EUROPEAN MECHANICS SOCIETY

# EUROMECH Workshop. Scientific Report

The aim of the Workshop was to bring together researchers who apply similarity and symmetry analysis to engineering problems in analytical and solid mechanics (for finding closed form solutions of boundary value problems, or to reveal invariance properties at the root of rheological models), researchers interested in the fundamental aspects associated with symmetries (conservation laws, geometric mechanics), numerical analysts who develop and use such methods in numerical schemes (symplectic schemes, variational integrators).

Symmetries are useful to integrate the differential equations underlying the boundary value problems encountered in solid mechanics ant those that result from the geometrical description of thin elastic solids. As to formal aspects, symmetries constitute the main ingredient of Noether's theorem, which is strongly related to Lagrangian and Hamiltonian formulations in continuum mechanics. The field of Eshelbian Mechanics (in the honour of the works of Eshelby), otherwise coined Configurational Mechanics, relies on translational symmetries in the so-called material space, for the writing of field equations in terms of Eshelby stresses. Those symmetries extended to rotations and dilatations have been intensively used to construct the well-known J, K, L, M integrals, which are widely used in fracture mechanics to characterize the singular stress field around the crack tip. Those path independent integrals result from conservation laws, which are the natural counterpart of symmetries.

In rheology, the response of materials under varying conditions of control parameters (such as temperature, strain rate) can sometimes be conveniently summarized into so-called master curves, resulting most of the time from an empirical construction. A typical example is the well-known time temperature equivalence principle, stating equivalence between the effect of time and of temperature for polymers, as originally proposed by Williams, Landel and Ferry (WLF) model. One important field in which similar relations are used is high temperature creep of metallic alloys, devoted to industrial applications. The most known relations in this context are the Larson-Miller and the Dorn models; similar invariant models for rupture are for instance the Monkman-Grant relation applicable to the 9Cr-1Mo alloy. The Lie symmetries can here be viewed as an interpolation method allowing to continuously linking experimental data, but relying on a limited - well chosen – set of experiments. In fracture mechanics similarly, the master curve concept allows to quantify the variation of fracture toughness with the temperature throughout the ductile-to-brittle transition region.

The Workshop covered the following **topics**:

- Symmetries and conservation laws in continuum mechanics. Numerical schemes Variational integrators. Symplectic schemes.
- Lagrangian and Hamiltonian formulations in solid mechanics. Configurational mechanics. Geometric mechanics.
- Similarity methods in rheology, fatigue and fracture mechanics (path-independent integrals). Fractal mechanics.
- Geometry of thin elastic solids (membranes, biofilms, drops).

The Workshop consisted of introductory and advanced courses on the topic introduced by George Bluman (UBNC, Vancouver, Canada) and N. Ibragimov (State Aviation Technical University, Ufa, Russia), two world

recognized specialists in the field of symmetry methods; they each delivered 6 lectures of one hour during the week of the Workshop.
They were followed by 32 oral presentations of the 36 participants. The restricted size of the group of participants and the informal atmosphere allowed extensive interactions and discussions between the plenary lecturers and the participants, and overall between all participants.

The organizers have the feeling that the Workshop was successful, with a good balance between general lectures (including the courses) and more specialized talks.
As an outcome of the Workshop, a book will be published in spring 2014 by Springer in the series LNCAM (Lecture Notes in Computational and Applied Mechanics), entitled 'Similarity and symmetry methods. Subtitle: Applications in elasticity and mechanics of materials.' Due to the contribution of leading experts in the world, the book will provide a complete overview in the field still at a level accessible for non-specialists.