# Dynamic rupture and fragmentation of a bar with the Phase-field and Lip-field approach

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This work is about the modelling of rupture and fragmentation with the Phase-field and Lip-field approaches. Phase-field [1] has been widely used to model the failure of material since the last few years. On the other hand, Lip-field was introduced more recently in [2] as a new way to regularize softening material models. It was tested in 1D quasistatic in [2] and 2D quasistatic in [3].

The two approaches share some similarities. They formulate the mechanical problem to be solved as the minimization problem of an incremental potential. The minimization problem is not convex if the displacement and damage fields are considered as unknown at the same time. However, looking for the displacement field for a given damage field is a convex problem, and vice versa. Therefore, the displacement and damage field at each time step are usually obtained by a staggered algorithm, where the displacement field is computed for a fixed damage field, then the damage field is computed for a fixed displacement field. Both Phase-field and Lip-field introduce a characteristic length parameter $\ell_c$ to avoid mesh dependency, the main difference being how this parameter $\ell_c$ is introduced. In Phase-field, it is taken into account by a term in the incremental potential which depends on the gradient of the damage variable. On the other hand, with Lip-field, a Lipschitz constraint based on $\ell_c$ is imposed on the damage field. Another feature of the Lip-field approach is to provide bounds on the domain where the Lipschitz constraint is active, allowing to focus computing efforts on restricted zones.

In [4], the Phase-field incremental potential is obtained by equivalence with a linear cohesive zone model (CZM). A similar process was used in [5] for Lip-field. In the present work, we show that several choices are possible to get this CZM equivalence, but that some of them are numerically better than the others. Then, both Phase-field and Lip-field are applied to 1D dynamic rupture and fragmentation examples. In particular, for the fragmentation example and following the work of [5], computations with randomly distributed material properties are performed to get average fragment sizes and dissipated energies, which are compared to several experimental, analytical and numerical references.

## References

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