SP3

Model-based damage analysis

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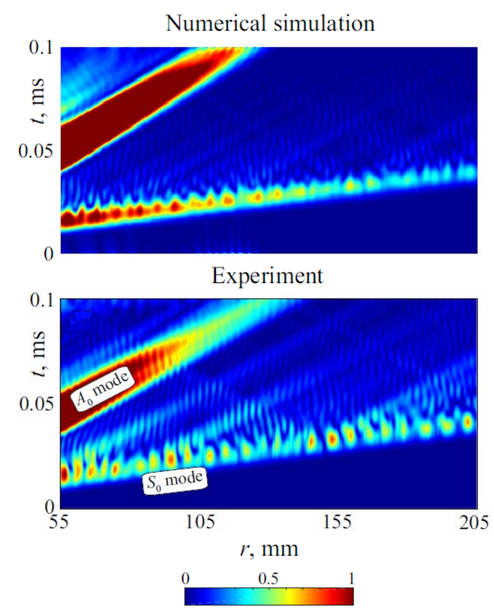
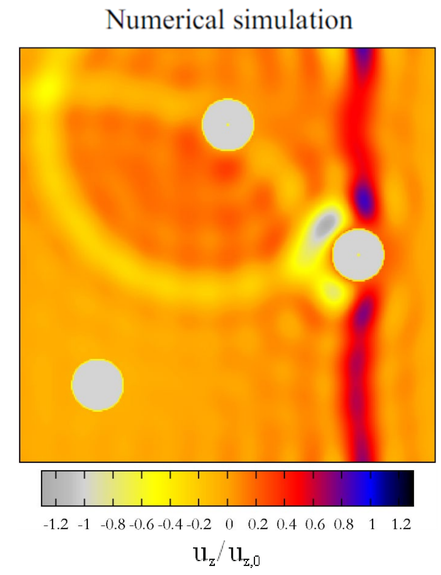
Most Important Preparatory Work

Preparatory work of the applicants regarding the proposed work program:

- In Lammering's WG, there is a lot of experimental and numerical experience in the field of SHM, especially of GUW in layered composite materials.
- Applicant Weber works on both the (semi-)analytical and numerical solution of wave propagation in heterogeneous materials. Of special interest is the influence of interphases.
- Applicant Rauter's focus lies on the nonlinear wave propagation of GUW, which is characterized by the generation of higher harmonic modes.
- Lorenz's WG has its main research focus on methods and algorithms for solving linear and nonlinear inverse problems.



GUW in undamaged CFRP

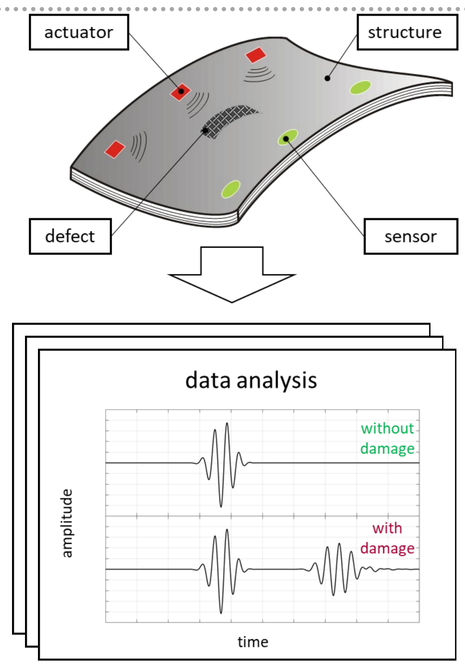


GUW considering obstacles

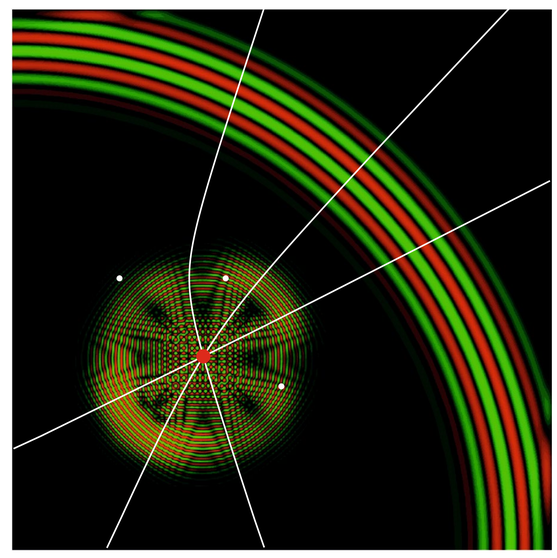
Objectives of the first funding period

The main objective of our subproject is the numerical simulation of a model-based system for SHM which is able to detect, localize, and characterize damage in FML structures by use of GUW. The following subgoals are formulated:

