Interface models for faults in geophysics

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The interface behavior along faults plays an essential role in the nucleation of earthquakes. Despite the complexity of the surface condition, simplified models can be very helpful to get a better understanding of the processes which can be considered as dynamics interface instabilities. Among these models, two main classes (with many variants) are currently used (see [1] [2] [3] [4] [8] [9]) :
- slip-weakening (SW) models where the friction coefficient is depending on the sliding displacement,
- rate-and-state (RS) models where the friction coefficient is depending on the sliding velocity.

In the present work, the interface law coupling friction and adhesion developed by Raous-Cangémi-Cocou-Monerie (RCCM see [6] [7]) is proposed to simulate the fault interface and is compared to the SW et RS laws. The consideration of eventual viscosity dissipation makes also the RCCM model rate and slip-sensitive in an implicit way.

Comparison is first conducted regarding the dissipation sources in the various models. A convenient identification of the constitutive parameters of every model is conducted in order to have an equivalent dissipation in the three cases. The differences are underlined on simple monotone tractions (with various velocities) for a monodimensional case.

It can be noted that the RCCM model accounts unloading and unilateral contact conditions which is not the case with the SW or RS laws where contact remains prescribed. With the RCCM model the dependence of the solution both upon slip (like SW laws) and slip rate (like RS laws) is taken into account by the viscosity and by the adhesion.

A qualitative dynamics analysis of a mass-spring system (Klarbring example) is presented for a material point sliding on a plane. A Non Smooth Contact Dynamics solver is used in order to account the discontinuities of velocity.

Finally, a nucleation analysis is conducted for a semi-infinite fault. Using the spectral code MDSBI, one computes, for the various interface laws, the evolution of the solution when an initial stress condition, corresponding to the imminent sliding, is imposed on the fault and a perturbation patch is prescribed at the center of the fault ([5]).

A synthesis of the main differences between these three kinds of interface laws is presented and the consequences on the behavior of the faults and the nucleation process are illustrated on the presentation of numerical simulations.

References

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