

**Successful R&I in Europe 14-15 Feb**  
**10th European Networking Event – ZENIT/NRW Düsseldorf**

**Workshop – Session 5 – 15Feb**  
**Nanotechnology - Materials - Manufacturing (NMN)**

M. Buisson, Univ Rennes, CNRS, IPR (Institut de Physique de Rennes) – UMR 6251- France

« *Theoretical Boussinesq indentation of an elastic-brittle material:  
investigate nucleus of cone-crack via Cartan geometry* »



**Université de Rennes 1 (UR1):**

- ✓ 29,000 students (representing 125 nationalities)
- ✓ 3,700 staff members, 22 joint research units associated with national research centers (e.g. Inria, INSERM, CNRS, INRA) and awards over 250 PhD degrees every year.
- ✓ Currently involved in more than 20 H2020 projects, has been involved in 43 FP7 projects, and in numerous other European initiatives such as the *EIT Digital* and *Erasmus Mundus Master Courses*.
- ✓ Research at UR1 is organized along four major domains, corresponding to four graduate schools: Mathematics & ICT, Life Sciences, Materials Science, and Humanities & Social Sciences.

The Institut de Physique de Rennes is a joint CNRS-Université de Rennes-1 research unit divided in 6 department and covering several areas of physics. It hosts 86 researchers for a total of 183 staff members. It publishes about 120 articles a year and awards around 15 PhDs every year.



A. SEEGER asked J. ESHELBY to consider the book of A.E.H. Love's A (Treatise on the Mathematical Theory of Elasticity, the fourth edition (Oxford, 1972)) to strengthen new concepts of great importance in material science with eigenstress and eigenstrain problems (see in **Collected Works of J.D. Eshelby, Springer 2006** )



In Physica B – 2017 (see ref.a) eigen-strain is due to photo-expansion ; image of the displacement at the surface by photoexpansion ( after data of ref.a )

Densified zone under indentation (ref.b, IMS 2008-Maastricht): eigen-strain is due to densification of the glass under indentation

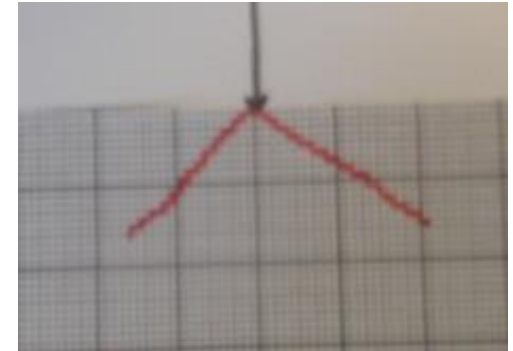


We insert center and doublet forces (A.E.H. Love) (ref.c, Mat & Tech – 2015, published with financial support of ERC/DAMREG)

M. Buisson: Eshelbian mechanics of defects and inhomogeneities. (for glass photoexpansion in an affected zone under a spot laser ; or indentation with a nucleus of densification and doublet-forces...)

We aim to develop the model (ref (d), in french ) of M. Buisson and N. Antonio-Tamarasselvame issued from ref (e) but in the frame of a static problem related to low indentation of glasses with arising Hertz-cone decohesion.

*For this occurrence of defect, we start with the static stress field of Boussinesq (a single force punctually applied normal to the brittle surface) and extend it with introduction of the vector of Cartan devoted to approximate the discontinuity due to the arising conic nucleation of rupture: this nucleus of decohesion is assumed small so that a direct perturbation method is proposed to obtain a pragmatic semi-analytical solution, use of hypergeometric functions will appear to trap the apex angle of the cone which should depend mainly on the influence of Poisson's coefficient.*



Scheme of Hertz-cone of rupture under indentation

### **Partners sought:**

*Teams (students and colleagues) in:*

- Cartan geometry in mechanics of materials
- Hypergeometric functions
- Analytical calculus

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**Bibliographie :**

(a) « Mechanical model of giant photoexpansion in a chalcogenide glass and the role of Photofluidity », M Buisson, Y Gueguen, R Laniel, C Cantoni, P Houizot P. Lucas, J.C. Sangleboeuf - Physica B: Condensed Matter 2017

(b) « Low Indentation of glass : analytical calculus », M. Buisson, J.C. Sangleboeuf, N. Antonio Tamarasselvame , 9th INTERNATIONAL MATHEMATICA SYMPOSIUM, IMS08, Maastricht University .

(c) « Examen du modèle d'ampoule de E. Yoffe (Investigation of E. Yoffe's Blister model) »  
M. Buisson et T. Rouxel, *Matériaux & Techniques*, Volume 103, Number 6, 2015 (Indentation 2014)  
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(d) Antonio-Tamarasselvame and Buisson, Cong. Français Méca, Sess. 24, 409, (2011). <http://hdl.handle.net/2042/46712>

(e) « Wave propagation within some non-homogeneous continua »  
Nirmal Antonio Tamarasselvame; Manuel Buisson; Lalaonirina Rakotomanana-Ravelonarivo,  
Comptes Rendus Mécanique, Elsevier Masson, 2011, 339 (12), pp.779-788  
<http://dx.doi.org/10.1016/j.crme.2011.09.002>

"Hertzian cone cracks in brittle glasses; a second gradient model, influence of Poisson's coefficient and comparison with experimental data », M. Buisson, and N. Antonio-Tamarasselvame  
*EMMC14 - European Mechanics of Materials Conference 2014 Gothenburg August 27-29, 2014*

Antonio-Tamarasselvame , thesis report, (ARED Bretagne, Rennes FRA, 2010)

Buisson, Congrès Nantes matériaux-2010 → Matériaux et Techniques 99 , 2, (2011).

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