Update 04/03

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04/03/20

Averin Coupler - Pauli coefficients extraction

Qubit parameters:

$E_{J,q} = 99.34$ GHz,

$C_{J,q} = 4$ fF,

$L = 3.2$ nH,

$C_{sh} = 0$ fF.

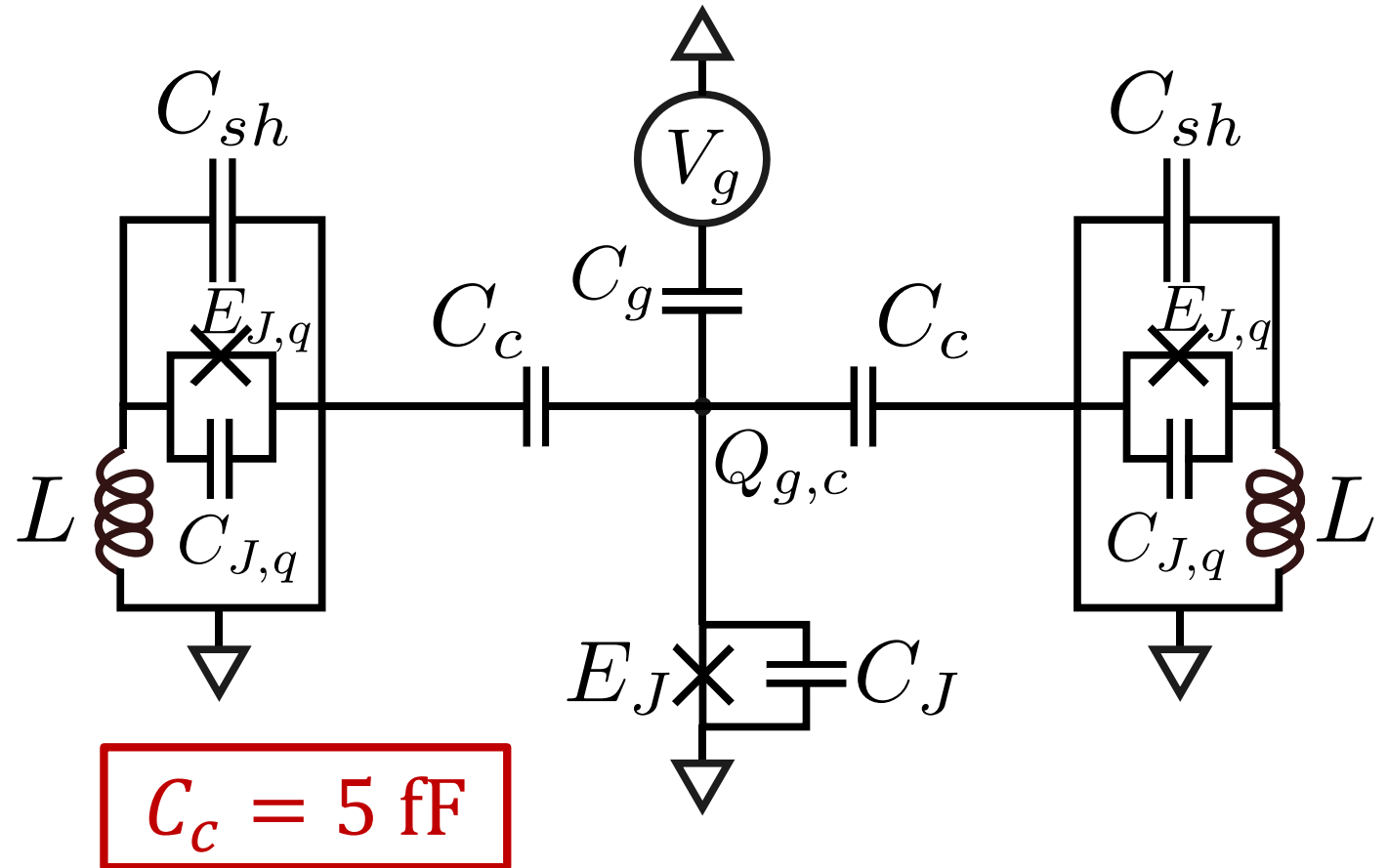**Coupler parameters:**

$E_J = 19.87$ GHz,

$C_J = 4.3$ fF,

$C_g = 2.5$ fF.

