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OF QUEENSLAND  
AUSTRALIA

CREATE CHANGE

# Autonomous Mechanical Error Correction

Presented by: Tina Jin

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# Motivation

- Problems of modern electronics:
  - Current leakage
  - Near-field effects
  - Thermal noise effects



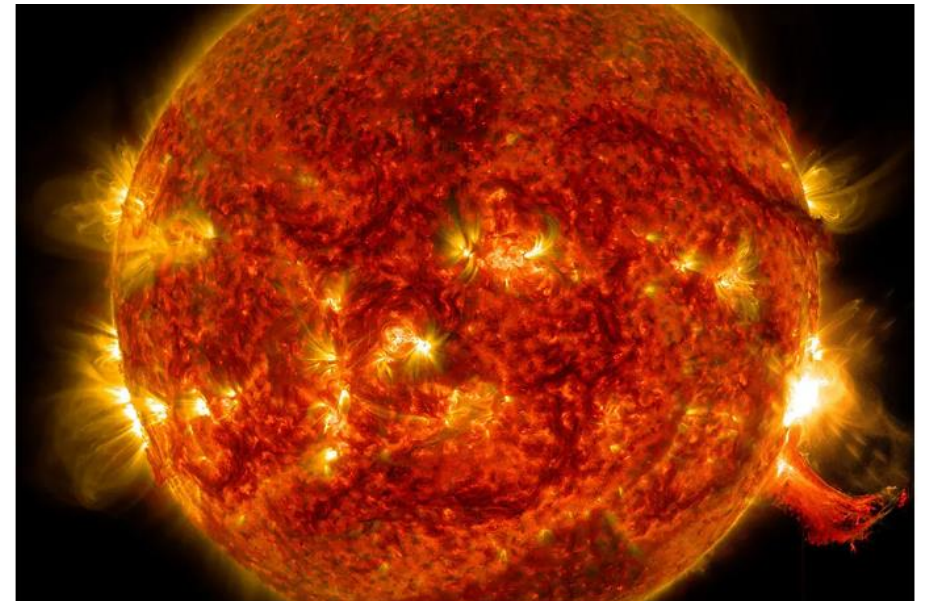
(Crain, phys.org, 2015)

# Motivation

- Electronics can be easily damaged by ionising radiation.

To avoid this, we consider mechanical computing.

## *Solar Storm Destroys 40 New SpaceX Satellites in Orbit*

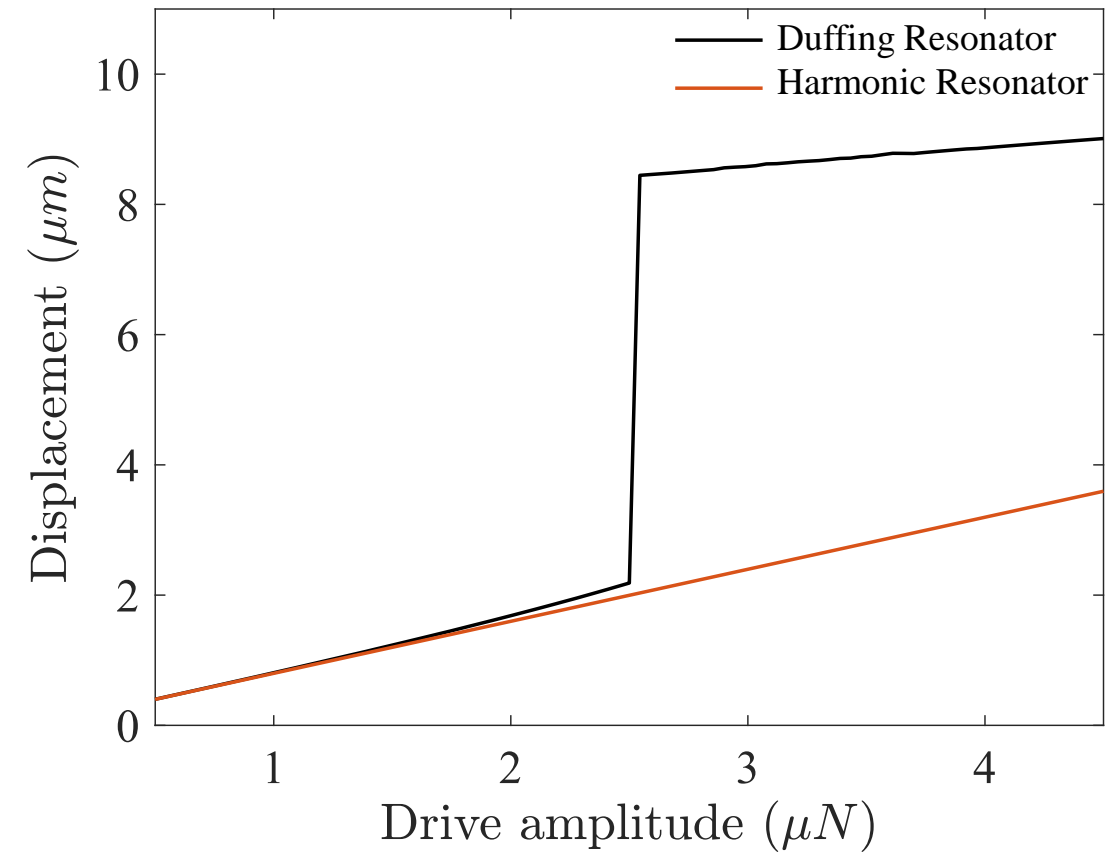
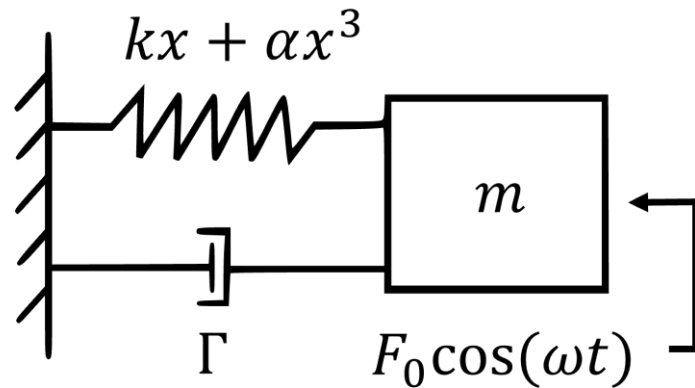


Solar flares emitting from the sun in 2014. A geomagnetic storm triggered by a recent outburst of the sun knocked out up to 40 of 49 newly launched Starlink satellites. GSFC/NASA

(Andrews, The New York Times, 2022)

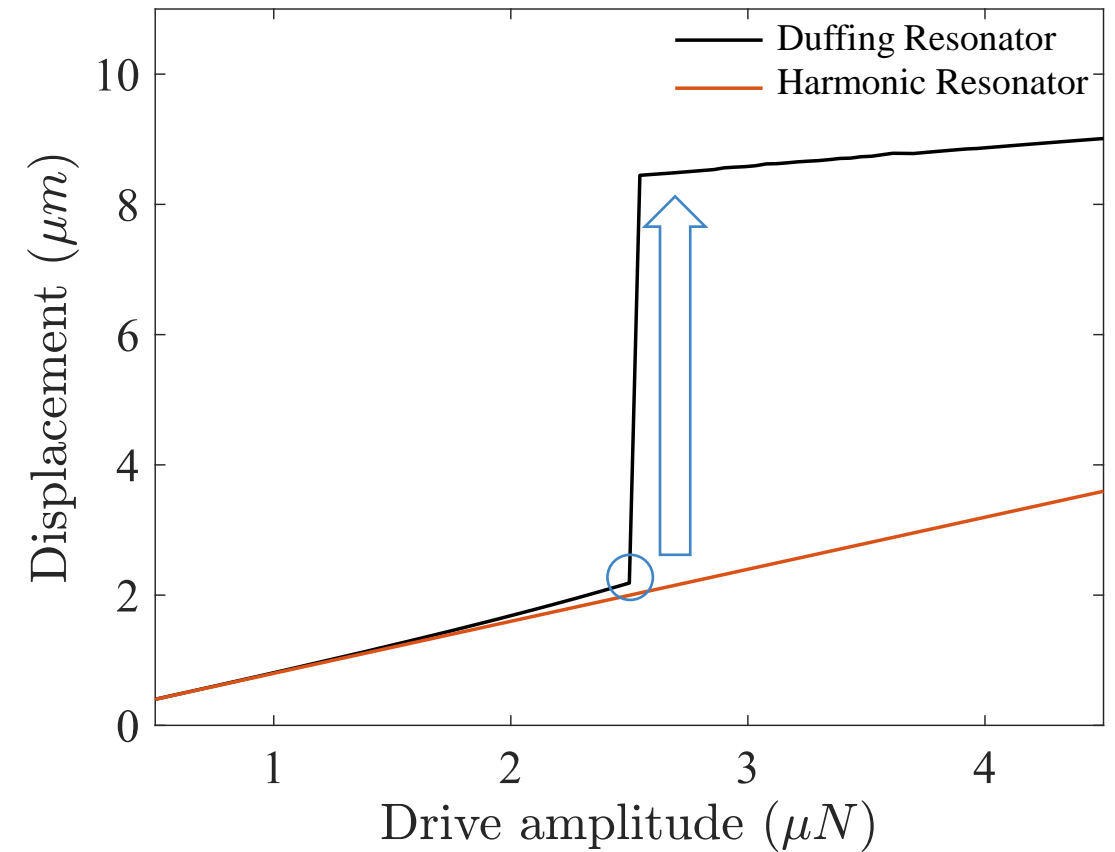
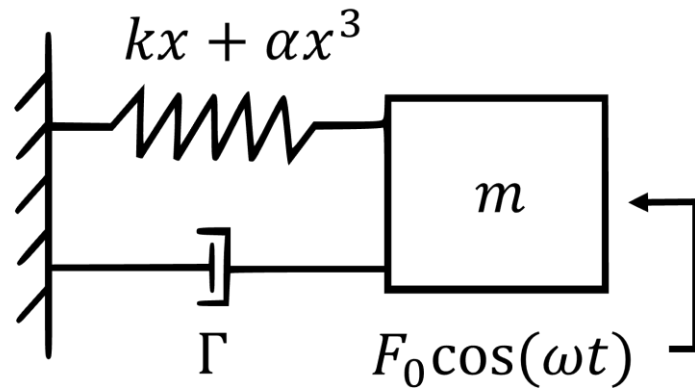
# Introduction to Mechanical Computation

