

Technical University of Denmark



## Macromechanical parametric amplification

Neumeyer, Stefan; Thomsen, Jon Juel

*Publication date:*  
2013

[Link back to DTU Orbit](#)

*Citation (APA):*

Neumeyer, S., & Thomsen, J. J. (2013). Macromechanical parametric amplification. Poster session presented at DCAMM 14th Internal Symposium, Nyborg, Denmark.

## DTU Library

Technical Information Center of Denmark

---

### General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

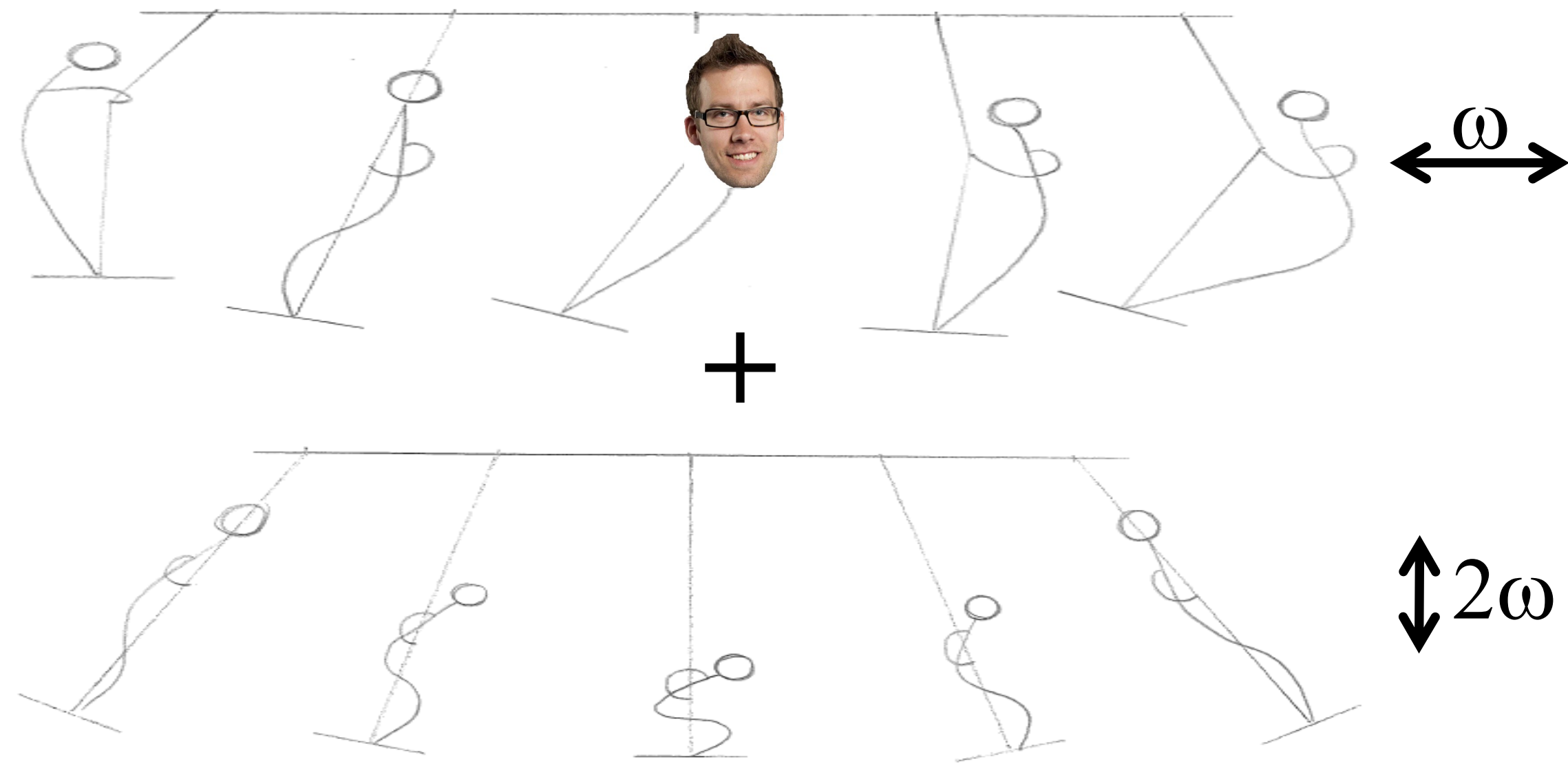


