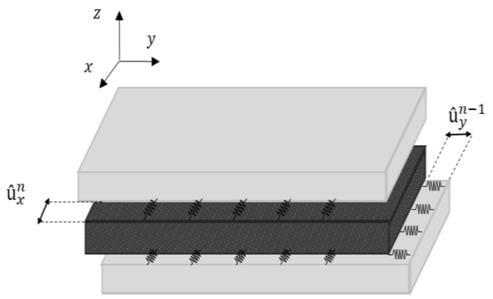
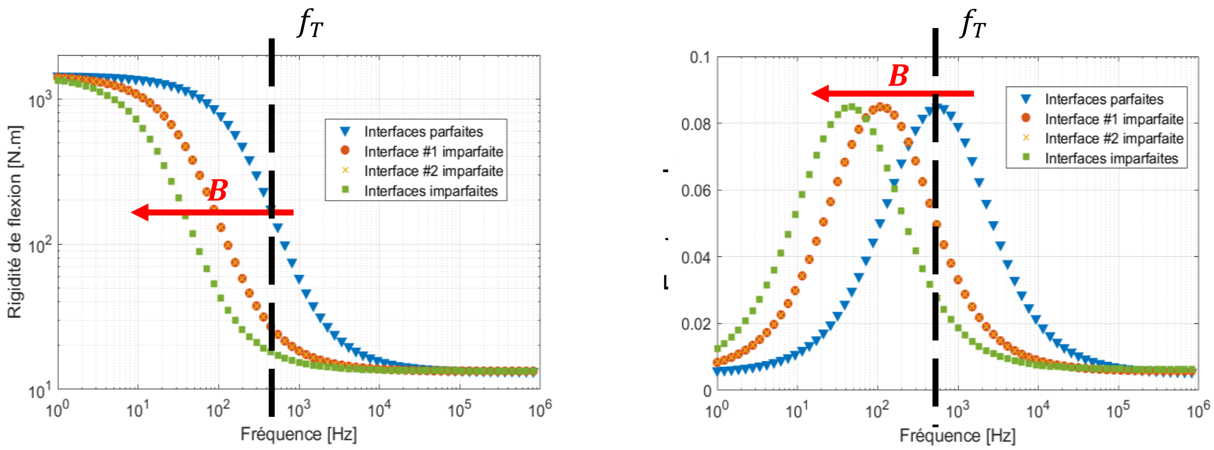
Equivalent vibro-acoustic model of multilayer structures with nonlinear interfaces

Post-doc (12 to 18 months) proposed by Kerem Ege (LVA-INSA) and Emmanuel Gourdon (LTDS-ENTPE)

Fundings: Centre Lyonnais d'Acoustique (CeLyA)



The aim of the post-doc is to implement non-linear modeling of imperfect interfaces in a vibro-acoustic equivalent model of multi-layer structures (in order to model the system response as a function of the amplitude of the load). Depending on the level of amplitude, this can enable a multilayer to be decoupled more or less rapidly, to target maximum damping over a range of target frequencies, and to obtain particular dynamic behaviors of interest for applications in control, localization, etc.



Figures taken from PhD defense of Nicolas Auquier [1]

Initial developments will be based on the PhD of Nicolas Auquier [1], who developed a dynamic equivalent multilayer model with imperfect interfaces. This model has its origins in the work of J.-L. Guyader [2], and more particularly in the approach of F. Marchetti, who recently generalized it to anisotropic multilayers [3]. A classical interface equation has been implemented in this model by modifying the conditions at its interfaces. Stress continuity was retained (as contact is always maintained), but the displacement field was made discontinuous by this new equation. This has enabled the implementation of imperfect interfaces.
As a result, the interface law employed in this work is widely used in the scientific community today. It's a simple law (linear stiffness + damping) very efficient for the description of interface effects. Its impact on the dynamic behavior of a multilayer has been demonstrated by calculating two dynamic parameters: equivalent bending stiffness and equivalent bending damping. These parameters are calculated from the frequency-dependent bending wave number injected into a thin plate model. The effect observed is a shift in dynamic parameters towards low frequencies. The decoupling is made easier by the imperfect interfaces.