- Driven, damped non-linear resonator



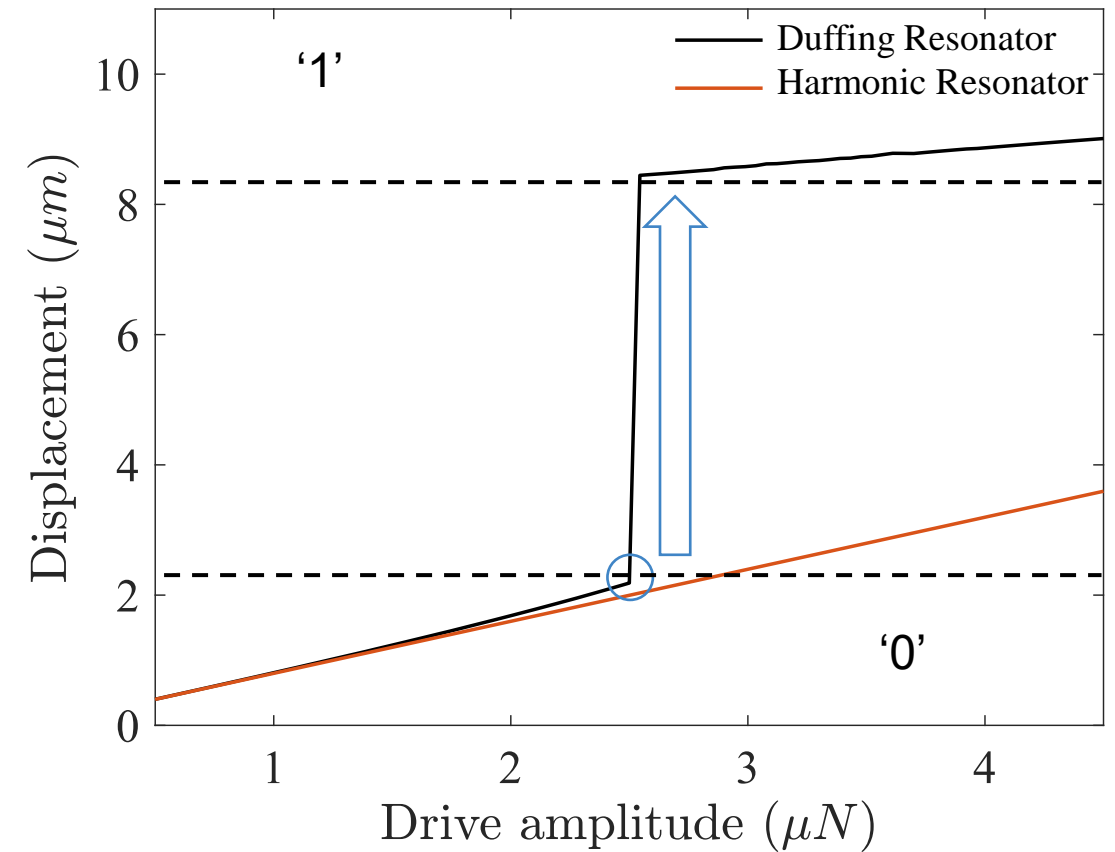
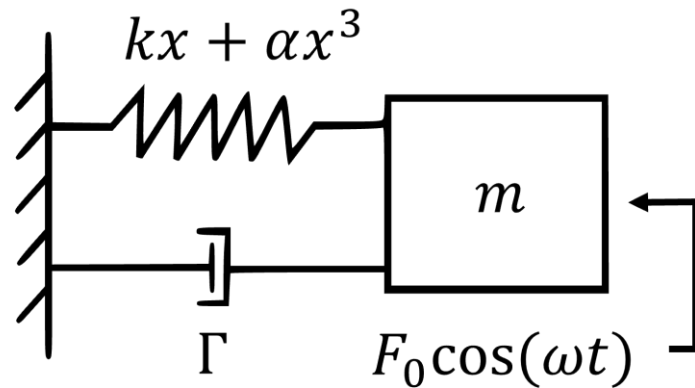
# Introduction to Mechanical Computation

- Driven, damped non-linear resonator



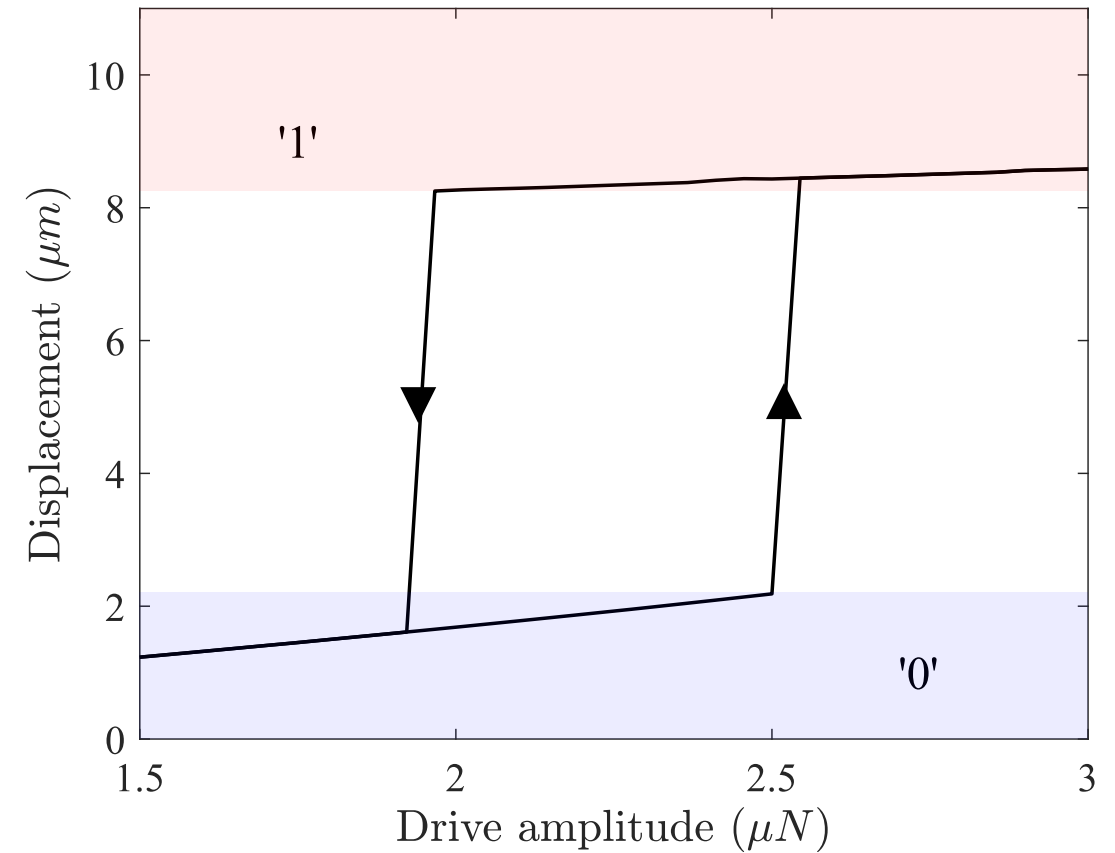
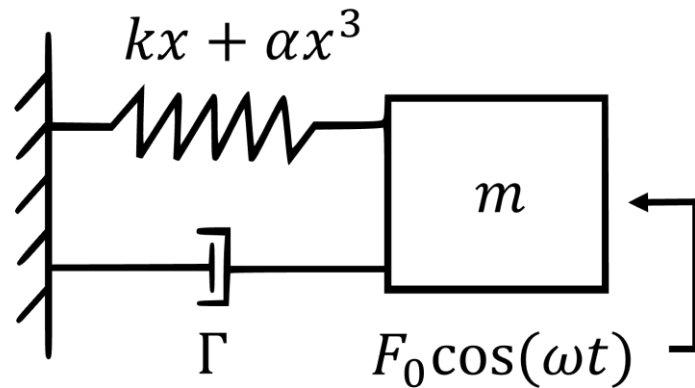
# Introduction to Mechanical Computation