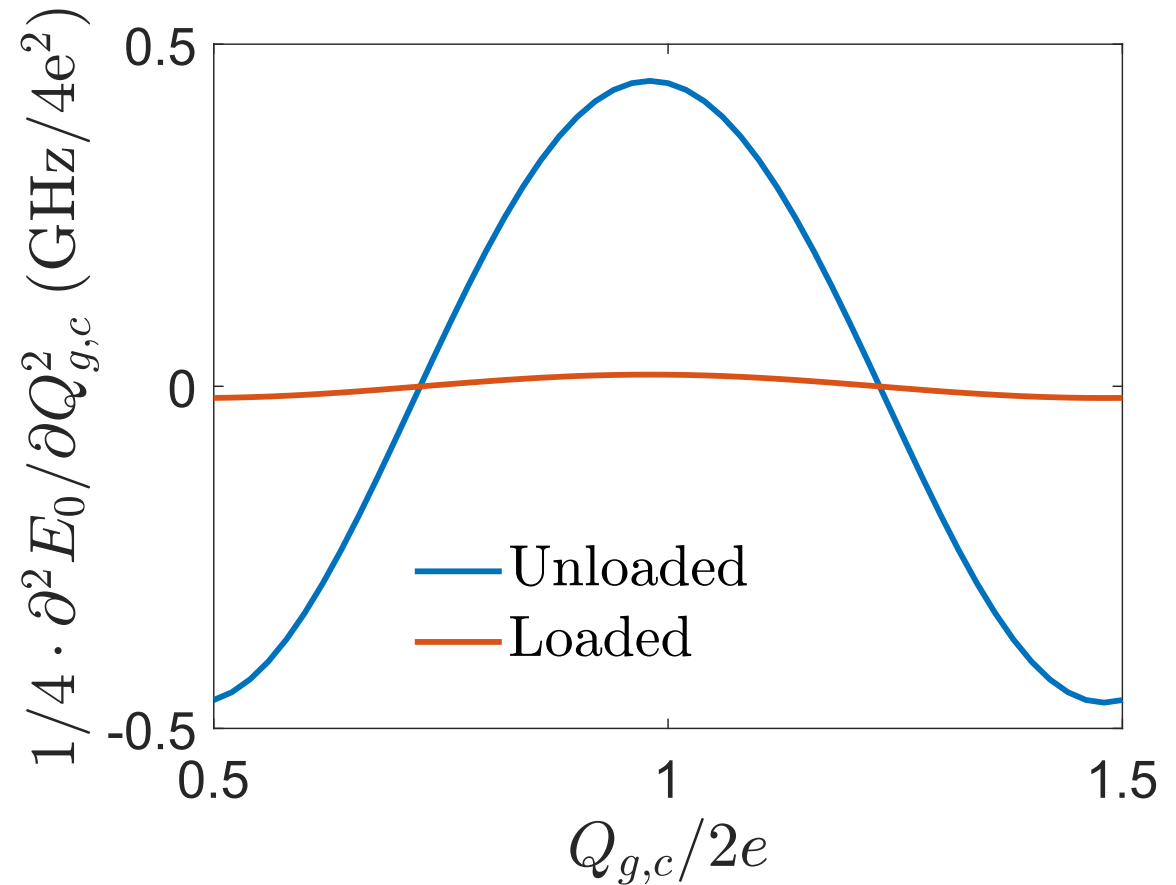
$C_c = 5$ fF

Averin Coupler - Pauli coefficients extraction
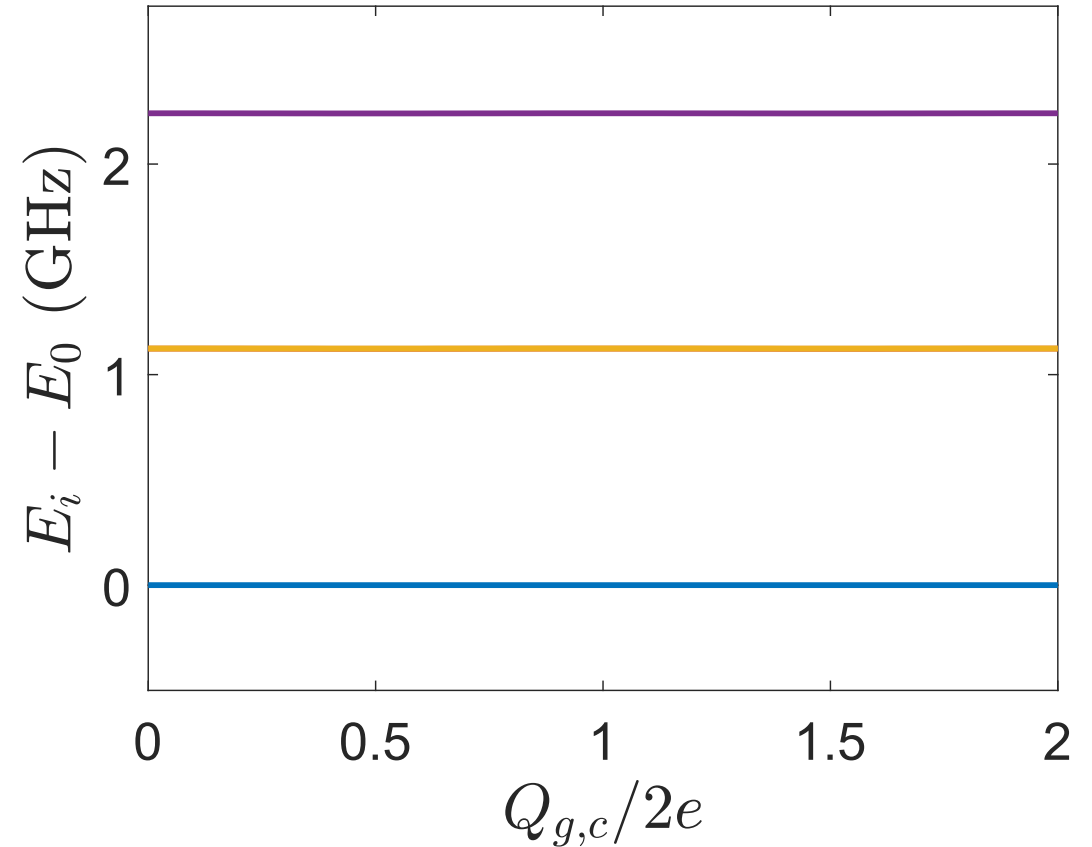
Coupling parameter (Averin):

Loaded coupler island capacitance = 13.7 fF. A larger capacitance reduces the interaction parameter
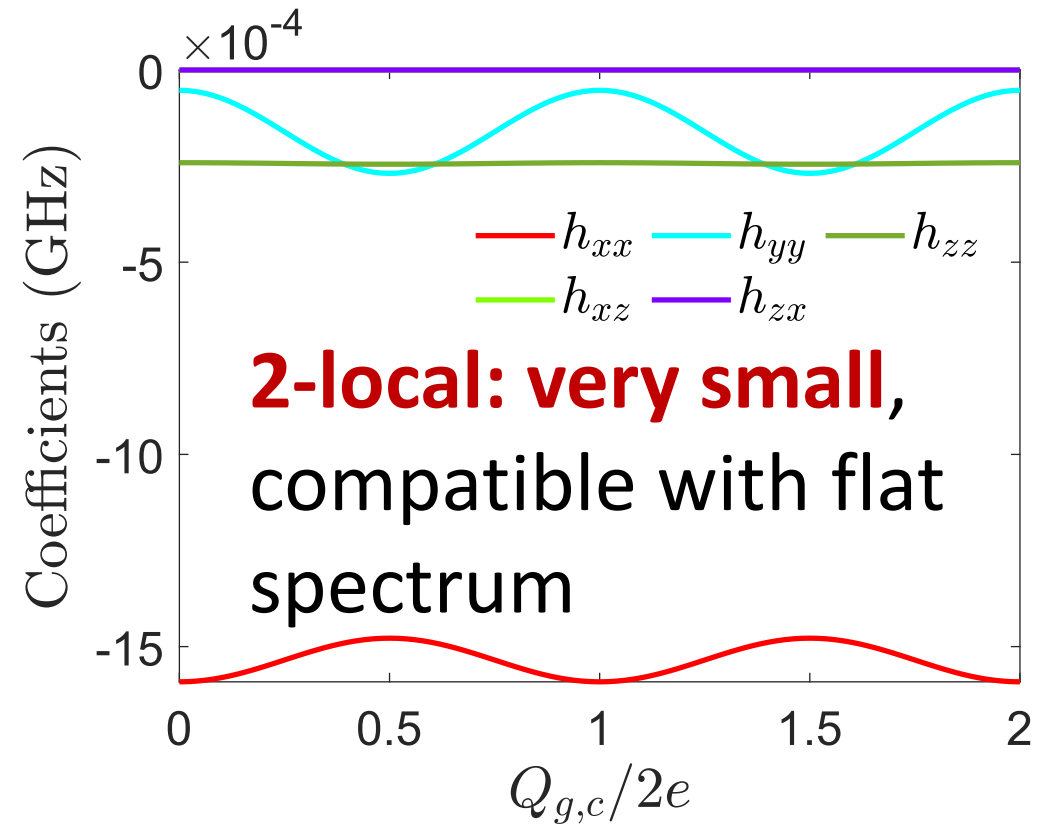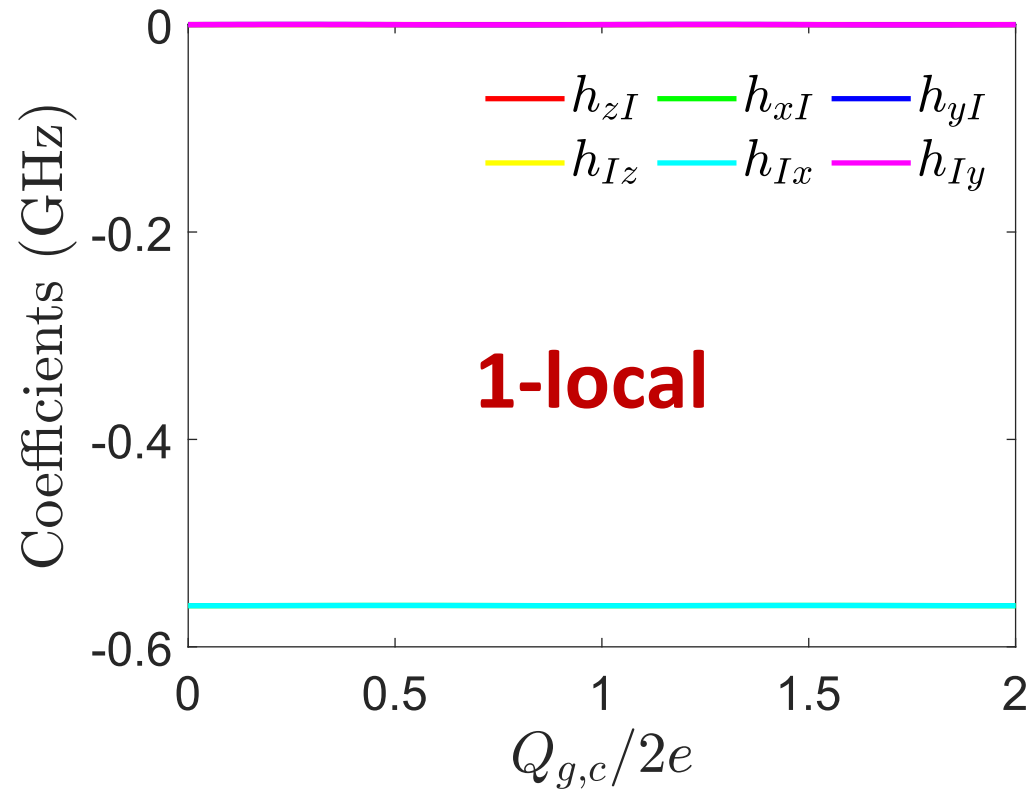
Averin Coupler - Pauli coefficients extraction

System spectrum:

Lowest 4 transition energies vs. coupler island charge bias (qubits biased at 0.5 Φ_0). Spectrum is basically **flat**.

