ParisTech

Arts et Métiers Sciences et Technologies

RESEARCH TOPIC FOR THE PARISTECH/CSC PHD PROGRAM

Field: Materials Science, Mechanics, Fluids

Subfield: Mechanical engineering, numerical simulation

Title: Measurement of residual stresses in materials: FEM-based simulation of X-ray diffraction

ParisTech School: Arts et Métiers Sciences et Technologies

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Lab location: Aix-en-Provence
(Lab/Advisor website): https://www.msmp.eu/

Short description of possible research topics for a PhD:
It is well known that, in many cases, residual stresses can improve lifespan of mechanical parts. In order to estimate those stresses in crystalline materials, one of the most used techniques is based on X-ray diffraction (XRD). The aim of this project is to build a framework for simulating the XRD experiment on a strained polycrystal. This simulation will be performed from the results of Finite Element Analysis (FEA) of a polycrystalline aggregate submitted to macroscopic stress, as illustrated in Figure 1.

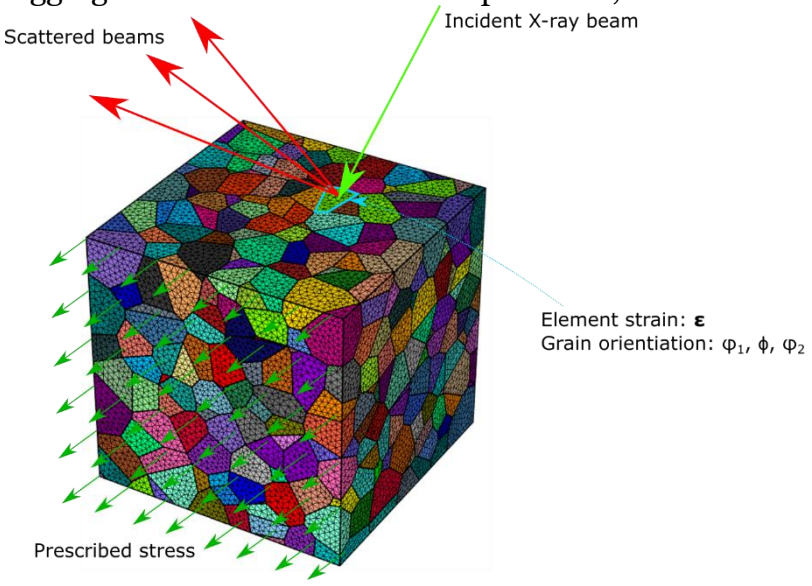

Figure 1. Schematic representation of the simulation: the scattered beams in a given element will be computed depending on the strain within the element and the orientation of the parent grain. Coulours in the mesh represent the unique grains.

Since FEA will be done at grain scale, the XRD simulation will take into account the heterogeneous strain inside each grain, due to crystalline anisotropy. The

corresponding mesh will be generated with the aid of numerical tools dedicated to synthetic aggregate generation (see refs. 1 and 2).

Required background of the student:
The student must have advanced knowledge in mechanical engineering, particularly in continuum mechanics: stress, strain, generalized linear elasticity (stiffness tensor), anisotropy. Basics of mechanics of materials (crystal plasticity, crystallography etc.) is highly recommended. The student may also be familiar with FEM and Object-Oriented programming (Python or/and C++).

A list of 5 (max.) representative publications of the group:

1. Depriester, D., Kubler, R. (2019). Radical Voronoï tessellation from random pack of polydisperse spheres: Prediction of the cells' size distribution. *Computer-Aided Design*, 107:37 – 49
2. Depriester, D., Kubler, R. (2019). Resolution of the Wicksell's equation by Minimum Distance Estimation. *Image Analysis & Stereology*, 38(3):213–226.
3. Pluyette E., Sprauel J.M., Lodini A., Perrin M., Todeschini P. (1996). Residual stresses evaluation near interfaces by means of neutron diffraction: modelling a neutron spectrometer. *ECRS4*, Cluny, pp. 153-163.
4. Pluyette, E. (1997). Evaluation par diffraction de neutrons, des contraintes résiduelles dans les liaisons bi-métalliques. PhD thesis, ENSAM.
5. Pluyette E., Sprauel J. M., Lodini A., Perrin M., Ceretti M. and Todeschini P. (1996). Residual stresses evaluation near interfaces by means of neutron diffraction: modelling a spectrometer, in *Proceedings of the ECRS-4*, S. Denis et al. (eds), June 4–6, Cluny, France, pp. 153–163.