- Driven, damped non-linear resonator



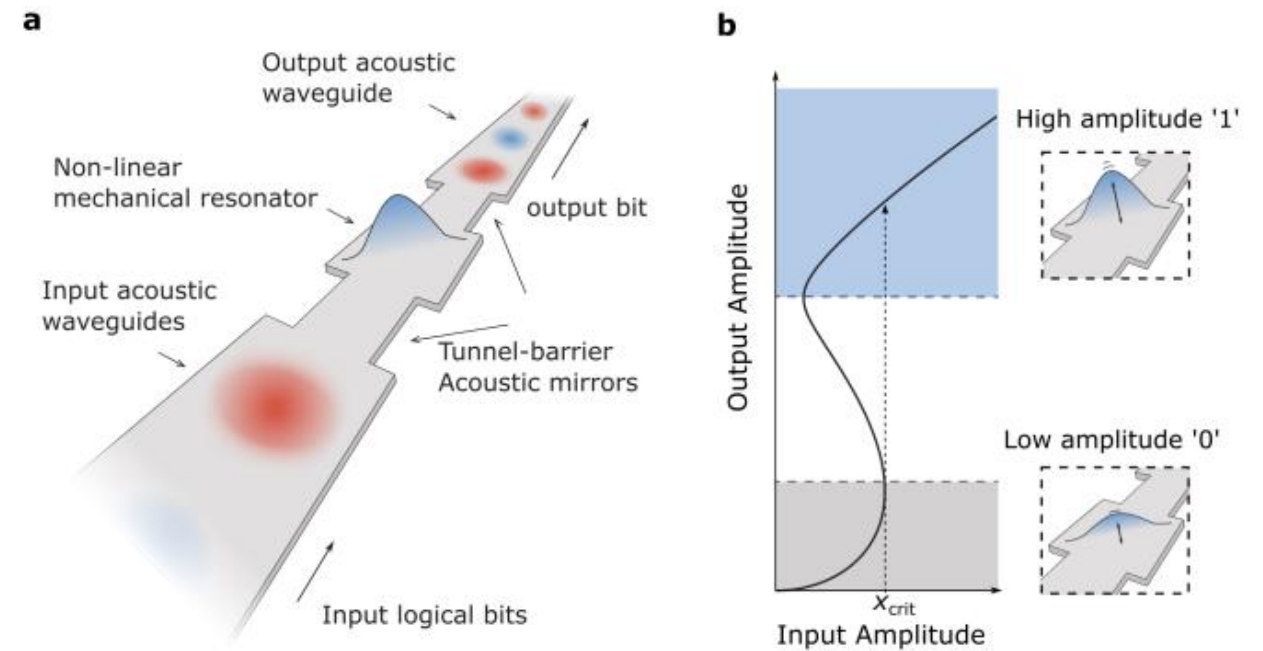
# Introduction to Mechanical Computation

- Driven, damped non-linear resonator



# Previous Studies

- Mechanical logic gate ✓
- Mechanical memory ✓
- Error correction

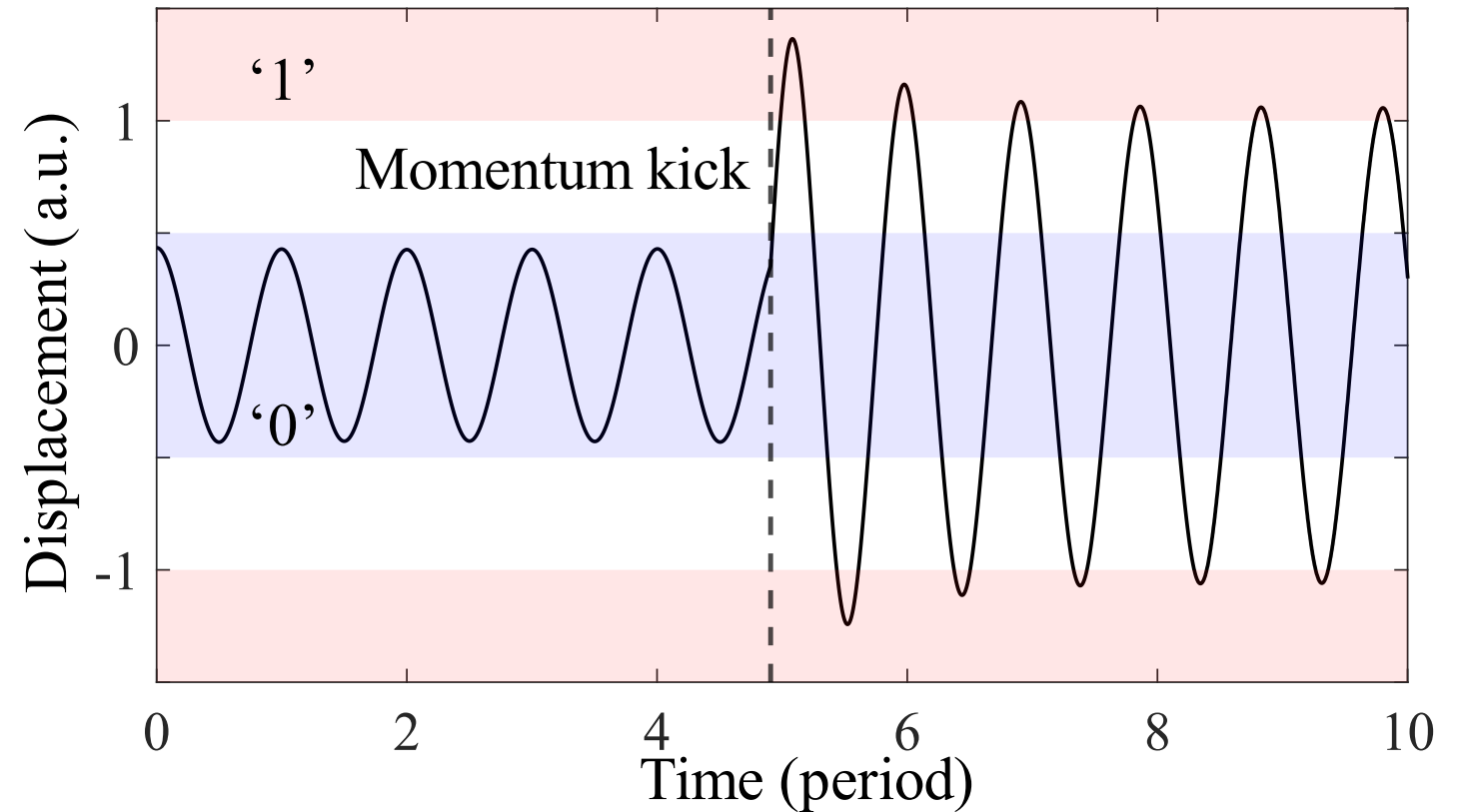


(Romero et al., [arXiv:2206.11661](https://arxiv.org/abs/2206.11661), 2022)



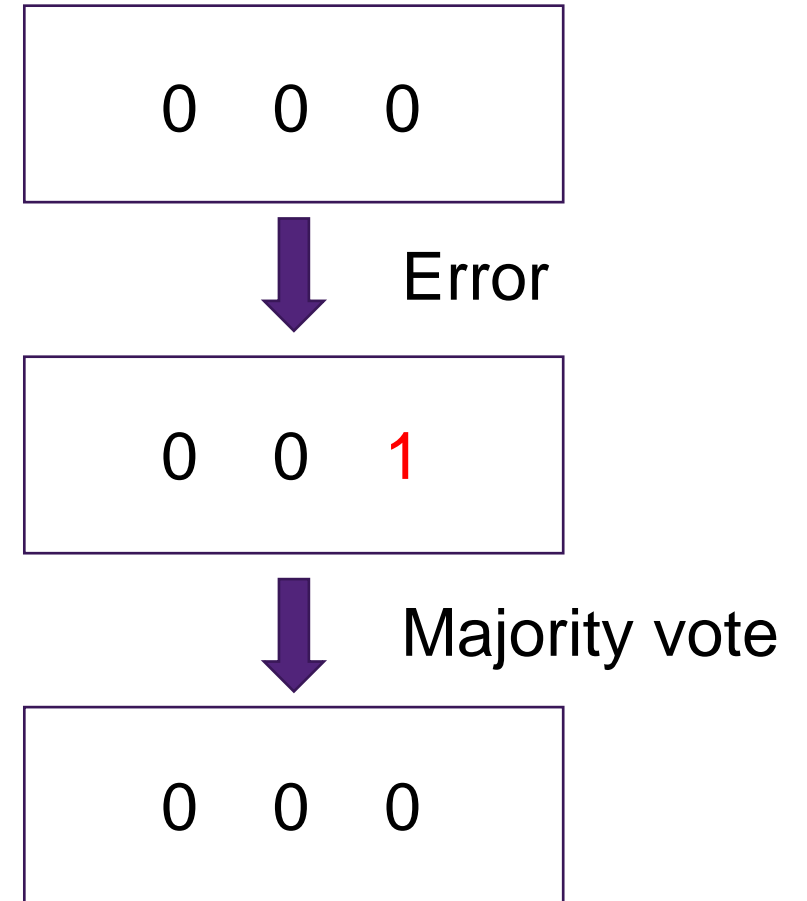
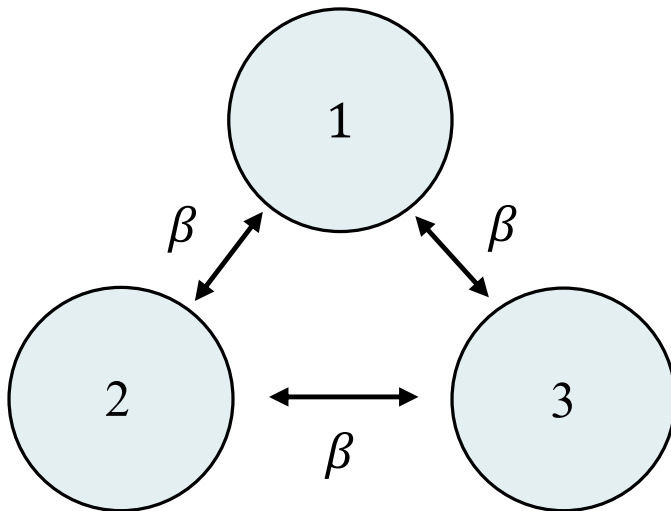
# Mechanical Error Correction

- Radiation, vibrations and other perturbations can introduce logic errors.

