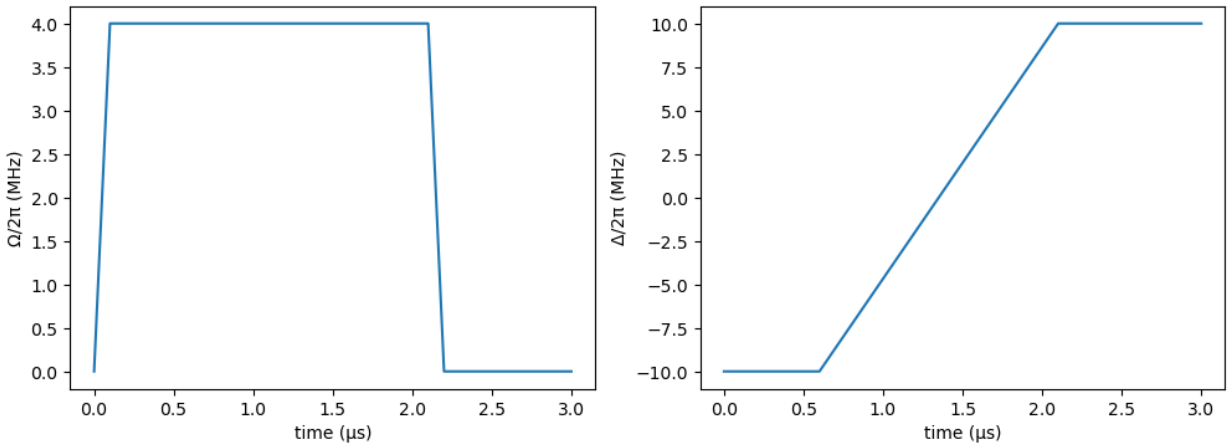
In [2]:
```
using Bloqade
using PythonCall
using KrylovKit
using SparseArrays

plt = pyimport("matplotlib.pyplot");
```

Define time-dependent Rabi frequency, $\Omega(t)$, and detuning parameter, $\Delta(t)$

In [3]:
```
t_tot = 3.0;
Ω_max = 2π * 4;
Ω = piecewise_linear(clocks = [0.0, 0.1, 2.1, 2.2, t_tot], values = [0
U = 2π * 10;
Δ = piecewise_linear(clocks = [0.0, 0.6, 2.1, t_tot], values = [-U, -U

fig, (ax1, ax2) = plt.subplots(ncols = 2, figsize = (12, 4))
Bloqade.plot!(ax1, Ω)
ax1.set_ylabel("Ω/2π (MHz)")
Bloqade.plot!(ax2, Δ)
ax2.set_ylabel("Δ/2π (MHz)")
fig
```

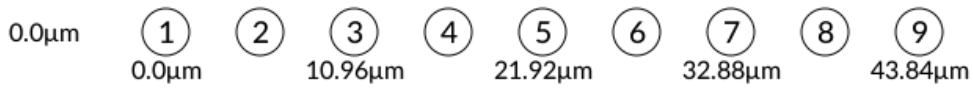
Out[3]:



Create 1D chain with 9 atom sites

In [4]:
```
nsites = 9
atoms = generate_sites(ChainLattice(), nsites, scale = 5.48)
```

Out[4]:



Define time-dependent Rydberg Hamiltonian

In [5]:
```
h = rydberg_h(atoms; Δ, Ω)
```

Out[5]:
$$\sum \frac{2\pi \cdot 0.863 \times 10^{6.0}}{|r_i - r_j|^6} n_i n_j + 1 \cdot \Omega(t) \cdot \sum \sigma_i^x - \Delta(t) \cdot \sum n_i$$