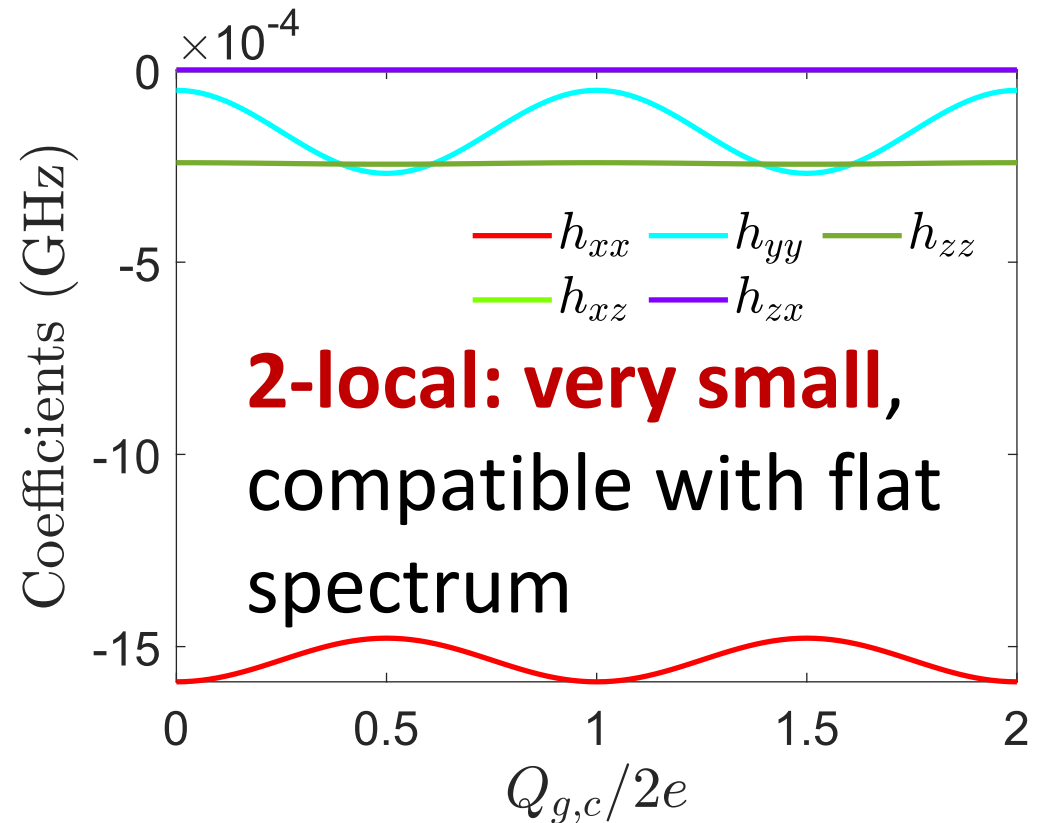# Averin Coupler - Pauli coefficients extraction

Extracted params:

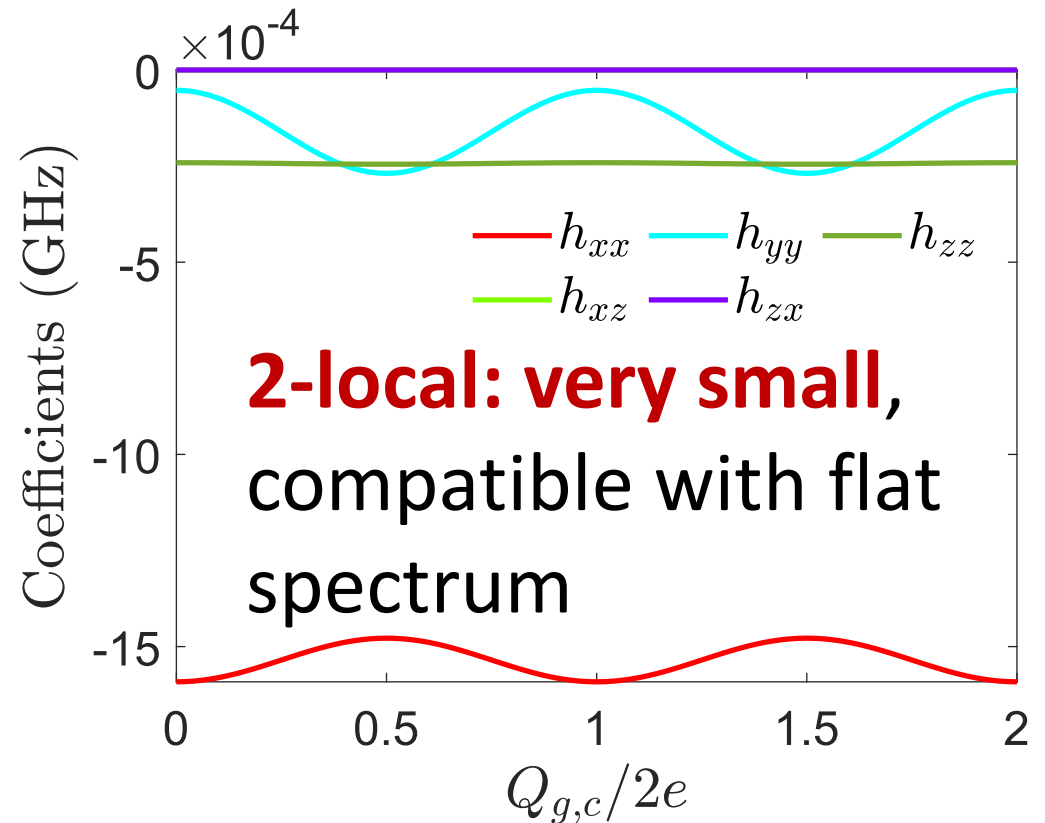# Averin Coupler - Pauli coefficients extraction

Extracted params:

Note how all the interactions are **"ferromagnetic"** (negative in sign)

2-local: very small, compatible with flat spectrum

Averin Coupler - Pauli coefficients extraction

Extracted params:

Note how all the interactions are **"ferromagnetic"** (negative in sign). This is because the capacitors configuration results in static interaction terms between qubit charges (same as in the inductive case)
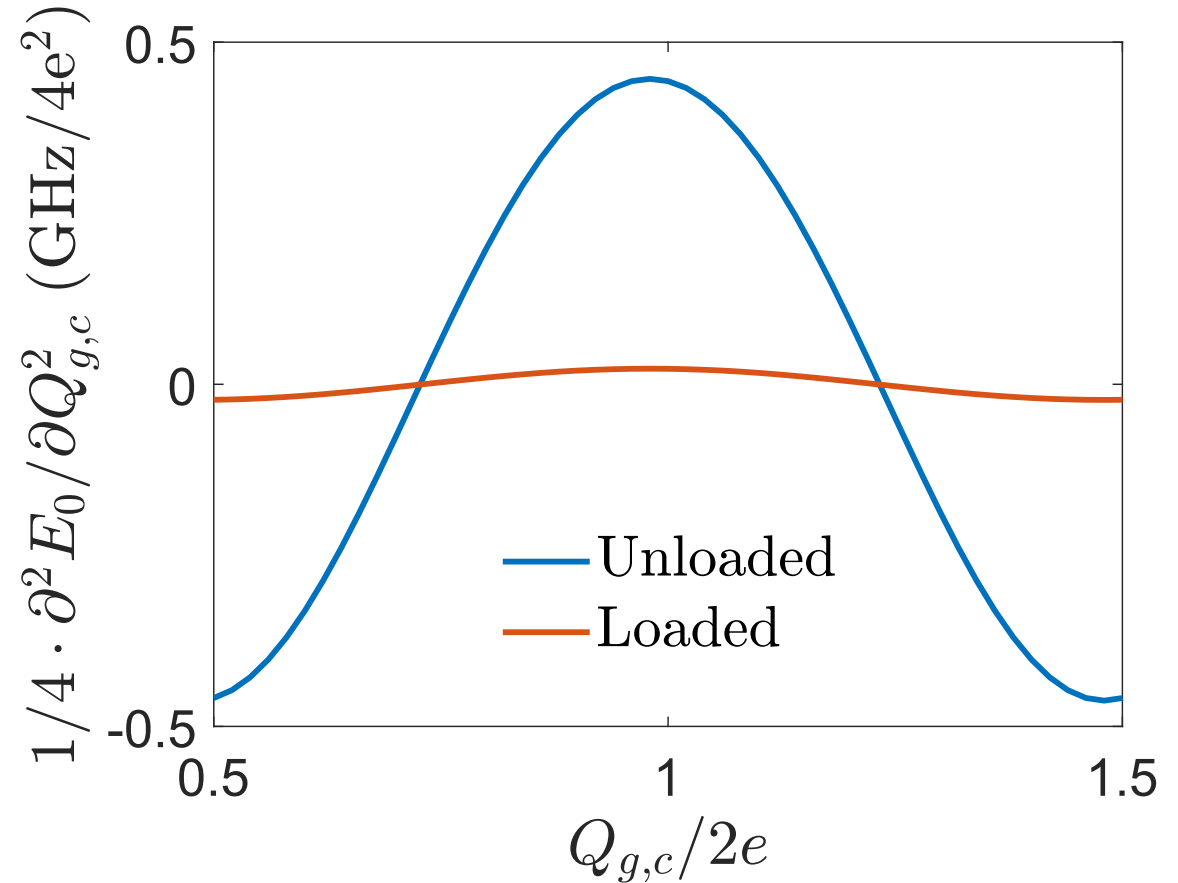