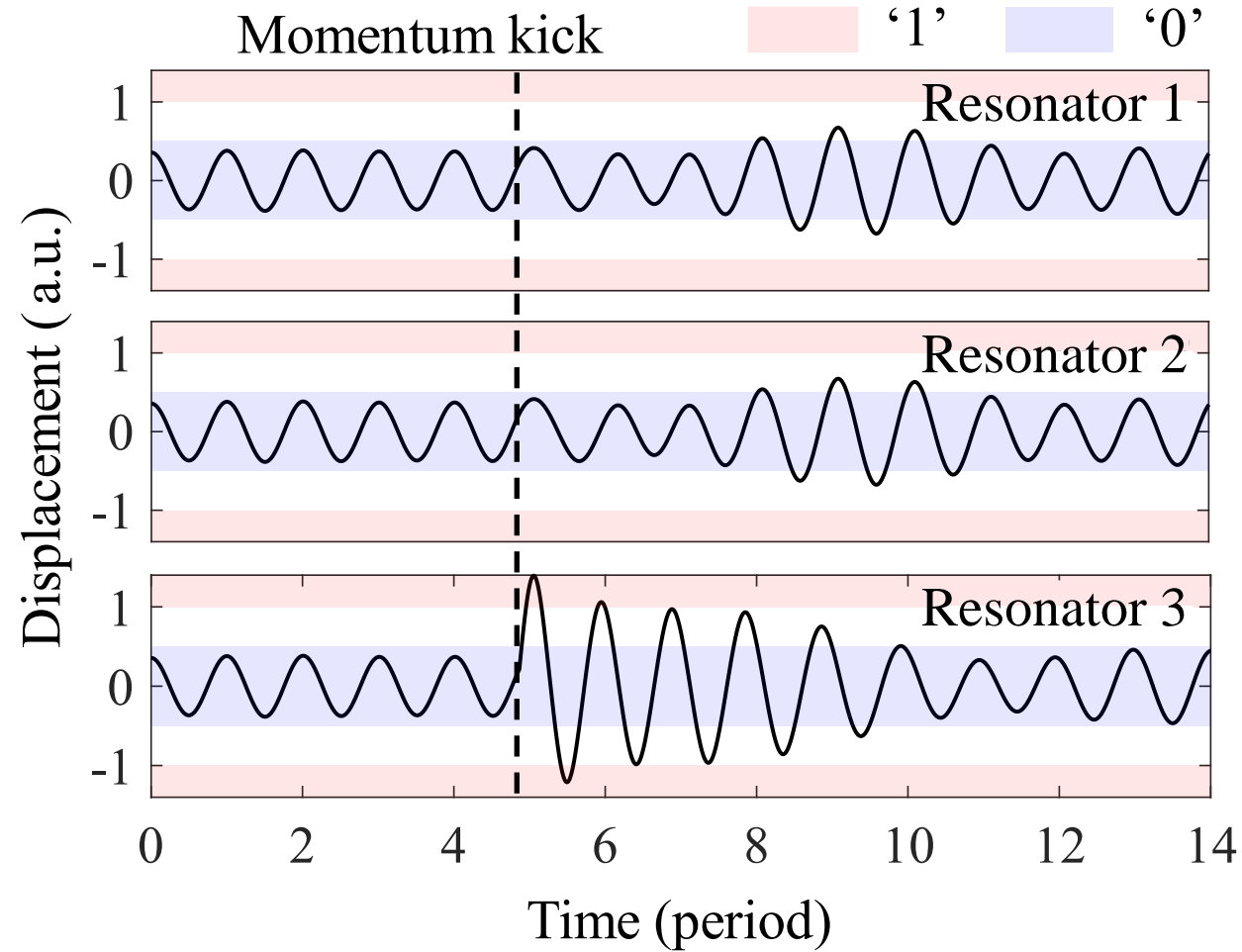


# Mechanical Error Correction

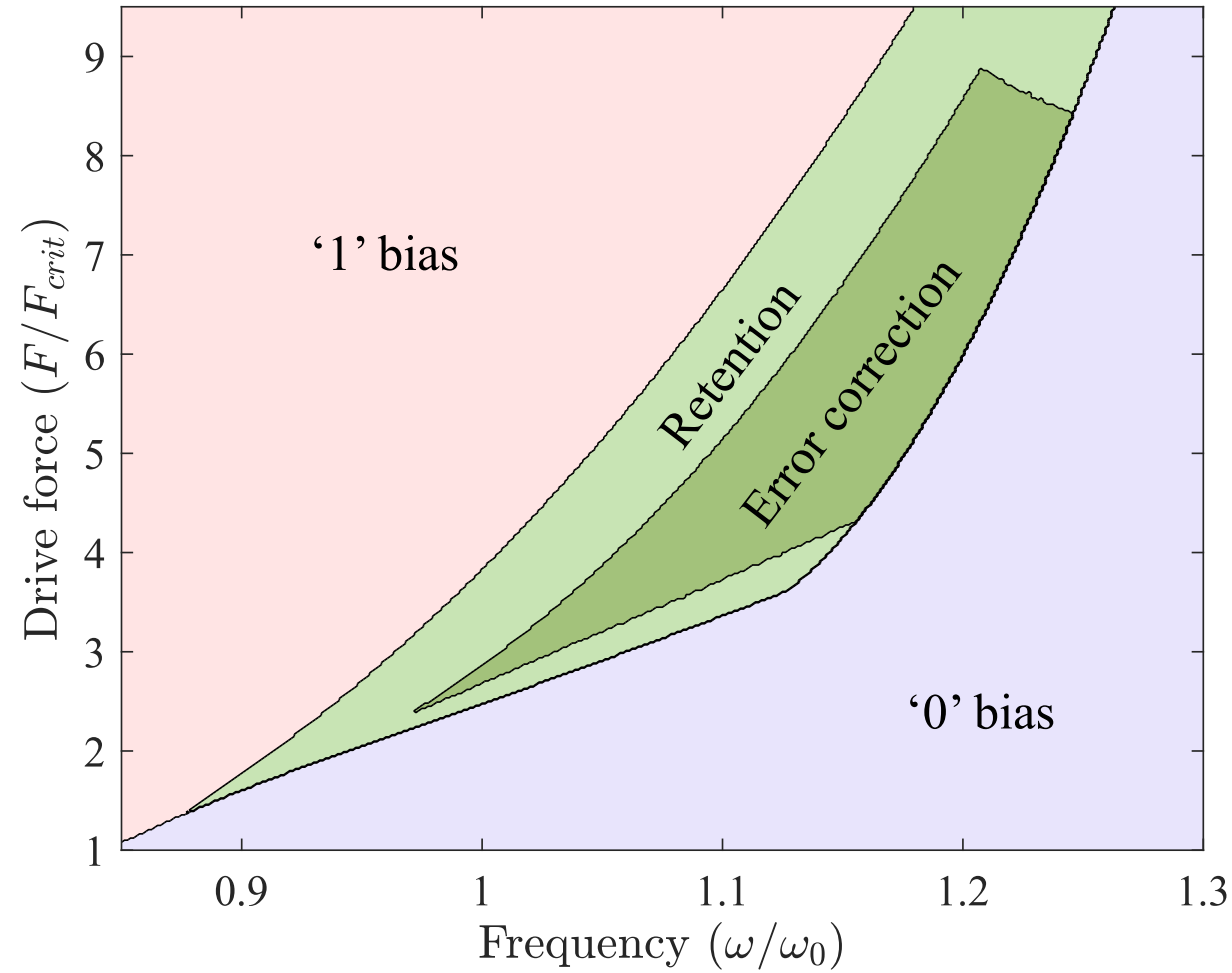
- Perform error correction with three linearly coupled Duffing resonators



