SiC_f-SiC_m is a leading candidate for next generation nuclear reactor fuel cladding due to its structural stability in extreme environments. However, heterogeneities formed during the complex manufacturing process can cause uncertainty in performance. Therefore, defect detection is crucial to ensure the cladding quality.

The major defects in these materials are excess deposition of matrix material, abnormal porosities, delamination, and braid angle anomalies. Evaluation methods currently in use include X-ray computer tomography (XCT), as well as optical and electron microscopy. These systems are generally cumbersome (impractical for use in the field), time-consuming to apply, and can be destructive. Thus, they are not suitable for in situ detection. An alternative nondestructive evaluation (NDE) method consists of inducing and measuring an ultrasonic wavefield into the material. Damaged regions exhibit diffraction, refraction, and changes in velocity, which can then be used to identify the defect. Yet, identifying and characterizing these defects remains a significant challenge.

In this work, we present the initial progress made in algorithm development for a nondestructive, computationally efficient regression for ultrasonic wave-informed defect detection. We collect the wavefield data with a laser Doppler vibrometer, which captures velocity through phase difference measurements. We present a wave-informed regularization to separate spatially and temporally heterogeneous modes from this data to identify and locate defects. To achieve this, we constrain the modes to satisfy a discretized version of the Helmholtz equation. This denoises data and separates wave modes. From this, we can identify which modes differ from the baseline wavefield. These differences highlight and characterize heterogeneities in the material.

We outline the mathematical framework for the algorithm and the experimental setup. We include results for a simulated wavefield and initial experimental data, both in flat, isotropic, and homogeneous media, such as metal plates. Additionally, we discuss future plans to address the increased complexity of media and curved cladding geometry.