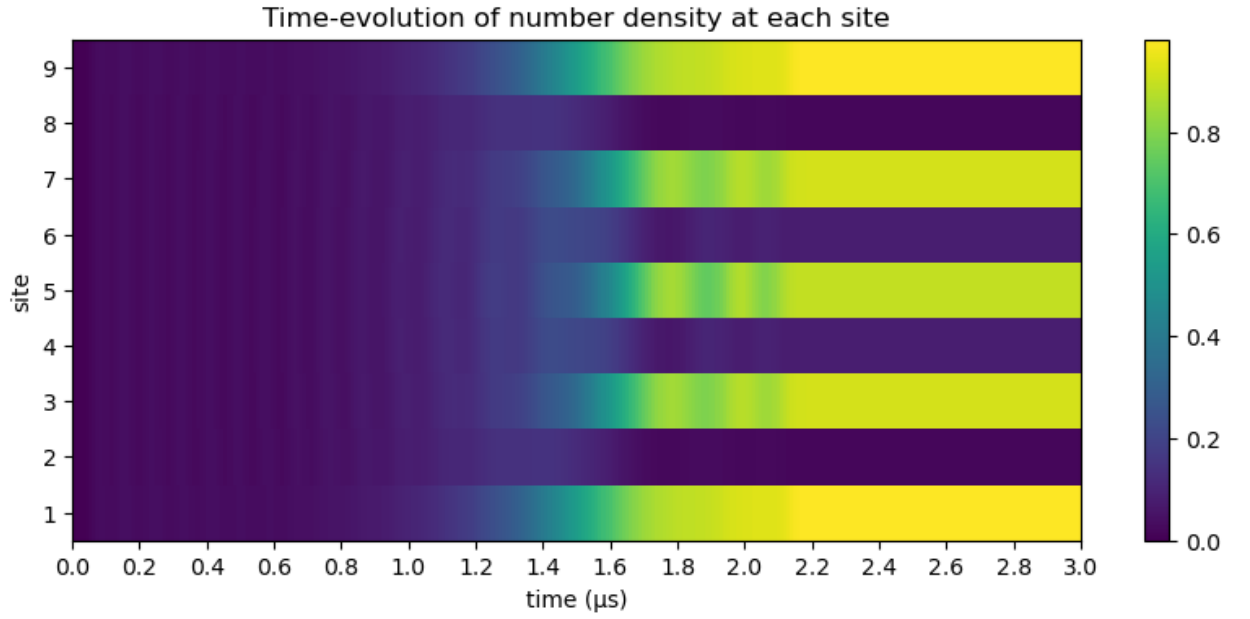
Set all atoms to ground state in initial state and set up time-evolution problem

In [17]:
```
reg = zero_state(9);
prob = SchrodingerProblem(reg, t_tot, h);
integrator = init(prob, Vern8());
```

Calculate the site number densities, $\langle n_i(t) \rangle$, as the initial state adiabatically time-evolves

In [18]:
```
densities = []
for _ in TimeChoiceIterator(integrator, 0.0:1e-2:t_tot)
    push!(densities, rydberg_density(reg))
end
D = hcat(densities...);

fig, ax = plt.subplots(figsize = (10, 4))
shw = ax.imshow(real(D), interpolation = "nearest", aspect = "auto", e
ax.set_title("Time-evolution of number density at each site")
ax.set_xlabel("time (μs)")
ax.set_ylabel("site")
ax.set_xticks(0:0.2:t_tot)
ax.set_yticks(1:nsites)
bar = fig.colorbar(shw)
fig
```

Out[18]:

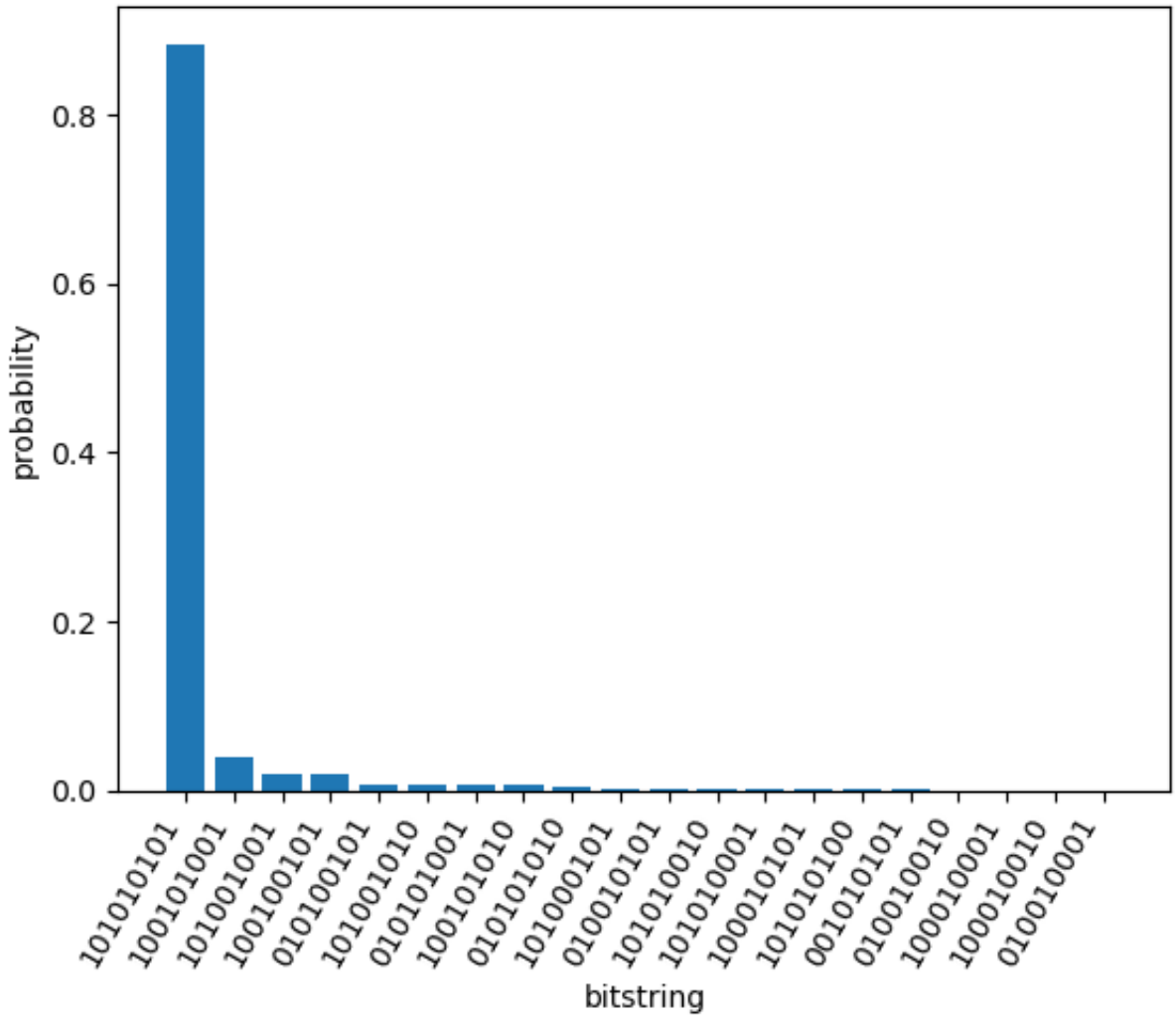


In [19]:
```
measure(reg)[]
```

Out[19]: 101010101 (2)