# Mechanical Error Correction

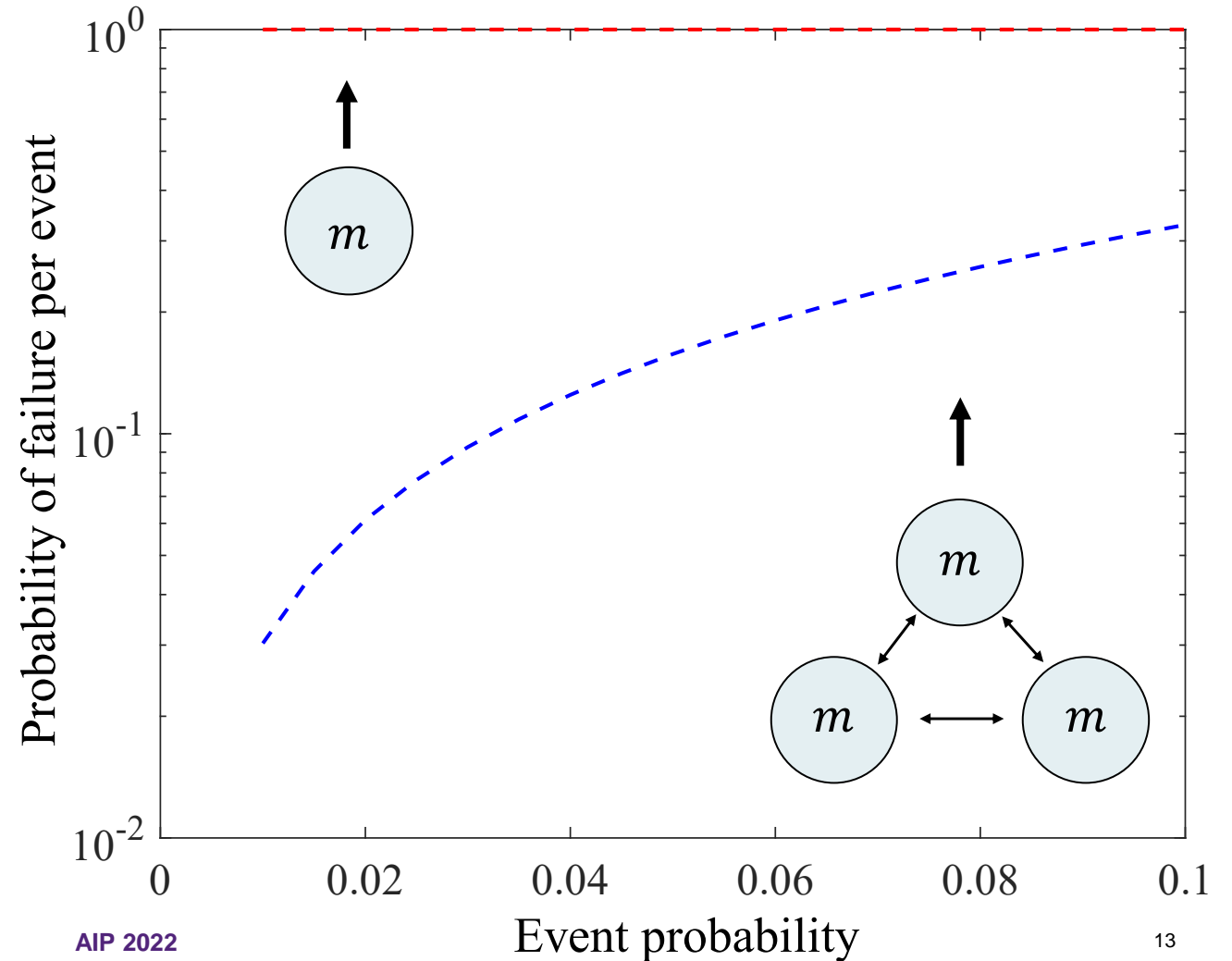


# Results – Phase Map



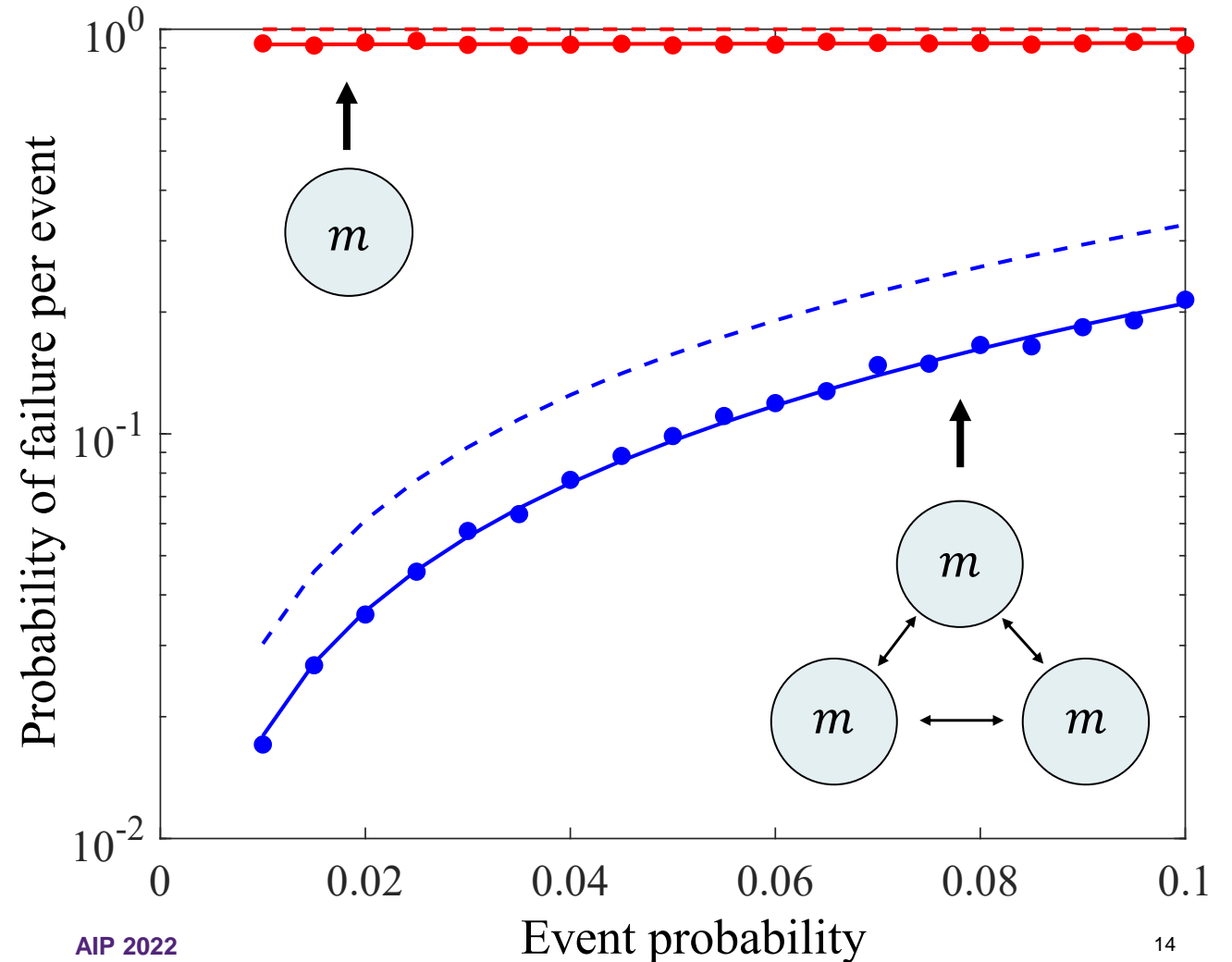
# Results – Predicted Failure Rate

- Single resonator expected to fail to error correct.
- Coupled resonators expected to correct single errors.



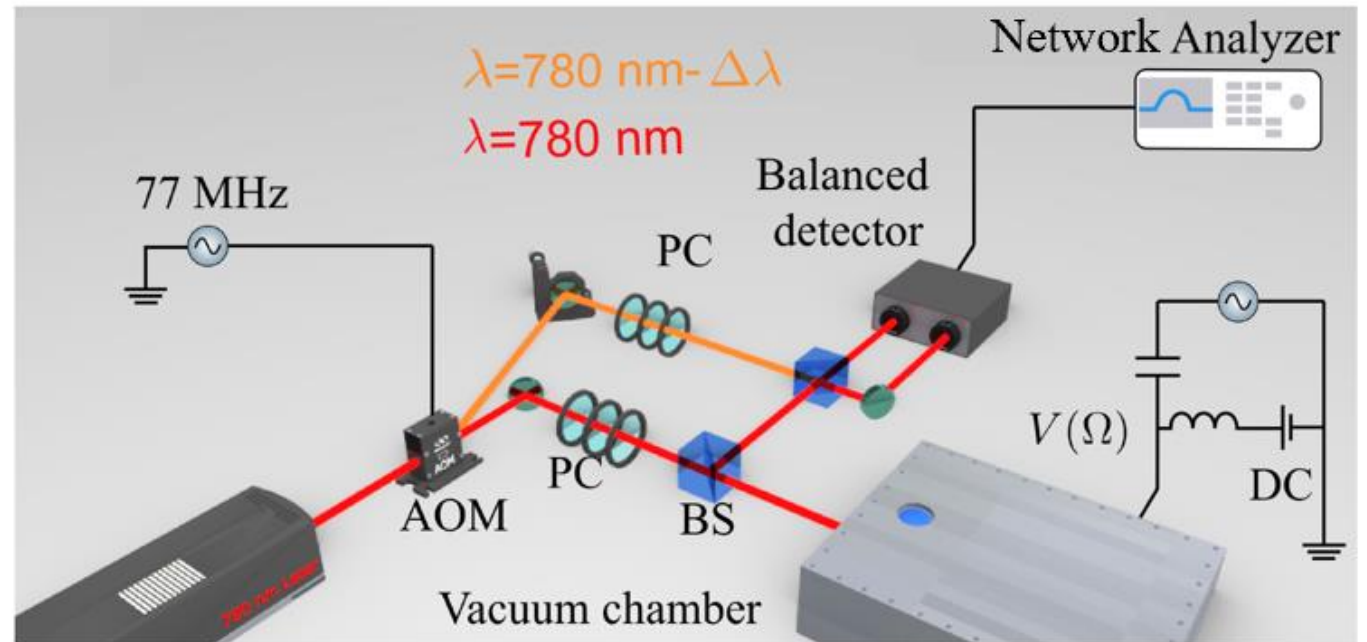
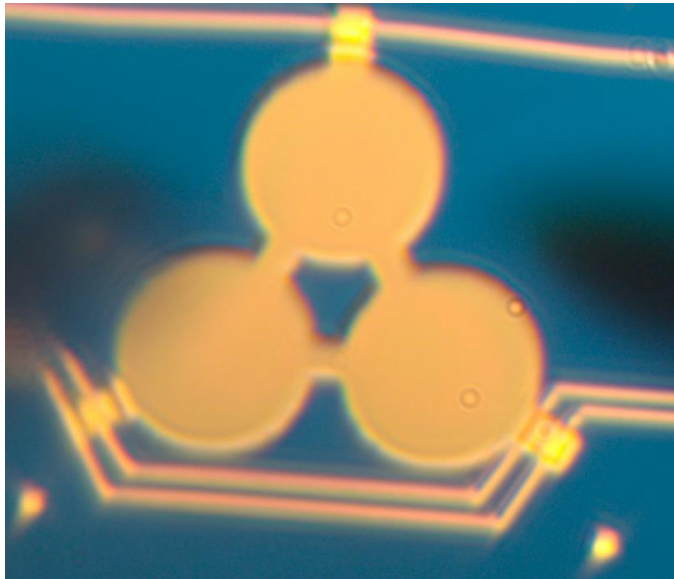
# Results – Simulated Failure Rate

- Coupled resonators can correct for all single errors.
- They can also correct double errors 40% of the time.