2-local: very small, compatible with flat spectrum

Averin Coupler - Pauli coefficients extraction

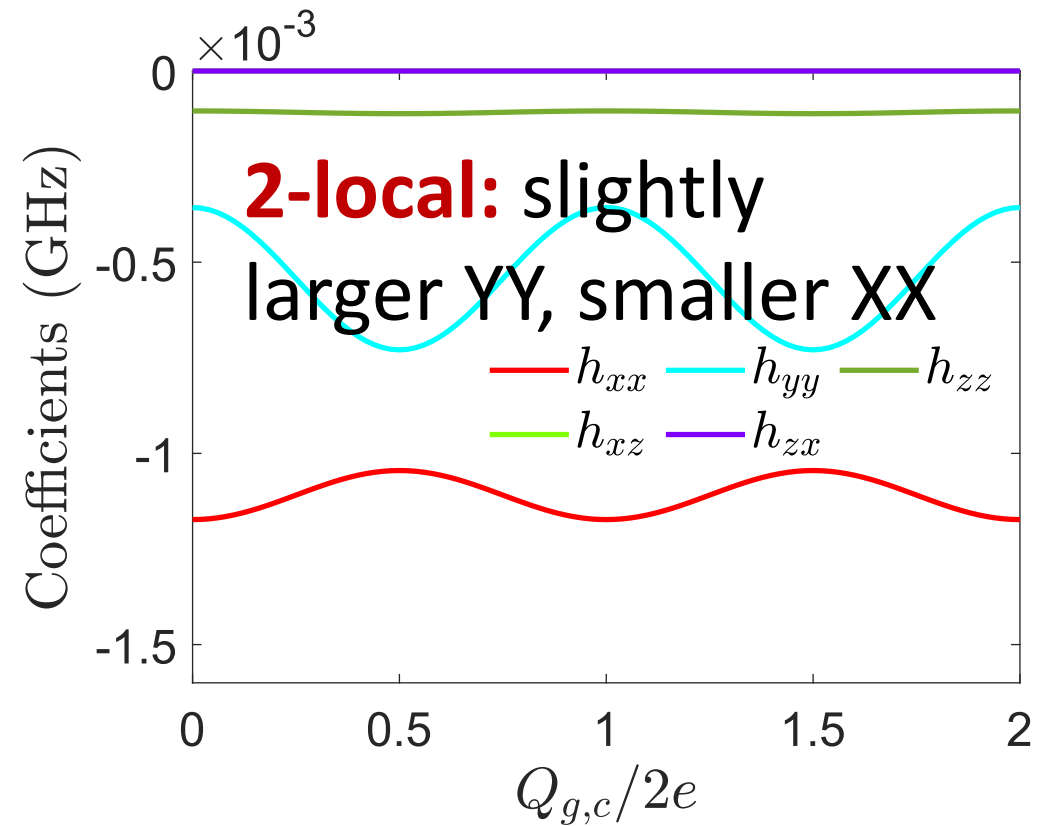$$C_c = 3.5 \text{ fF}$$
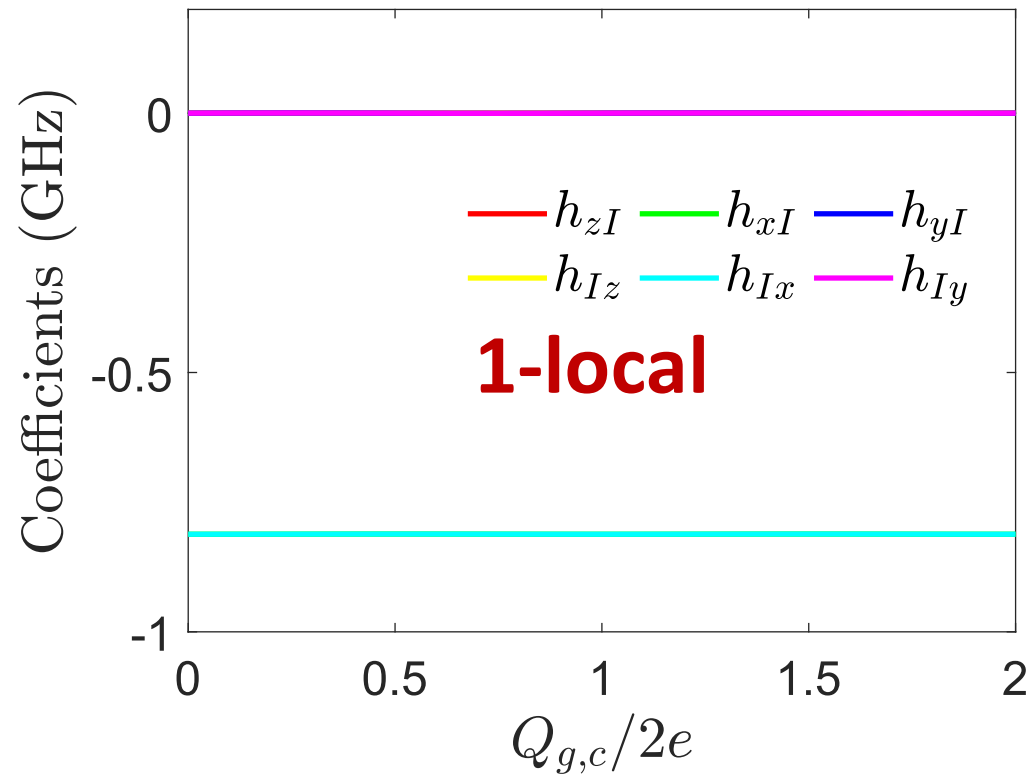
Coupling parameter (Averin):

Loaded coupler island capacitance = 13.0 fF

Averin Coupler - Pauli coefficients extraction

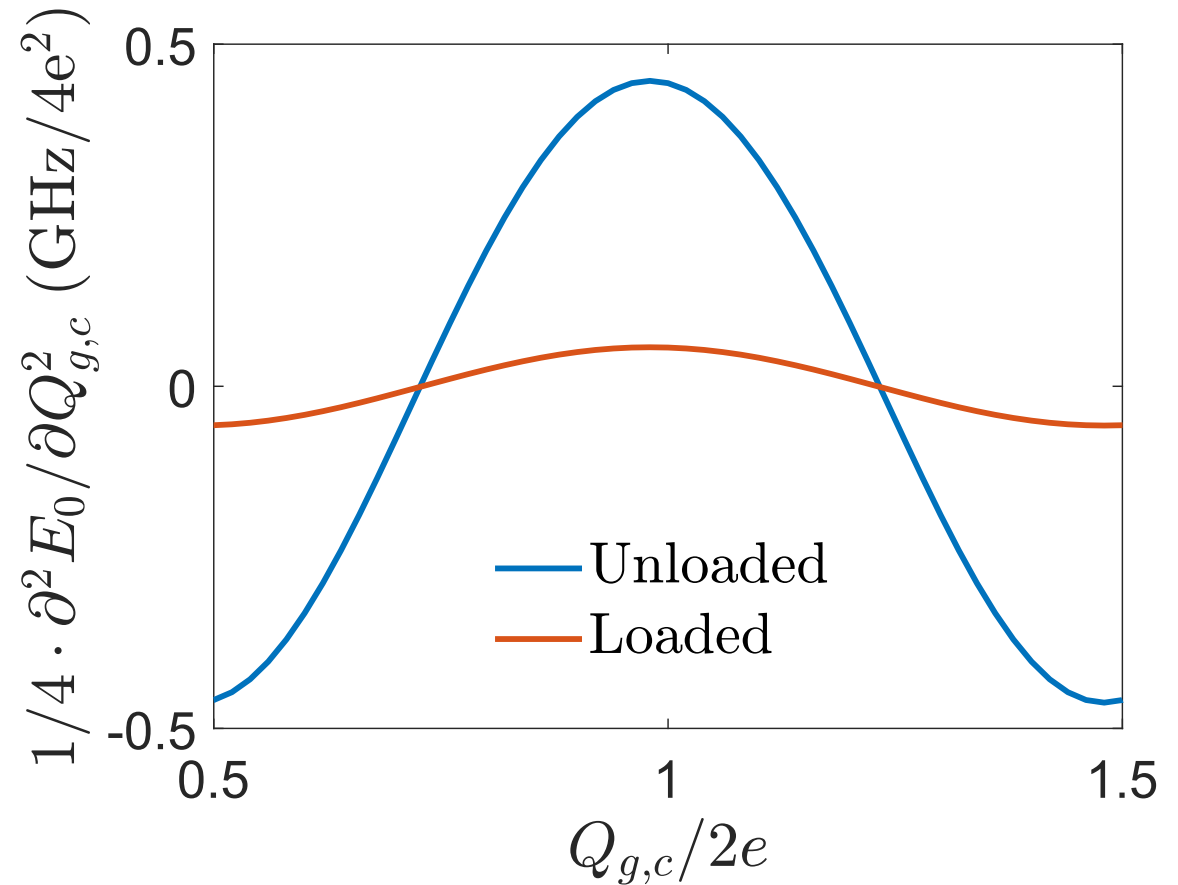**Extracted params:** $C_c = 3.5 \text{ fF}$