# Macromechanical parametric amplification

S. Neumeier<sup>\*,#</sup> and J. J. Thomsen<sup>□</sup>

## 1. What is it?

- Adding parametric excitations to externally driven near-resonant harmonic oscillations to amplify vibration amplitudes, e.g., a playground swing:



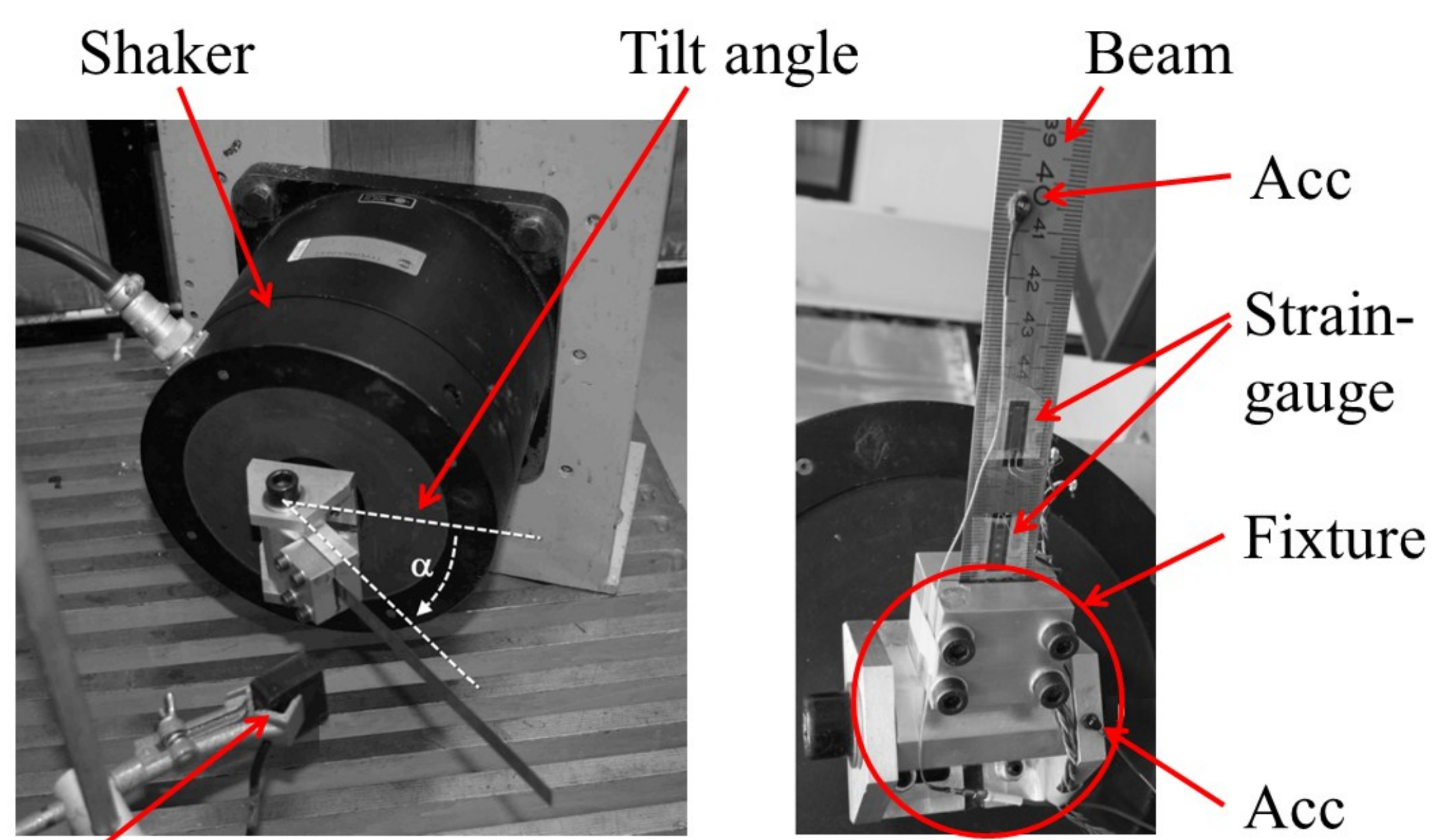
- The ratio between the stationary vibration amplitudes of the directly and parametrically excited system, and the directly excited system, is defined as the *gain*.