# Future Work

- Experimentally verify mechanical error correction



# Acknowledgements

## Supervisors and other collaborators

Dr. Glen Harris



Prof. Warwick Bowen



Dr. Erick Romero



Dr. Nicolas Mauranyapin



Dr. Christopher Baker

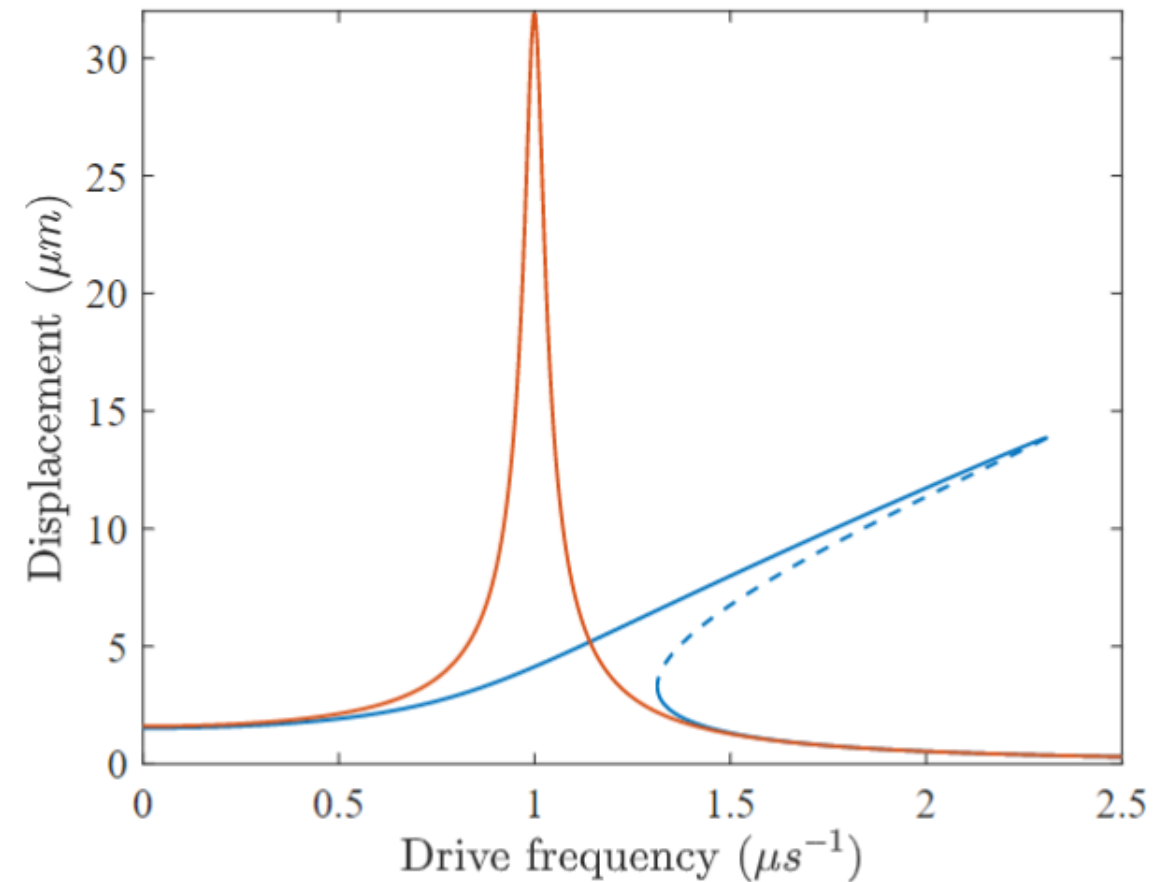
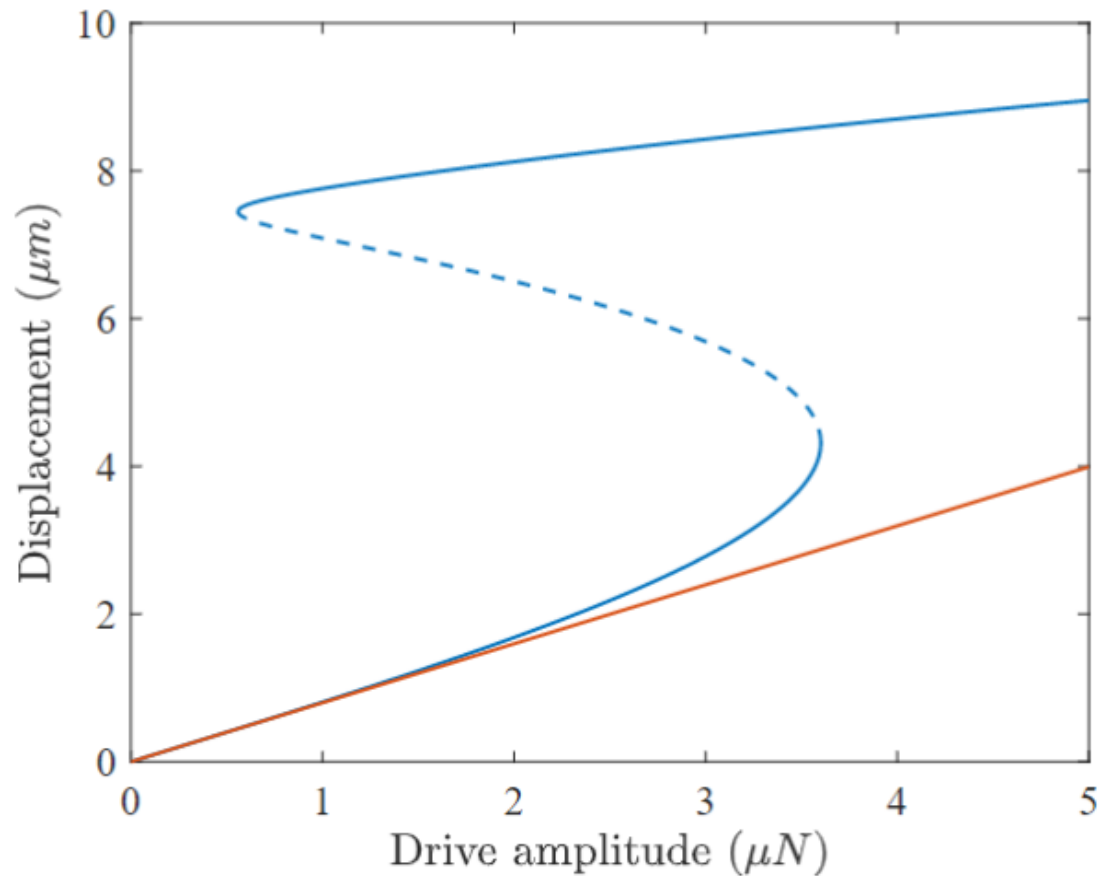