Averin Coupler - Pauli coefficients extraction
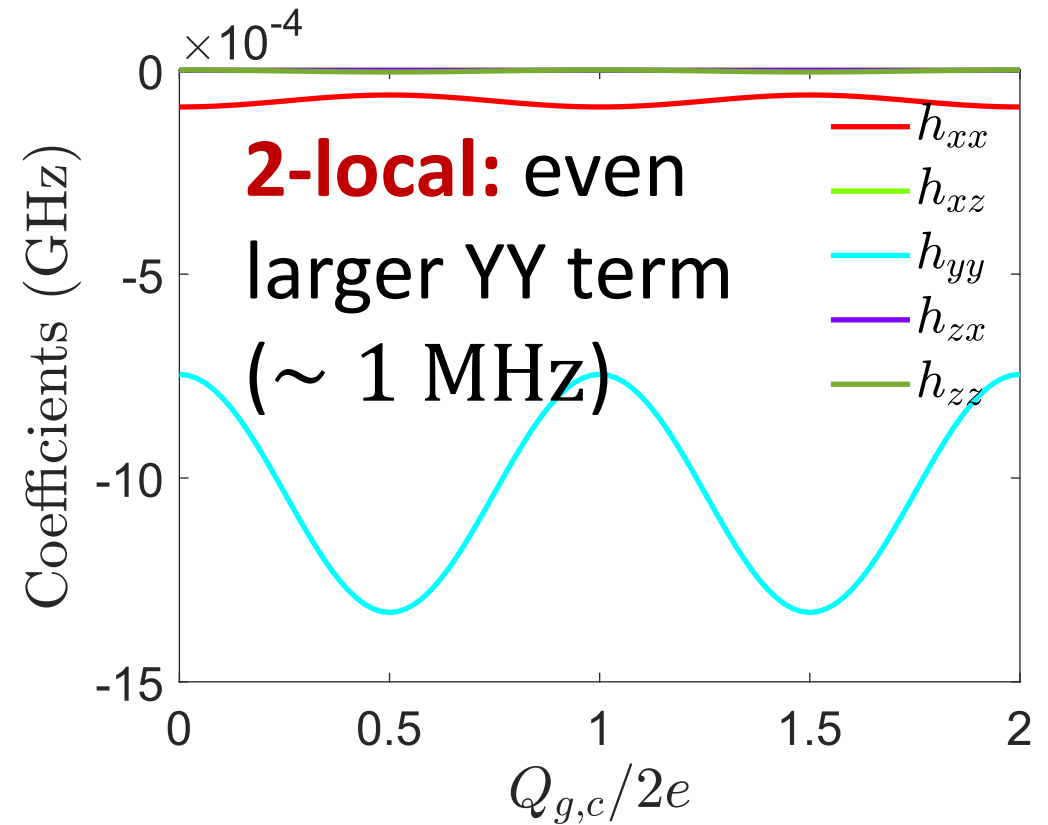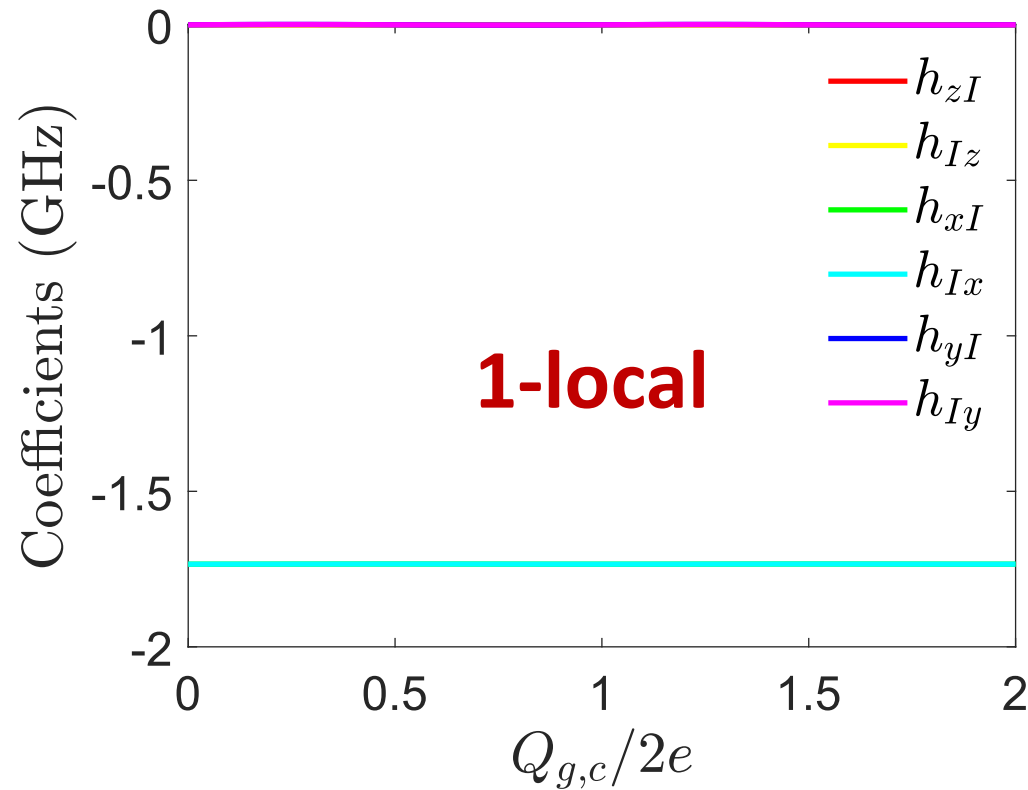
$$C_c = 1 \text{ fF}$$

Coupling parameter (Averin):

Loaded coupler island capacitance = 10.9 fF

Averin Coupler - Pauli coefficients extraction

Extracted params: $C_c = 1\ \text{fF}$

J_{yy} and $c = \frac{1}{4}\partial^2 E_{0,c}/\partial Q_{g,c}^2$ seem related by a linear transformation dependent on the coupling capacitance C_c:

Here ratio is defined as

$$Ratio = \frac{c - \langle c \rangle}{J_{yy} - \langle J_{yy} \rangle},$$

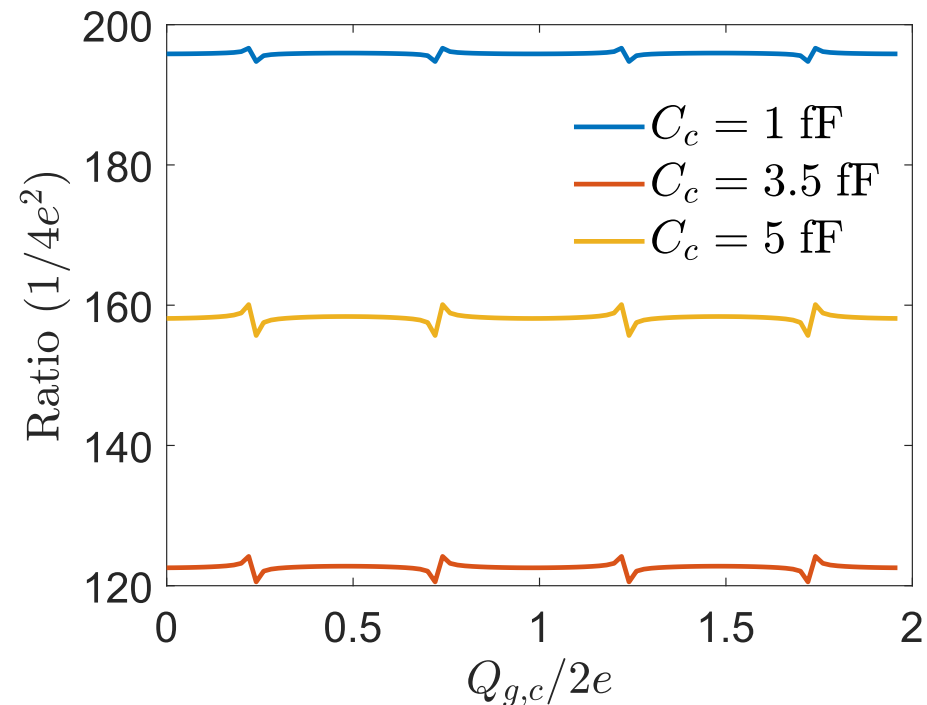where $\langle \cdot \rangle$ is the average over a period.