In [20]:
```
bitstring_hist(reg; nlargest = 20)
```

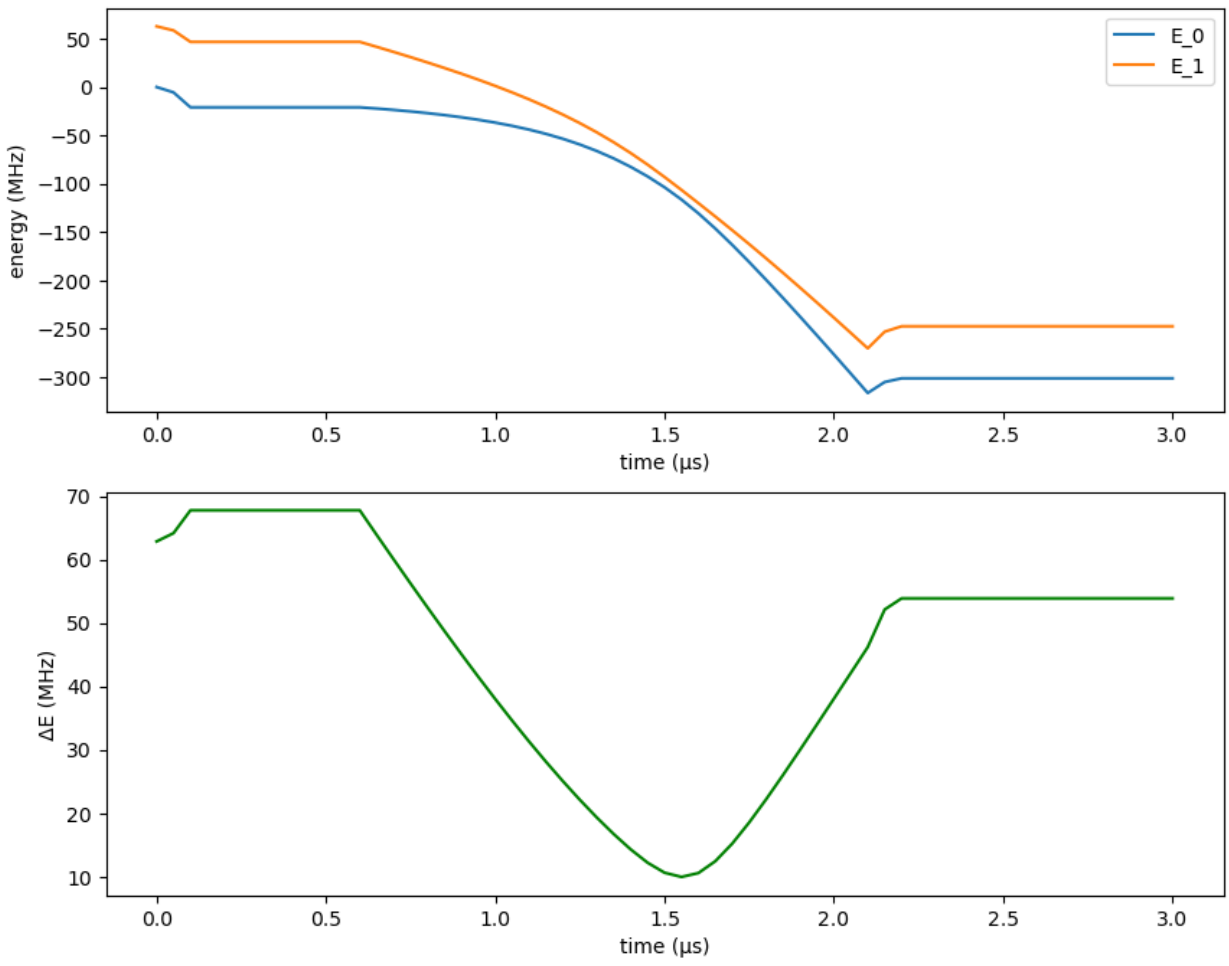
Out[20]:



Energy of ground and first excited states

In [9]:
```
E0 = []; E1 = [];
tseq = collect(0.0:0.05:t_tot)
for t in tseq
    ht = h |> attime(t)
    h_m = mat(ht)
    vals, vecs, info = KrylovKit.eigsolve(h_m, 5, :SR)
    push!(E0, vals[1]);push!(E1, vals[2]);
end

fig, (ax1, ax2) = plt.subplots(nrows = 2, figsize = (10, 8))
ax1.plot(tseq, E0, label = "E_0")
ax1.plot(tseq, E1, label = "E_1")
ax1.set_xlabel("time (μs)")
ax1.set_ylabel("energy (MHz)")
ax1.legend()
ax2.plot(tseq, E1 - E0, 'g')
ax2.set_xlabel("time (μs)")
ax2.set_ylabel("ΔE (MHz)")
fig
```

Out[9]:



In [11]:
```
minimum(E1 - E0)
```

Out[11]:
```
9.95423632964821
```

Expectation value, $\langle \sigma_i^x \rangle$, at each site

In [23]:
```
measure(reg)[]
```

Out[23]:
```
101010101 (2)
```

In [22]:
```
println("Expectation value of X at site")
for i in 1:9
    println(i, ": ", expect(put(9,i=>X), reg))
end
```

```
Expectation value of X at site
1: -0.0009154741016707858 + 0.0im
2: -0.002741274442991784 + 0.0im
3: 0.01565263209333362 + 0.0im
4: -0.002034021969768495 - 1.0842021724855044e-19im
5: 0.02624159404006243 + 0.0im
6: -0.0020340219697753278 - 2.168404344971009e-19im
7: 0.0156526320931435 + 6.938893903907228e-18im
8: -0.002741274442967876 5 + 4.336808689942018e-19im
9: -0.0009154741018149708 + 0.0im
```

In [ ]:
```
```