Mr. Timothy Hirsch

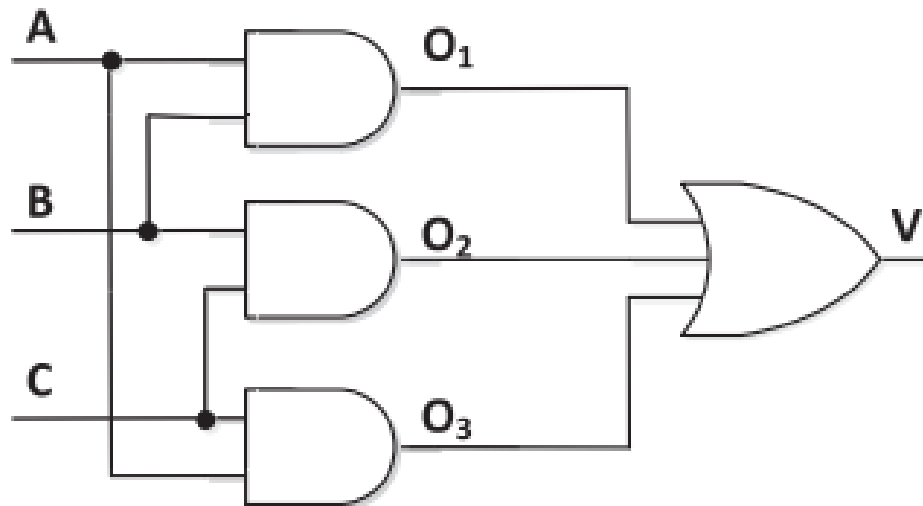




# Analytical amplitude + frequency response



# Traditional majority voting system



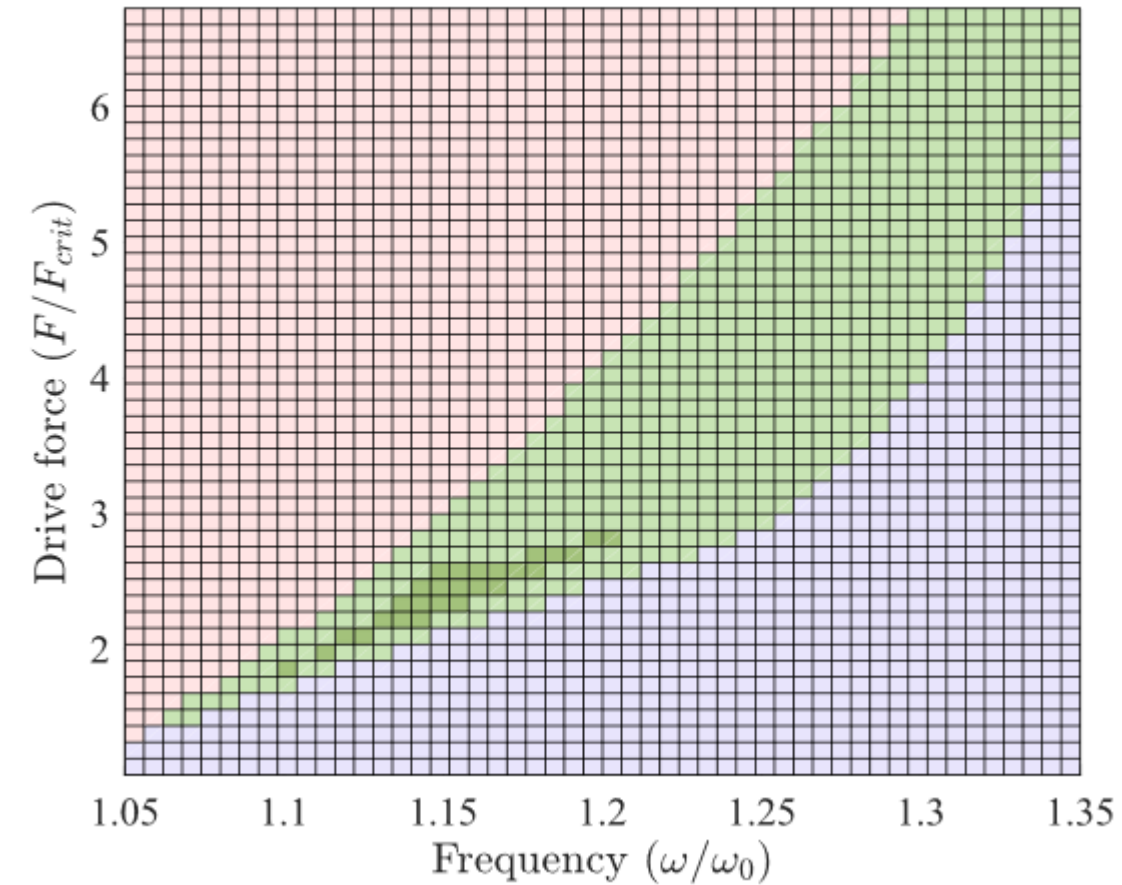
Truth table

C	B	A	V
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	1
1	1	1	1

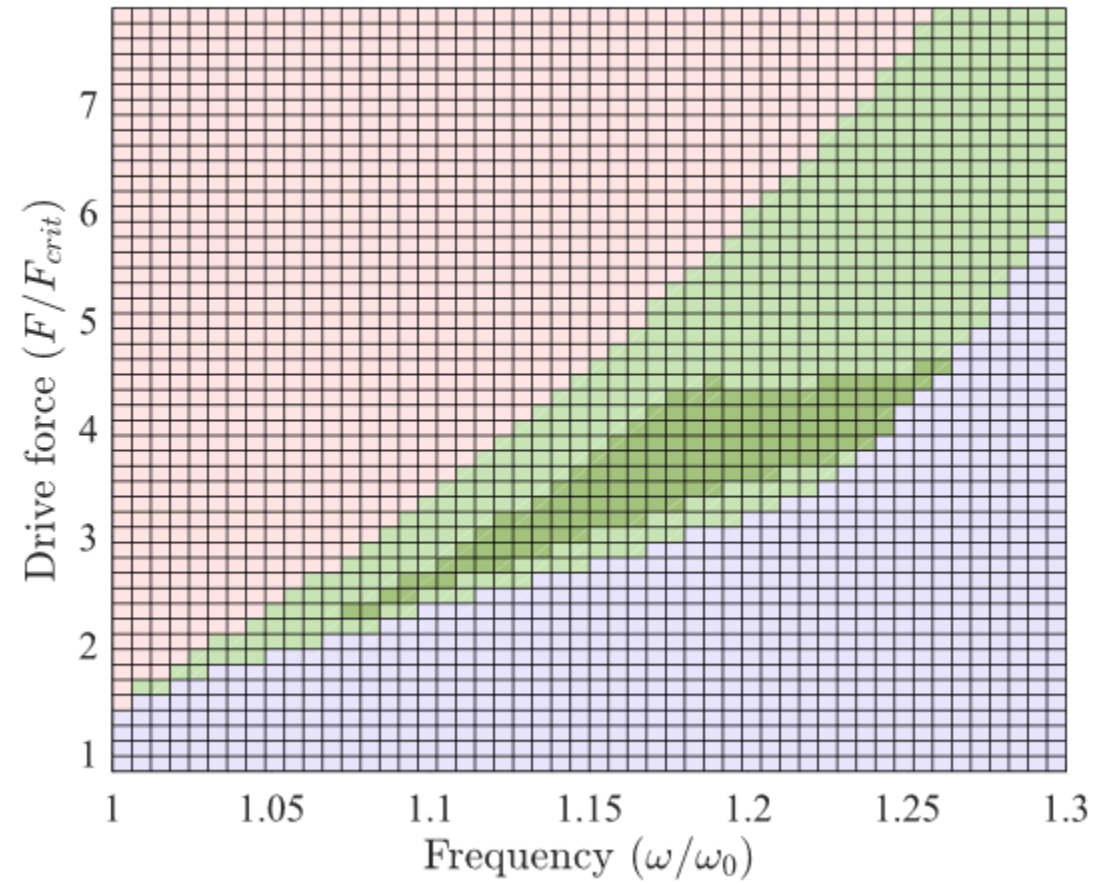
(Liu et al., IEICE Electronics Express **11**(4), 2014)