Averin Coupler - Pauli coefficients extraction

J_{yy} and $c = \frac{1}{4}\partial^2 E_{0,c}/\partial Q_{g,c}^2$ seem related by a linear transformation dependent on the coupling capacitance C_c:

Here ratio is defined as

$$Ratio = \frac{c-\langle c\rangle}{J_{yy}-\langle J_{yy}\rangle},$$

where $\langle\cdot\rangle$ is the average over a period.

The order of magnitude of this ratio seems compatible with $1/\left|\langle g|\hat{Q}|e\rangle\right|^2$ (in units of $1/4e^2$), where $\langle g|\hat{Q}|e\rangle$ is a matrix element of the qubit charge operator.

Averin Coupler - Pauli coefficients extraction

Extracted params: <u>shunted qubits variant</u>

Qubit parameters:

$E_{J,q} = 99.34 \text{ GHz}$,

$C_{J,q} = 4 \text{ fF}$,

$L = 1.6 \text{ nH}$,

$C_{sh} = 45 \text{ fF}$.

$C_c = 5 \text{ fF}$ (coupler island loaded capacitance = 18.4 fF): SWT breaks ☹, coupler 1st excited state below 2*qubit first excited state.

Averin Coupler - Pauli coefficients extraction

Extracted params: <u>shunted qubits variant</u>

Qubit parameters:
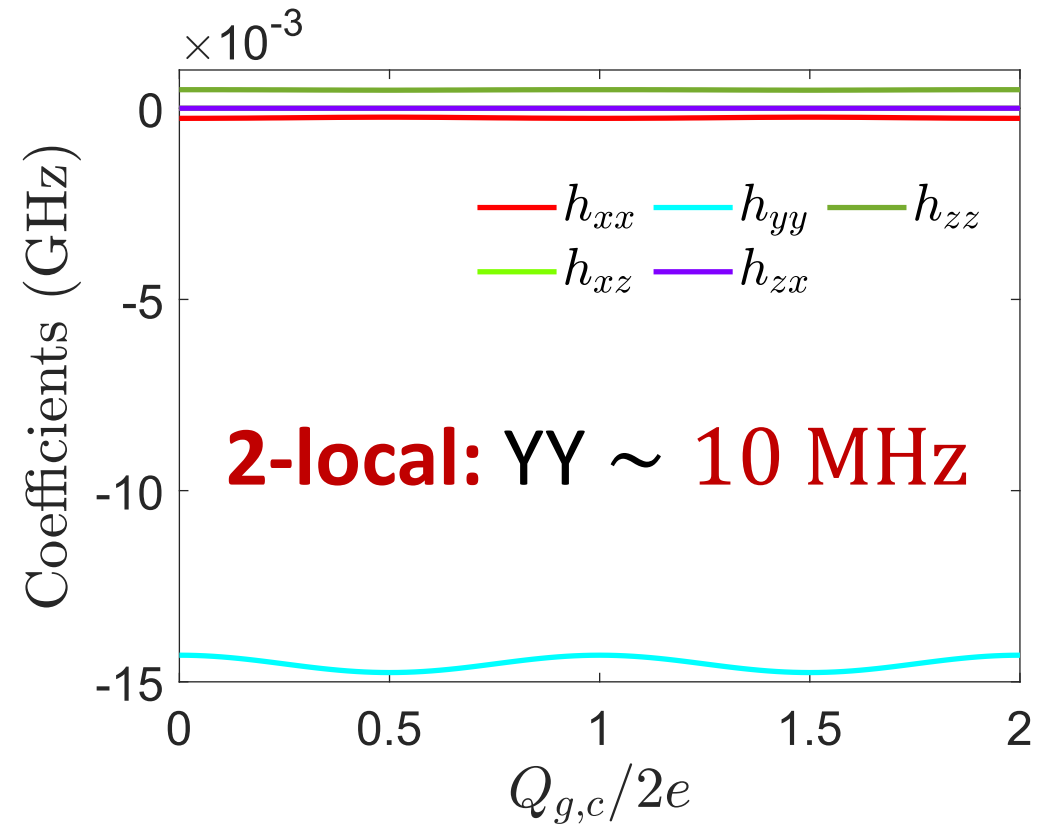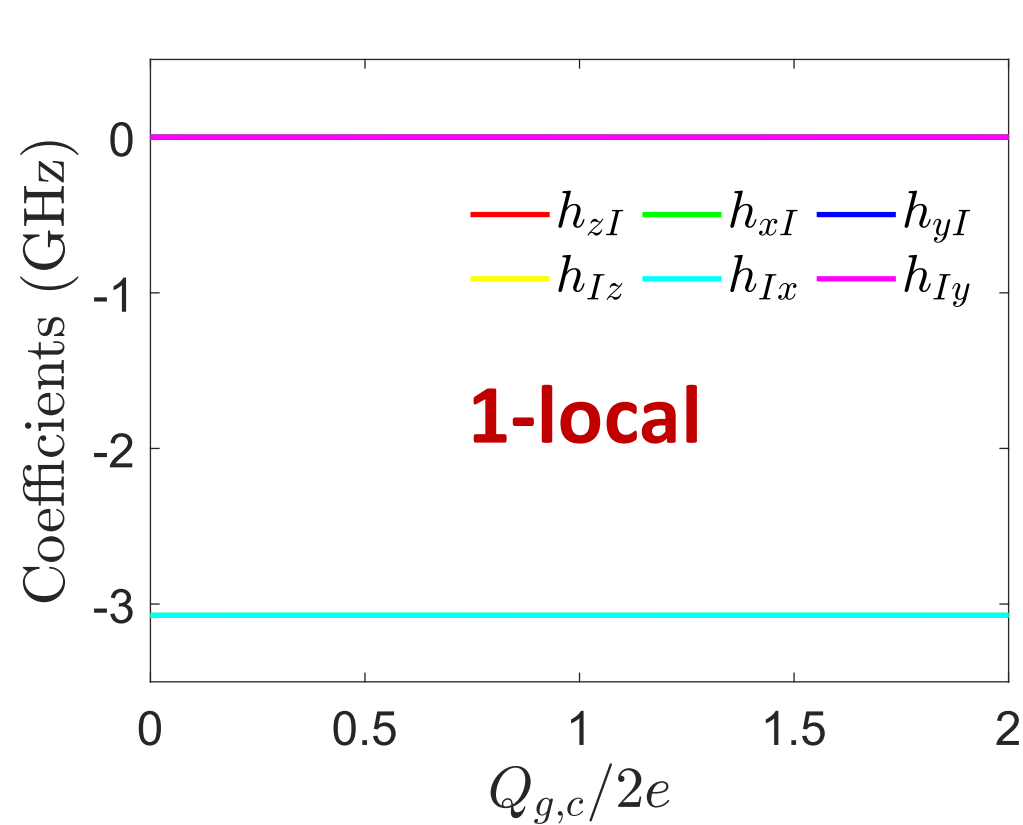
$$E_{J,q} = 99.34 \text{ GHz},$$