## 2. This study?

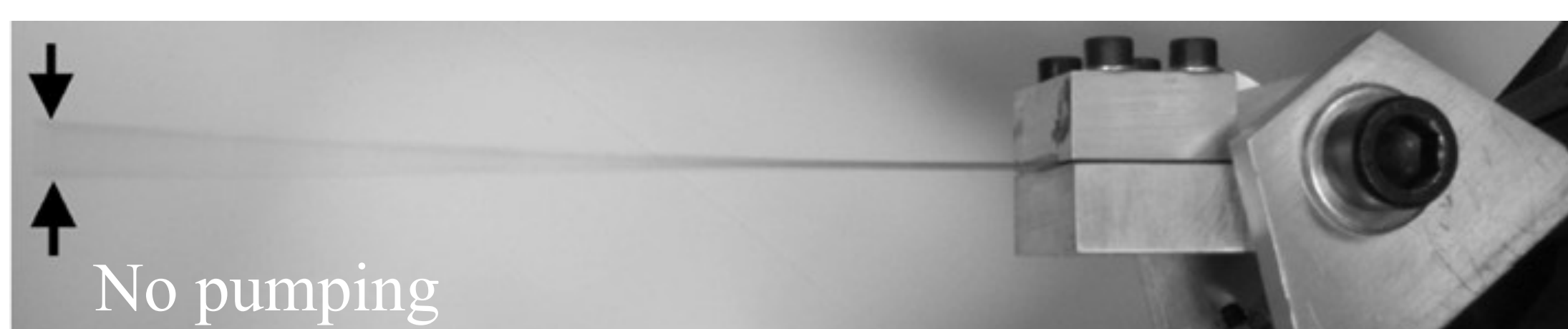
- Phenomenological study
- Effects of third-order nonlinearities
- Optimal gain and tilt angle
- Parametric amplification of higher order vibration modes
- Superthreshold pumping

## 3. Realization in current study?

Tilted base-excited cantilever beam:

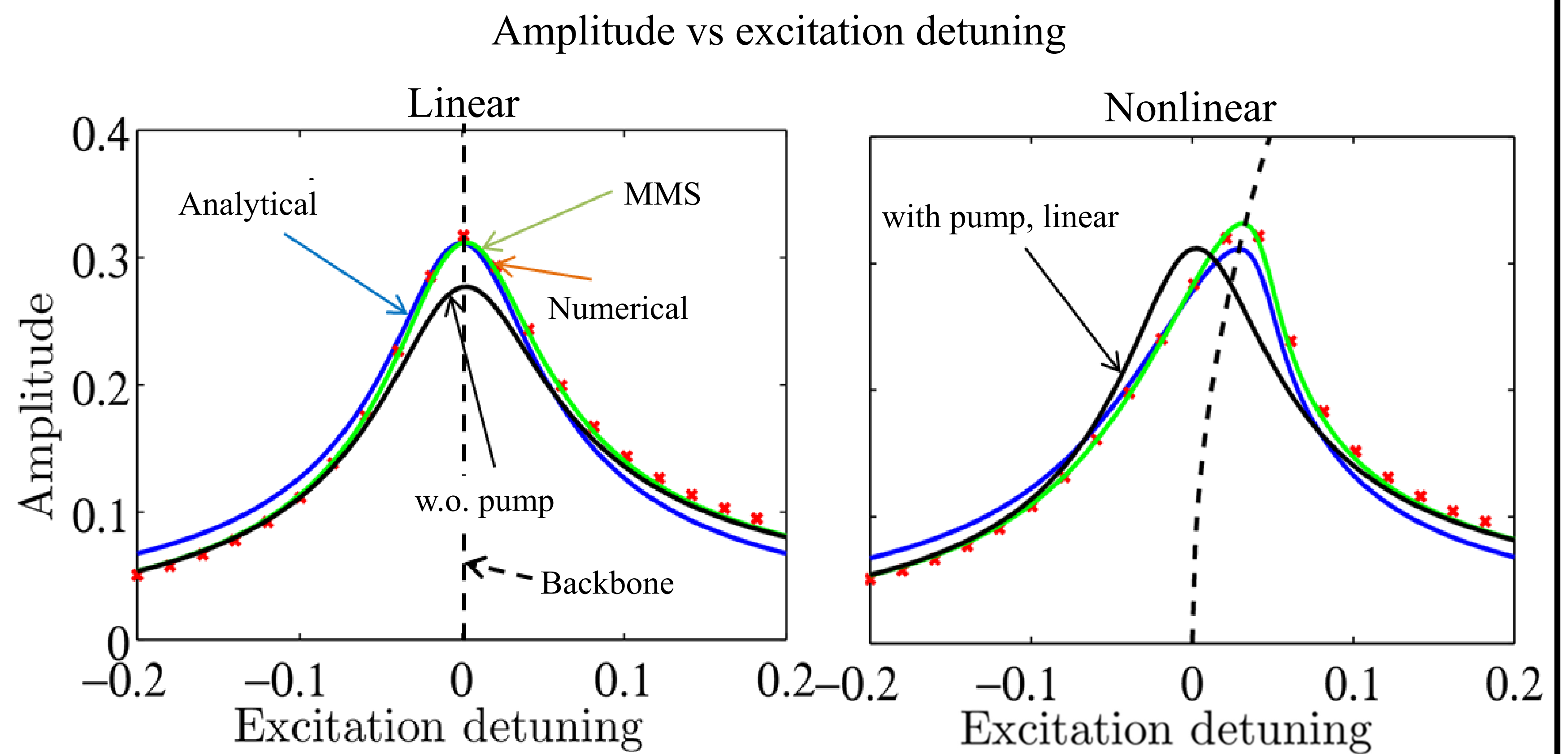


Laser displacement sensor



