

# Colloquium Final Report Form

**Title of the Colloquium:** EUROMECH Colloquium 548  
on “Direct and variational methods for nonsmooth problems  
in mechanics”

**Date and location:** June 24-26, 2013, Amboise, Indre-et-Loire, France

**Chairperson:** Pr. Géry de Saxcé

**Co-chairperson:** Pr. Gianpietro Del Piero

**Is there need of another Colloquium on the same or a related subject?  
Which year?**

**Full registration fee:** 424 €

**What other funding was obtained?**

CNRS : 2000 €

University Lille 1: 1000 €

Laboratoire de Mécanique de Lille: 1000 €

Association Française de Mécanique: 1000 €

**What were the participants offered?**

The registration fee covers:

- Full board (accommodation, breakfast, lunch, dinner and breaks)
- Cocktail party and conference banquet
- Conference proceedings on a USB flash drive
- Backpack with paper block, ballpoint pen, and souvenir gift (DVD on Leonardo da Vinci’s machines at Clôds-Lucé)
- Railway station-hotel shuttle bus
- Shuttle bus for visit of Clôds-Lucé (Leonardo da Vinci’s cattle)

[www.euomech.org](http://www.euomech.org)

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**Number of members of Euomech (reduced registration fee):** 10

**Number of non-members of Euomech (full registration fee):** 26

**Number of participants from each country:**

Czech Republic : 1

France: 20

Germany: 2

Greece: 1

Italy: 12

Lithuania: 1  
Switzerland 1  
**Total: 38**

**List names of Applicants to EUROMECH:**

Roberto ALESSI, Pierre ARGOUL, Ferdinando AURICCHIO,  
Paolo BISEGNA, Gedimas BLAZEVICIUS, Giovanna BONFANTI, Carlo CALLARI,  
Eric CHERKALUK, Alexandre CHARLES, CHENG Long, Marius COCOU, Andrei  
CONSTANTINESCU, Gianpietro DEL PIERO, Géry DE SAXCE, Serge DUMONT,  
Michel FREMOND, Fabrizio GEMELLI, Jaroslav HASLINGER, Andrés Alessandro  
LEON BALDELLI, Lorenzo LEONETTI, Christian LICHT, Massimiliano LUCCHESI,  
Franco MACERI, Habibou MAITOURNAM, Michele MARINO, NGUYEN QUOC  
Son, Abdelbacet OUESLATI, Michael PEIGNEY, Nelly POINT, Michel RAOUS,  
SHEN Wanking, Paul SICSIC, Jaan-Willem SIMON, Konstantinos SPILIOPOULOS,  
TO Quy Dong, Giuseppe VAIRO, Claude VALLEE, Kerim YUNT

**Scientific Report**

Please type your report on the following pages. Use additional pages if required. Put the date and your signature at the end.

## Colloquium No 548 Scientific Report

In solid mechanics and in the mechanics of structures, engineers and scientists are faced to a large class of nonsmooth phenomena such that unilateral contact, friction, adhesion, collisions, plasticity, viscoplasticity, fracture. A common feature to these problems is that they are unilateral, in the sense that their formulation and modelling requires a systematic use of inequalities. Since several decades, significant theoretical advance was achieved in different ways.

One of the objectives of this colloquium was to bring together two European communities concerned by these themes: the group "Limit states of materials and structures - Direct Methods", whose researchers share their latest results each two years (Aachen 2007, Lille 2009, Athens 2011) and the "Unilateral Problems in Structural Analysis" group which has quite similar research interests, but more focused on the formulation of the problems and in the quest of the most appropriate solution techniques (Siracusa 2007, Palmanova 2010).

There were thirty-eight people coming from seven countries: Italy, France, Greece, Czech Republic, Germany, Switzerland, Lithuania and thirty-one communications (25') were delivered in a unique session.

The final program has enabled fruitful exchanges on many topics:

- contact mechanics with friction and adhesion for continuum or discrete systems,

- ductile and brittle fracture mechanics with new developments based on limit analysis or variational approaches,
- shakedown analysis of structures (beams, frames, ...),
- numerical treatment of Shape Memory Alloys (SMA),
- Thin film behavior and damage,
- New developments based on bipotentials.
- The confrontation between different visions or approaches of similar problems was possible in the proposed time schedule. The large coffee breaks promote also these exchanges. Finally, a visit of the “Clos Lucé” in Amboise, the last home of Leonardo Da Vinci, showed that engineers problems are from time to time almost the same: lightweight, reliable and efficient structures. We can see that this colloquium’s research topics are going in this way.

The Colloquium will give rise to special issues of:

- Annal of Solid and Structural Mechanics, edited by Michel Frémond and Franco Maceri and published by Springer
- Advances in Mathematical Sciences and Applications, edited by Noboyuki Kenmochi and published by Gakkōtoshō.

## Colloquium No 548 Scientific Report

### Direct and variational methods for nonsmooth problems in mechanics

#### Intended scientific scope:

In solid mechanics and in the mechanics of structures, engineers and scientists are faced to a large class of nonsmooth phenomena such that unilateral contact, friction, adhesion, collisions, plasticity, viscoplasticity, rupture. A common feature to these problems is that they are unilateral, in the sense that their formulation and modelling requires a systematic use of inequalities. Since several decades, significant theoretical advance was achieved in different ways.

To determine limit loads for structures operating beyond the elastic limit is since ever one of the most important tasks of engineers. For this purpose, the so-called Direct Methods play an increasing role due to the fact that they allow rapid access to the requested information in mathematically constructive manners. They embrace limit analysis, the most developed approach now widely used, and shakedown analysis, a powerful extension to the variable repeated loads potentially more economical than step-by-step inelastic analysis. In these subjects, one of the proponent communities is active at the European level through a group "Limit states of materials and

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structures-direct methods", whose researchers share their latest results each two years.

The second proponent group, "Unilateral Problems in Structural Analysis" has quite similar research interests, but more focused on the formulation of the problems and in the quest of the most appropriate solution techniques. In the last two meetings (Siracusa 2007, Palmanova 2010) the dominant areas were contact and adherence, friction, interfaces, collisions, and no-tension materials.

At present, the two research communities are interested both in the development of classical direct methods, and in the numerical solution techniques provided by the recent theoretical progress in the variational approach to inelastic phenomena. A comparison of the results obtained in these fields is expected to be most fruitful for the respective future activities. In particular, the meeting will be an excellent occasion for exchanging state-of-the-art, modelling and results at the crossroad of the respective work areas. Emphasis will be put on creative ideas, as opposed to technicalities and to purely numerical contributions.

The topics to be discussed at the colloquium are:

- Contact, friction
- Fatigue and fracture,
- Impact and collisions,
- Multiscale analysis of complex materials and structures,
- Nonsmooth analysis,
- Shakedown and limit analysis,
- Direct methods in general.

Applications to geomechanics, biomechanics, composites and heterogeneous materials will be particularly considered.

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