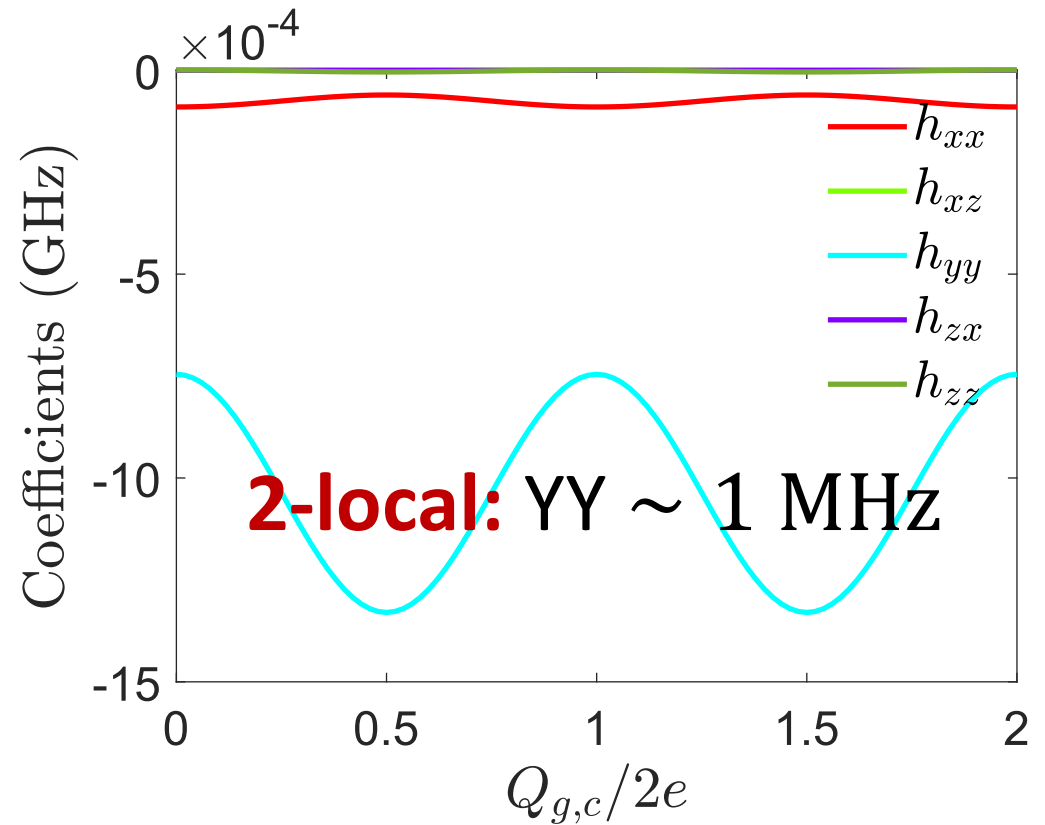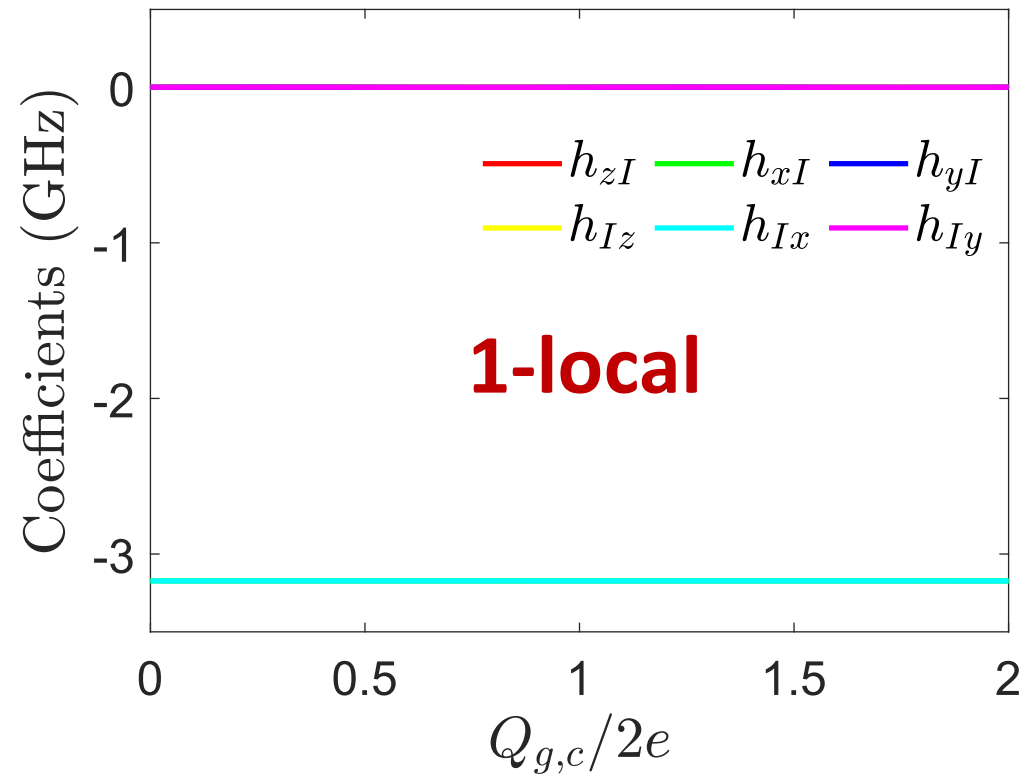$$C_{J,q} = 4 \text{ fF},$$

$$L = 1.6 \text{ nH},$$

$$C_{sh} = 45 \text{ fF}.$$

$C_c = 3.5 \text{ fF}$ (coupler island loaded capacitance = 15.8 fF)

Averin Coupler - Pauli coefficients extraction

Extracted params: shunted qubits variant

Averin Coupler - Pauli coefficients extraction

Extracted params: <u>shunted qubits variant</u>

Qubit parameters:

$E_{J,q} = 99.34$ GHz,

$C_{J,q} = 4$ fF,

$L = 1.6$ nH,

$C_{sh} = 45$ fF.

$C_c = 1$ fF (coupler island loaded capacitance = 11.1 fF)

Averin Coupler - Pauli coefficients extraction

Extracted params: <u>shunted qubits variant</u>

Averin Coupler - Pauli coefficients extraction

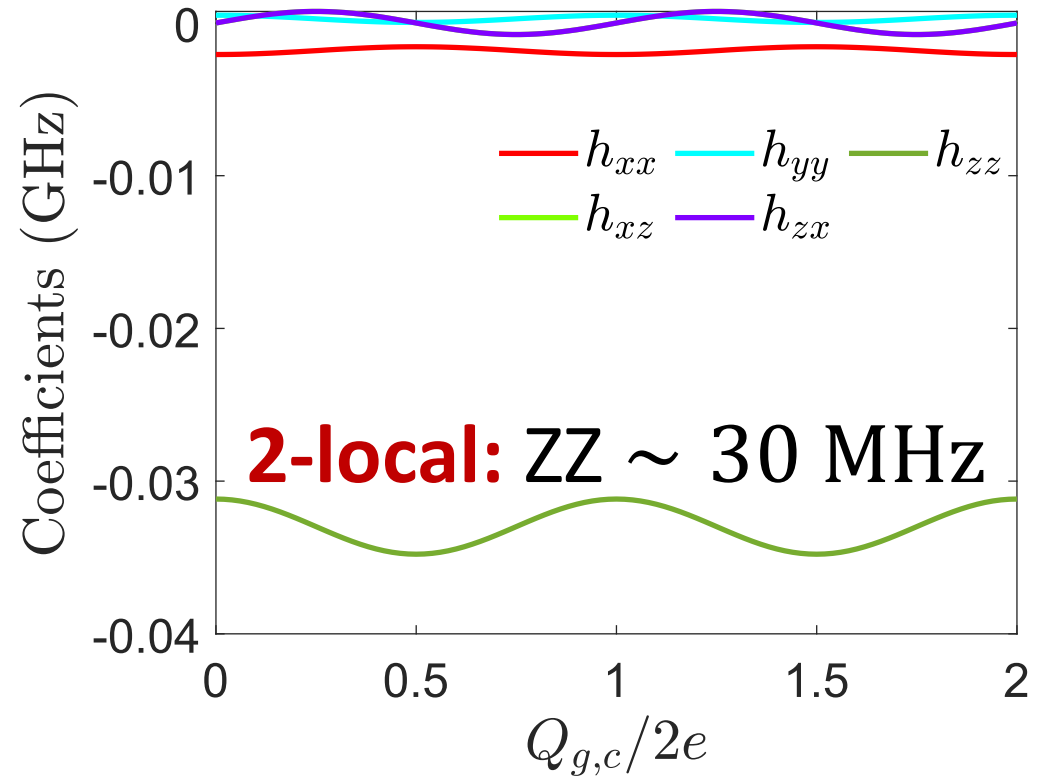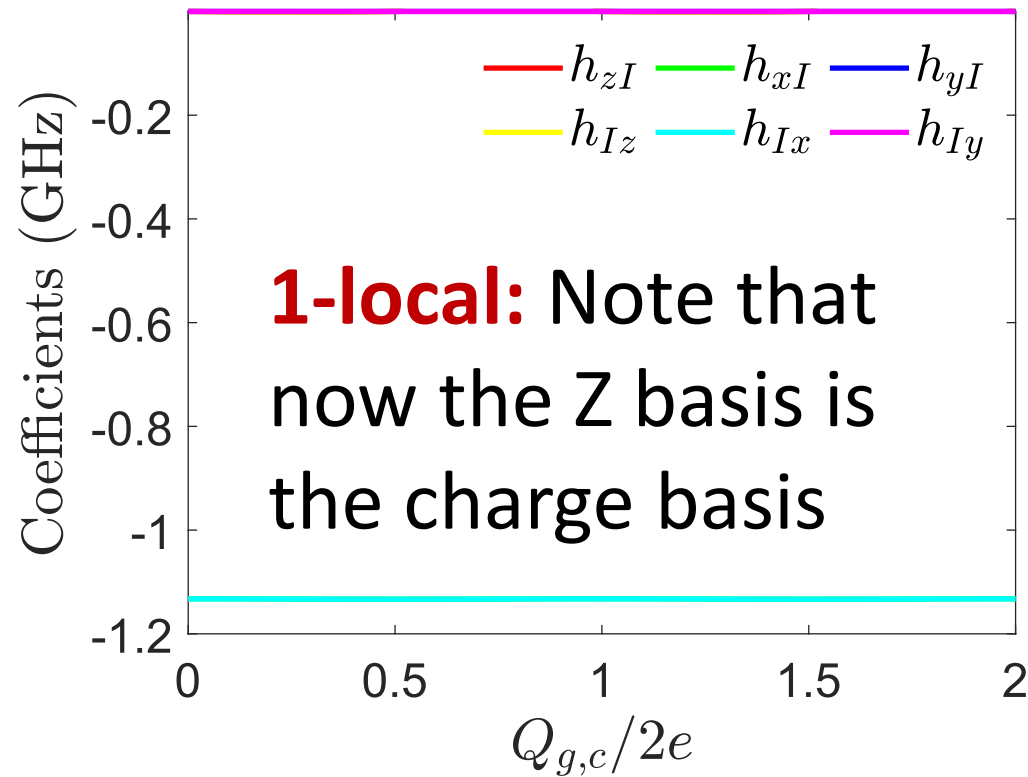**Charge qubits case:**