# Error correction maps

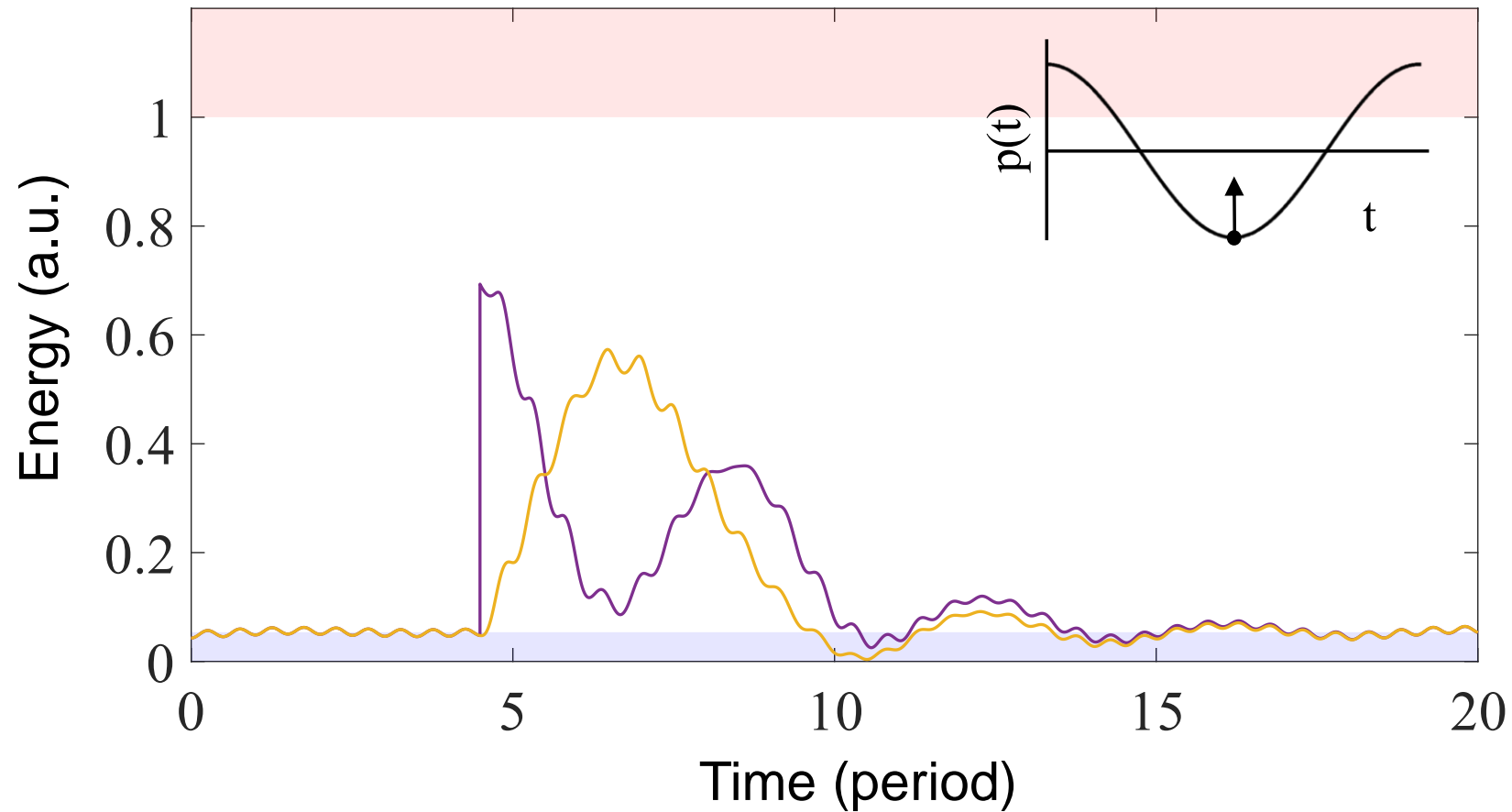
Weakly coupled



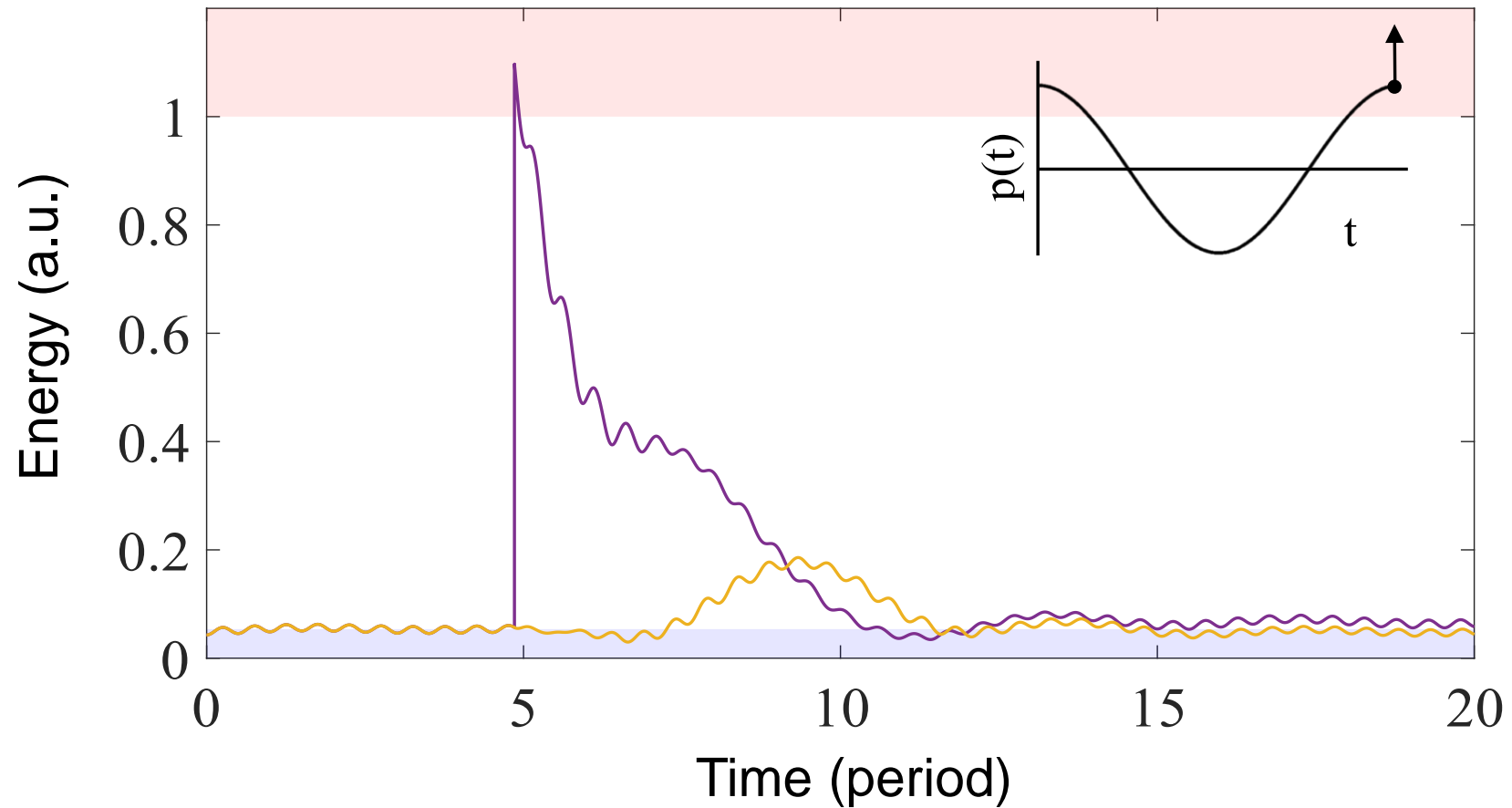
Strongly coupled



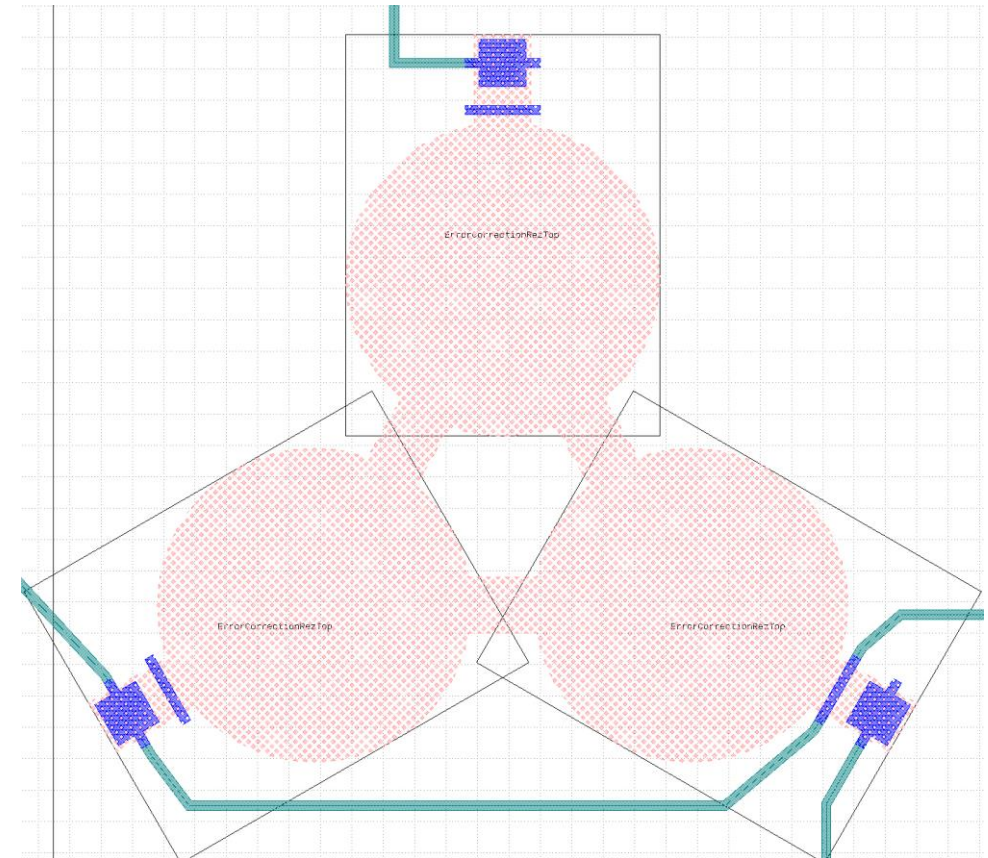
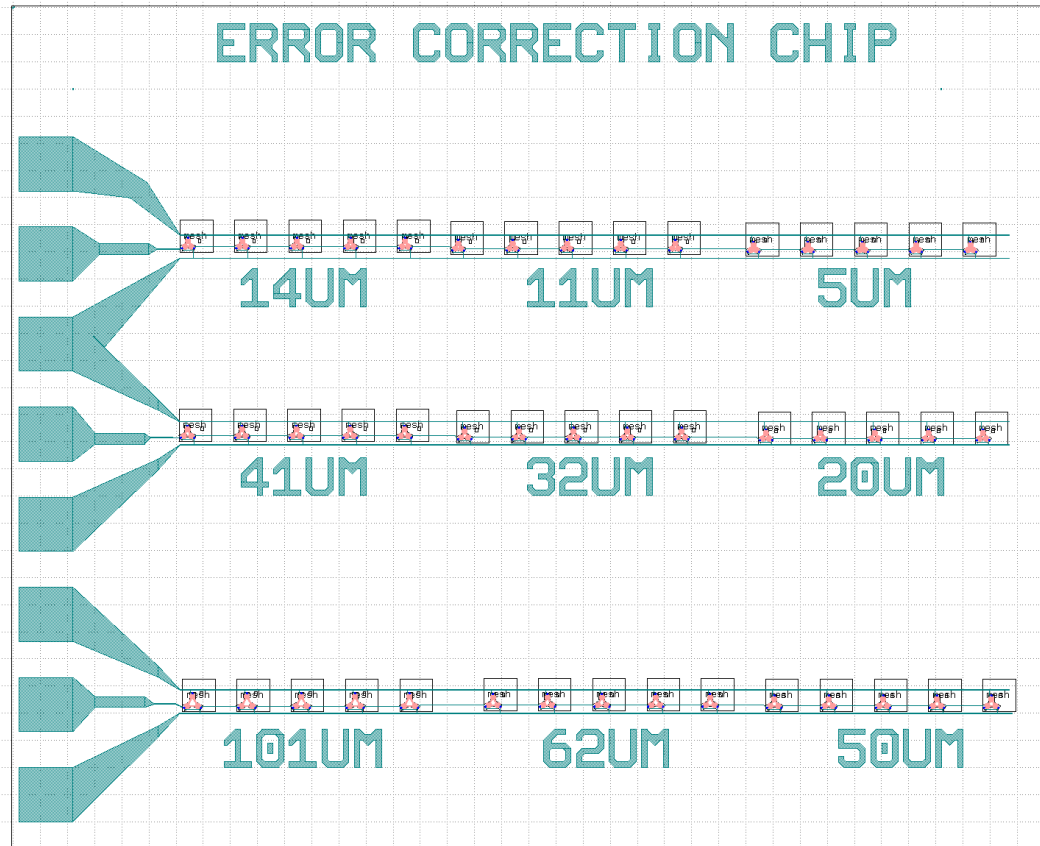
# Phase of the kicks



# Phase of the kicks



# Error correction chip



# Transient effect

- Phase response curve of a Duffing resonator

