

## 2018-00547 - Non-smooth modeling and simulation of energy dissipation processes during rockfall [PhD Campaign]

Niveau de diplôme exigé : Bac + 5 ou équivalent  
Fonction : Doctorant

### A propos du centre ou de la direction fonctionnelle

Grenoble Rhône-Alpes Research Center groups together a few less than 800 people in 35 research teams and 9 research support departments.

Staff is localized on 5 campuses in Grenoble and Lyon, in close collaboration with labs, research and higher education institutions in Grenoble and Lyon, but also with the economic players in these areas.

Present in the fields of software, high-performance computing, Internet of things, image and data, but also simulation in oceanography and biology, it participates at the best level of international scientific achievements and collaborations in both Europe and the rest of the world.

### Contexte et atouts du poste

TRIPOP is a joint research team of Inria Grenoble Rhône-Alpes and of the Laboratoire Jean Kuntzmann and started in January 2018 as a follow up of the BIPOP team. The team is mainly concerned by the modeling, the simulation and the control of nonsmooth dynamical systems. Nonsmooth dynamics concerns the study of the time evolution of systems that are not smooth in the mathematical sense, i.e., systems that are characterized by a lack of differentiability, either of the mappings in their formulations, or of their solutions with respect to time. In mechanics, the main instances of nonsmooth dynamical systems are multibody systems with Signorini's unilateral contact, set-valued (Coulomb-like) friction and impacts, or in continuum mechanics, ideal plasticity, fracture or damage.

The members of the team have a long experience of nonsmooth dynamics modeling together with the development of simulation software. With the integration of Franck Bourrier as a new research member, a part of the activities of the theme is now focused in rockfall trajectory modeling and natural hazard mitigation.

### Mission confiée

Rockfall is one of the most common natural hazards in mountainous regions. The assessment of this hazard, related with block detachment conditions and propagation, is essential for mitigation strategies that include hazard zones determination and protection structures design.

Block trajectory simulation models are routinely used for the quantitative assessment of rockfall hazard. In these models, one of the major difficulties is the development of physically consistent and field applicable approaches to model the interaction between the block and the natural terrain. The models either consider the block as a single material point or explicitly account for the fragment shape. The first approach, although largely empirical, has been extensively investigated and calibrated. Consequently, it is efficient for global hazard zoning purposes because of its reduced number of input parameters and its computational efficacy. However, it remains limited for a detailed analysis of the propagation process with the objective of designing protection structures. The second type of approaches, that explicitly accounts for the fragment shape, is either based on regularized Discret Element Methods (DEM) or on nonsmooth contact dynamics methods.

These approaches have not yet been extensively investigated and calibrated. They remain based on simple models of block interaction with the terrain that only partially integrate the energy dissipation processes. As a consequence, they remain almost not used in practice.

The objective of this PhD is to improve the modeling of the dissipation processes occurring during the propagation of blocks through mountain slopes. These processes are related with momentum exchanges, friction at the interface, wave propagation through the soil, visco-plastic strains of the soil and the breakage of the rock. The novelty will consist in the development of contact laws with rolling friction, and with the integration of rock breakage due to impact.

## Informations générales

- **Thème/Domaine** : Optimisation et contrôle de systèmes dynamiques
- **Ville** : Montbonnot
- **Centre Inria** : [CRI Grenoble - Rhône-Alpes](#)
- **Date de prise de fonction souhaitée** : 01-10-2018
- **Durée de contrat** : 3 ans
- **Date limite pour postuler** : 01-05-2018

## Contacts

- **Equipe Inria** : [TRIPOP](#)
- **Recruteur** :  
Bourrier Franck / [franck.bourrier@inria.fr](mailto:franck.bourrier@inria.fr)

## Conditions pour postuler

### Sécurité défense :

Ce poste est susceptible d'être affecté dans une zone à régime restrictif (ZRR), telle que définie dans le décret n°2011-1425 relatif à la protection du potentiel scientifique et technique de la nation (PPST). L'autorisation d'accès à une zone est délivrée par le chef d'établissement, après avis ministériel favorable, tel que défini dans l'arrêté du 03 juillet 2012, relatif à la PPST. Un avis ministériel défavorable pour un poste affecté dans une ZRR aurait pour conséquence l'annulation du recrutement.

### Politique de recrutement :

Dans le cadre de sa politique diversité, tous les postes Inria sont accessibles aux personnes en situation de handicap.

**Attention**: Les candidatures doivent être déposées en ligne sur le site Inria. Le traitement des candidatures adressées par d'autres canaux n'est pas garanti.

## References

- Bourrier, F. and Hungr, O. (2013) Rockfall Dynamics: A Critical Review of Collision and Rebound Models, in Rockfall Engineering (eds S. Lambert and F. Nicot), John Wiley & Sons, Inc., Hoboken, NJ, USA. doi:10.1002/9781118601532.ch6
- Numerical Methods for Nonsmooth Dynamical Systems: Applications in Mechanics and Electronics Vincent Acary, Bernard Brogliato Springer Verlag, 35, pp.526, 2008, Lecture Notes in Applied and Computational Mechanics, 978-3-540-75391-9
- A DEM model for soft and hard rocks: Role of grain interlocking on strength. L. Scholtes F. V. Donze. Journal of the Mechanics and Physics of Solids, Elsevier, 2013, 61 (2), pp.352-369.

## Principales activités

- Literature review. This review will focus on the modeling approaches potentially usable for the integration of the dissipation processes during the impact of a block on a soil, modeling of contact law with rolling friction and of block breakage.
- Formulation and numerical implementation of a novel contact law integrating rolling friction in the framework of second-order cone complementarity.
- Modeling of block breakage. The approach proposed will be based on the modeling of the block as an assembly of rigid or deformable tetrahedron linked by cohesive contact laws. The challenge relies on the implementation of relevant cohesive contact laws, able to reproduce at the macroscopic level the main fracture phenomena.
- Dimensional analysis. This final phase of the project will consist in the assessment of the relevance of the models over large ranges of block size based on the joint use of dimensional analyses and simulations.

## Compétences

The PhD candidate should have competences in solid mechanics and numerical modeling.

A strong theoretical background in solid mechanics is mandatory.

Furthermore, the applicant must show a strong interest for software development in computational Mechanics. He also has to be motivated by applied research in collaboration with researchers from different disciplines.

A good level of English and subsequent writing capacities are also requested.

## Avantages sociaux

Restaurant on site

Financial participation for public transport

Social security

Social and sporting activities

Arranging working time

French courses