Qubit parameters:

$E_{J,q} = 2.48 \text{ GHz},$

$C_{J,q} = 1 \text{ fF}.$

$C_c = 5 \text{ fF}$ (coupler island loaded capacitance = 13.0 fF)

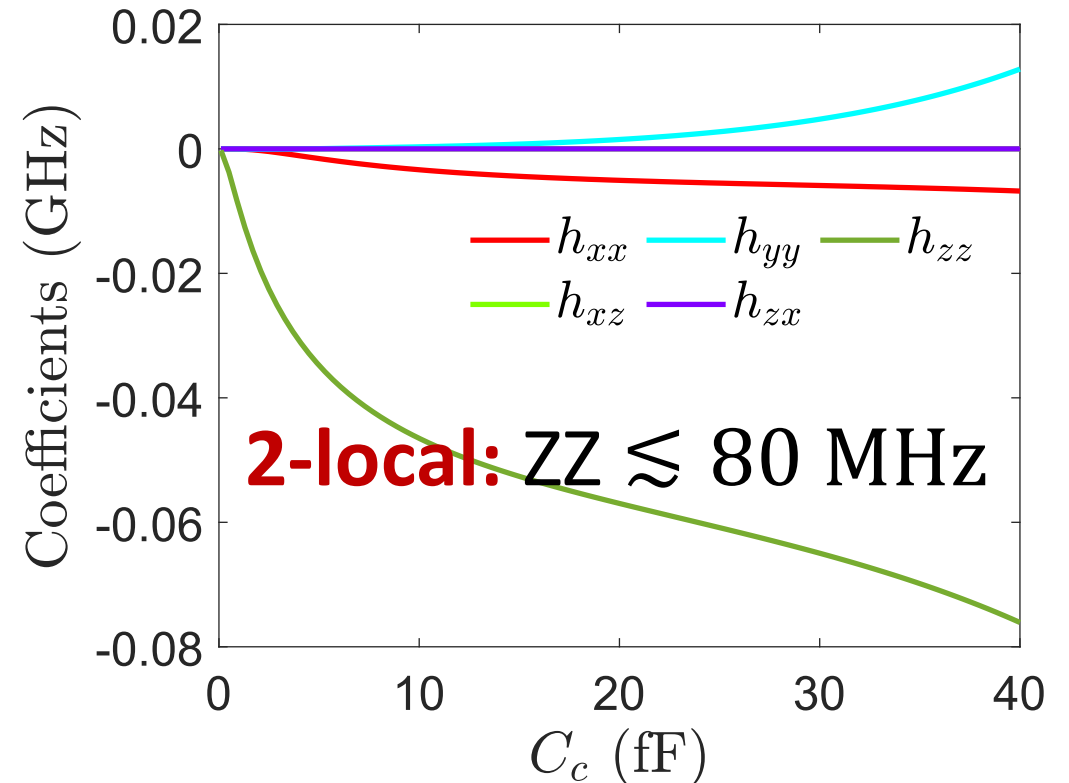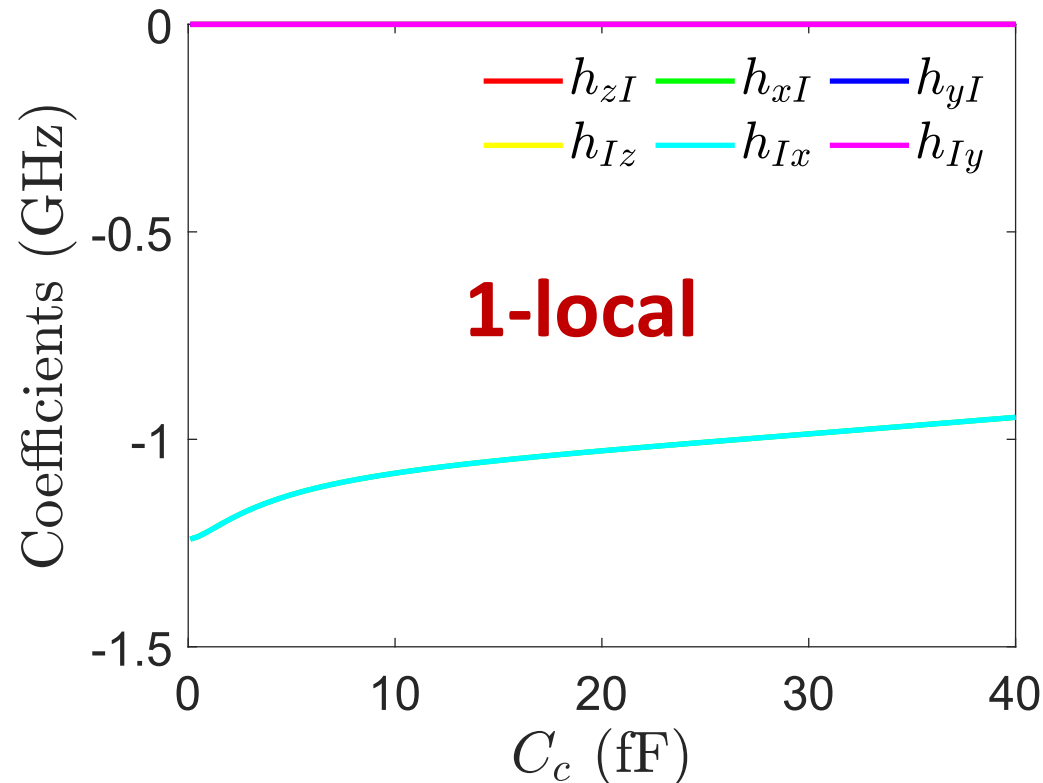# Averin Coupler - Pauli coefficients extraction

Charge qubits case: extracted parameters

1-local: Note that now the Z basis is the charge basis

2-local: ZZ ∼ 30 MHz

Averin Coupler - Pauli coefficients extraction

Charge qubits case: extracted parameters **vs coupling** capacitance C_c $(Q_{g,c} = 0.5)$

Averin Coupler - Pauli coefficients extraction

Charge qubits case: extracted parameters **vs coupling capacitance** C_c ($Q_{g,c} = 0.5$)

Note that the coupler levels are always well separated due to the qubits small capacitance (small loading)

2-local: ZZ $\lesssim$ 80 MHz