- At first a suitable and robust mathematical model which reflects the main effects of wave propagation in undamaged FML considering environmental effects like temperature and moisture is developed.
- Using the forward model powerful inverse algorithms are formulated.
- In a next step sensors are integrated into both the mathematical and mechanical model to investigate unwanted effects in the forward and inverse simulation on the one hand side and to guarantee high precision measurements on the other hand.
- Different damage scenarios are implemented into the forward model, that are typical for material with layers of large impedance differences.



Sensor signals



Damage reconstruction

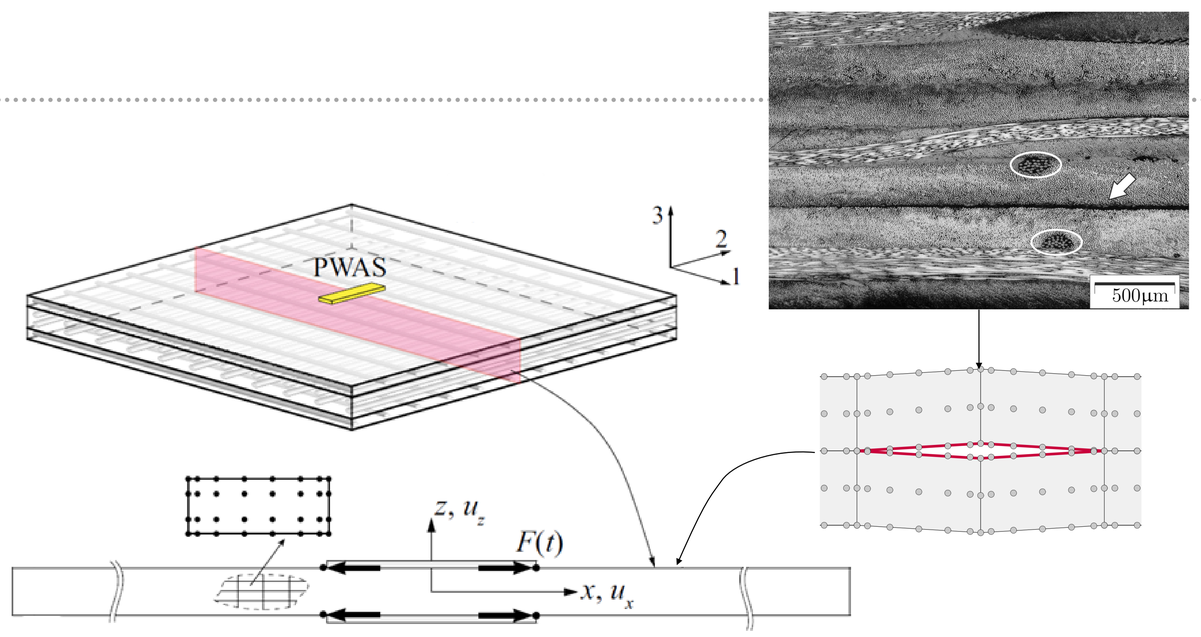
Methods

The proposed objectives are achieved by using different methods from the mechanical and mathematical perspective. Regarding the numerical simulation and the representation of damage from a mechanical point of view the two main methods are:

- FEM (2D/3D) with special regard to the numerical challenges (adapted elements) and the structural conditions (layered inhomogeneous material).
- Interfaces can be modeled by using contact elements on the one hand, on the other hand cohesive zone models are suitable for the implementation of interphases.

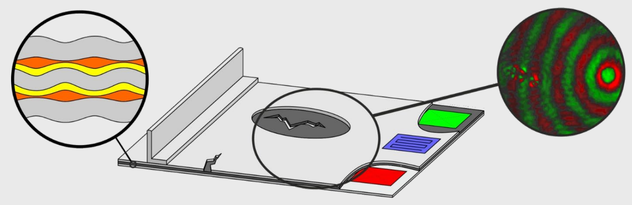
For the detection, localization, and characterization of damage in FML structures the following methods are used:

- Ad hoc methods based on known signal characteristics.
- Variational regularization methods based on discretized FEM forward models.



Generation of a 2D FE model for the wave propagation in CFRP with integrated damage

Ultrasonic Monitoring of Fibre Metal Laminates Using Integrated Sensors



Research Unit FOR3022