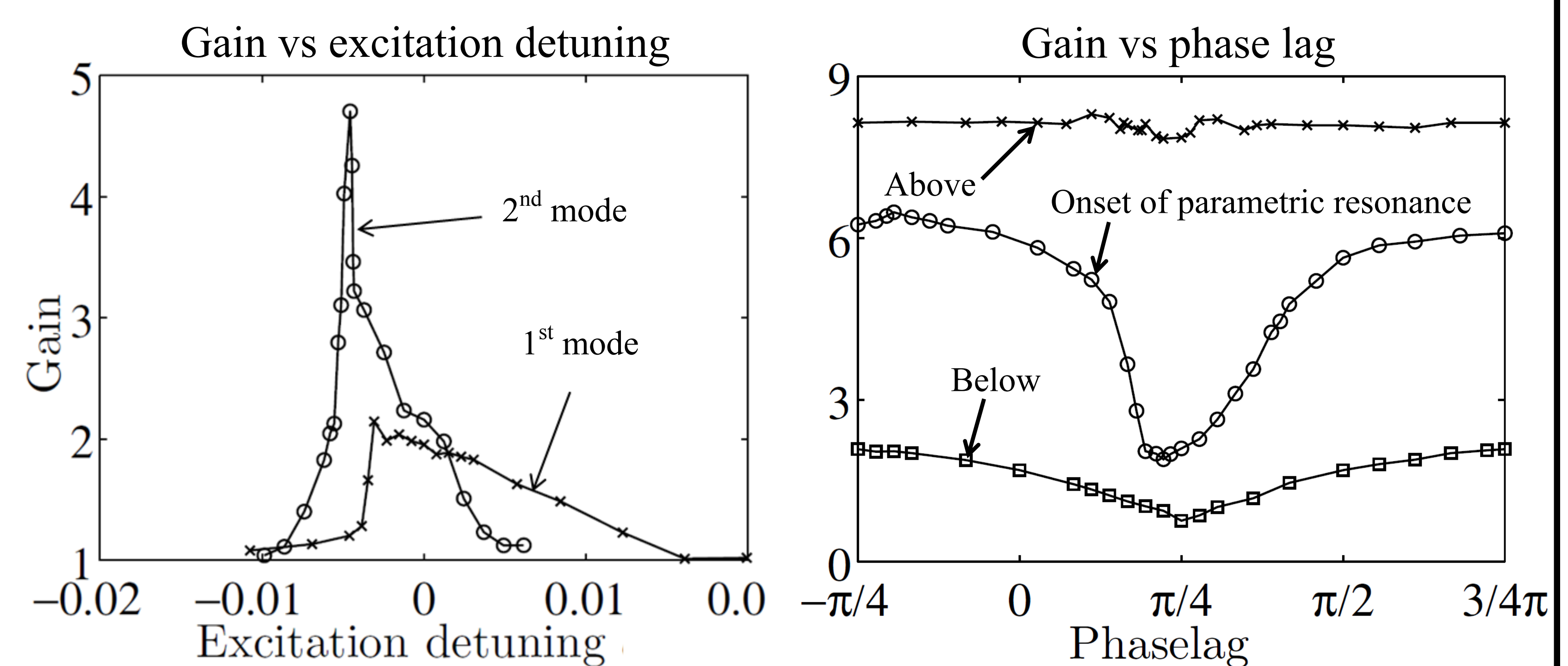
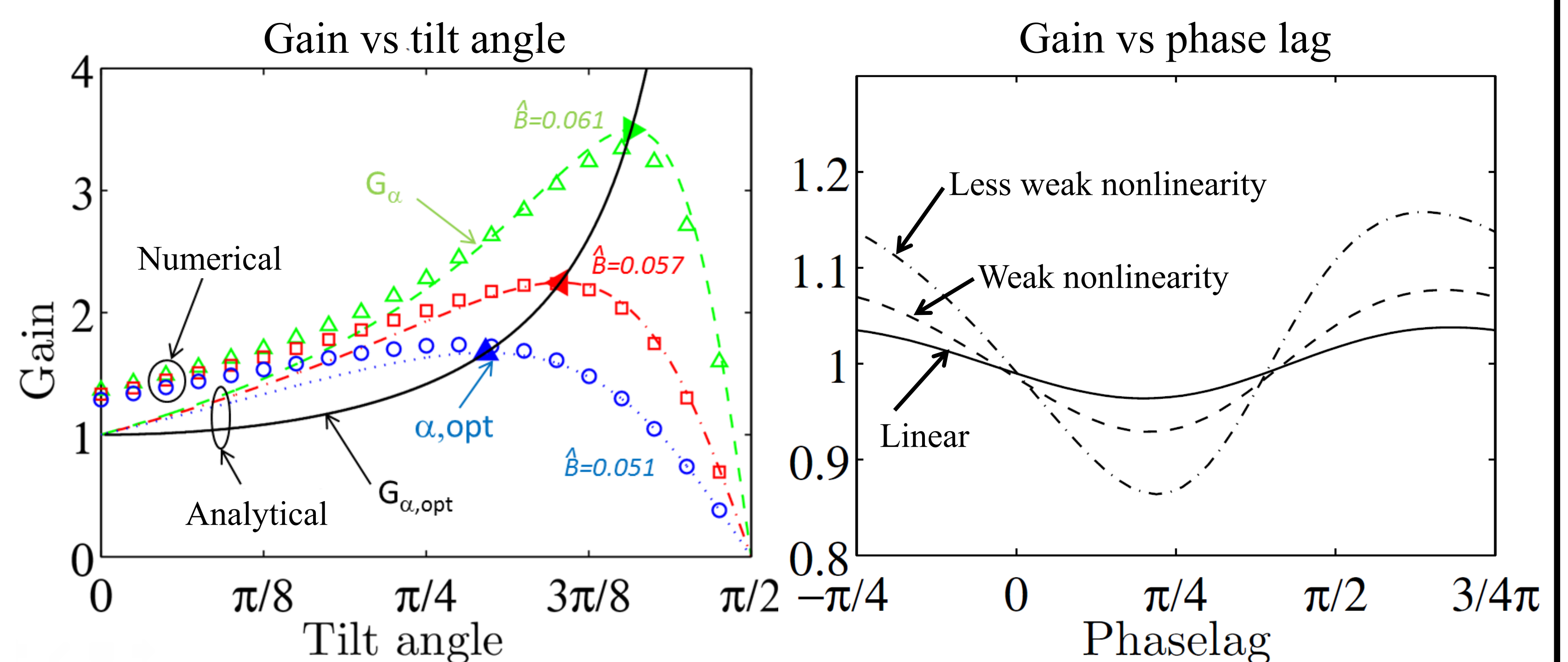
## 4. Current work? [1,2]