The aim of the present post-doc **is to extend this method to the case of non-linear interfaces with a non-linear interface law**. The implementation of a nonlinear interface parameter could be inspired in its form by improved Hertz laws. Initially, the simplest approach might be to take a piecewise linear interface parameter (a function of the applied stress) so as not to alter the original modeling too much, and thus retain moderate simplicity of implementation. Modifying the interface behavior equation will have an effect as soon as the displacement field is written, and all the steps will have to be rewritten in order to arrive at a condensed model. Other methods, such as transfer matrix methods, may also be considered, in order to take non-linear interfaces into account in the final condensed model.

Depending on the progress of the modeling work, experiments on beams or plates may be considered in order to verify the results experimentally and/or characterize non-linear interfaces, or even obtain specific dynamic behaviors thanks to these non-linear interfaces (control, damping, localization...).

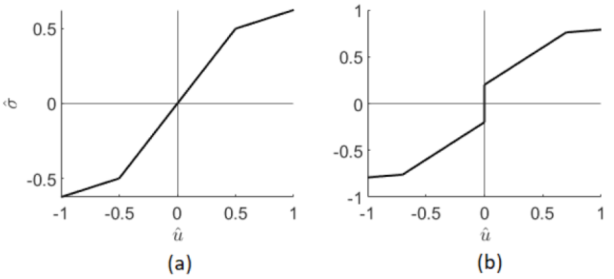


FIGURE C.1 – Illustration de (a) une interface purement élastique avec un paramètre linéaire par morceaux, (b) une interface élastique au paramètre linéaire par morceaux avec une ordonnée à l'origine différente de zéro.

Figure taken from PhD of Nicolas Auquier [1]

References

[1] PhD of Nicolas Auquier (Thèse MEGA-ENTPE, financement Labex CeLyA soutenue le 26 octobre 2023, (co-encadrement Kerem Ege et Emmanuel Gourdon): Modèle équivalent de structures multi-couches à interfaces complexes (Numéro d'ordre : 2023ENTP0008, École Doctorale Mécanique, Énergétique, Génie civil, Acoustique, ED 162).
[2] F. Marchetti. Modélisation et caractérisation large bande de plaques multicouches anisotropes. PhD, Institut National des Sciences Appliquées de Lyon (INSA Lyon), France, 2019. NNT : 2019LYSEI130.
[3] J.-L. Guyader and C. Lesueur. Acoustic transmission through orthotropic multilayered plates, part I : Plate vibration modes. Journal of Sound and Vibration, 58(1) :51-68, May 1978.

Candidates must have a PhD in Acoustics/Mechanics. Experience in the subject will be appreciated.
To apply, please send a cover letter, CV and any other information you feel is relevant to demonstrate your skills and competencies (PhD reports, professional contacts, etc.).

Supervisors

Kerem Ege (kerem.ege@insa-lyon.fr)
LVA (INSA-Lyon)
http://lva.insa-lyon.fr

Emmanuel Gourdon (emmanuel.gourdon@entpe.fr**)**
LTDS (site de l'ENTPE) UMR CNRS 5513
https://ltds.ec-lyon.fr (http://www.entpe.fr)

LVA and LTDS are members of the Centre Lyonnais d'Acoustique (CeLyA). The Centre Lyonnais d'Acoustique was created in 2011 with the ambition of federating all the researchers involved in acoustics at the University of Lyon. Recognized as a LabEx (Laboratory of Excellence) in 2011 by the "Investissements d'Avenir" program, and with over 80 researchers specializing in almost all aspects of sound (audible and ultrasonic), CelyA represents the largest center in France specializing in acoustic engineering and its applications.