$$\ddot{z} + 2\varepsilon\zeta\dot{z} + z + (\varepsilon\lambda_1\Omega^2 \cos(\Omega\tau + \phi) + \varepsilon\lambda_2\Omega^2 \cos(2\Omega\tau))z + \varepsilon k_3 z^3 + (\varepsilon\gamma_1\Omega^2 \cos(\Omega\tau + \phi) + \varepsilon\gamma_2\Omega^2 \cos(2\Omega\tau))z^3 + \varepsilon\alpha_n(\ddot{z}z^2 + \dot{z}^2 z) = \varepsilon\eta_1\Omega^2 \cos(\Omega\tau + \phi) + \varepsilon\eta_2\Omega^2 \cos(2\Omega\tau)$$



Gain squared:

$$G_{\alpha}^2(\sigma=0) = \frac{(1 + (\kappa \sin \alpha - 2 \sin 2\phi) \kappa \sin \alpha) \cos^2 \alpha}{(1 - \kappa^2 \sin^2 \alpha)^2}, \quad \kappa = \frac{\zeta}{\mu \hat{B}}, \quad G_{\alpha, \text{opt}}^2 = \frac{1}{1 - \kappa^2}$$



## 5. Conclusions? ...and so what?

- Insight through derivation of analytical expressions
- Gain is realized (larger than unity)
- Optimal mix between excitation parameters
- Other nonlinear effects
- Energy-considerations
- High-frequency excitation effects

[1] Neumeier, S. and Thomsen, J. J., Macroscale mechanical domain parametric amplification: superthreshold pumping and optimal excitation parameters, Euromech Colloquium 532 Time-Periodic Systems: Current trends in theory and application, 2012.

[2] Kumar V., Miller, J. K. and Rhoads J. F., Nonlinear parametric amplification and attenuation in a base-excited cantilever beam, Journal of Sound and Vibration, 330(22) (2011) 5401-5409.

\* Corresponding author, stene@mek.dtu.dk

# The guy on the picture

□ Supervisor, Associate Professor, Dr. Techn.