Contact Mechanics and Elements of Tribology

Foreword

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@ Centre des Matériaux
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Outline

- Acquaintance
- Questionnaire
- Teaching team
- Course content
- Complexity of contact physics
- Notations

Teaching team




- **Henry Proudhon**- Fretting and Wear
- **Andrei Shvarts** - Lubrication and Sealing
- **Basava Raju Akula** - Extended mortar method
- **Vladislav Yastrebov** - all the rest...

Program

Monday

- Lecture: Industrial Applications
- Lecture: Continuum Contact Mechanics
- Blackboard: Flamant's problem

Tuesday

- Lecture: Contact mechanics and material behavior
- Lecture: Micromechanical contact: roughness
- Practical work: Integration of Flamant's solution

Wednesday

- Lecture: Lubrication and Sealing (*given by Andrei Shvarts*)
- Lecture: Computational Contact Mechanics
- Practical work: Hertz contact (finite element method)

Program

Thursday

- Lecture: Wear and fretting (*given by Henry Proudhon*)
- Lecture: Friction
- Practical work: Frictional and frictionless contact (finite element method)

Friday

- Seminar: Extended surface-to-surface contact discretization (*given by Basava R. Akula*)
- Seminar: Mechanical Contact of Rough Surfaces
- Seminar: Elasto-Dynamic Friction
- Practical work: Elasto-plastic Contact
- Lunch  all together
- Exam

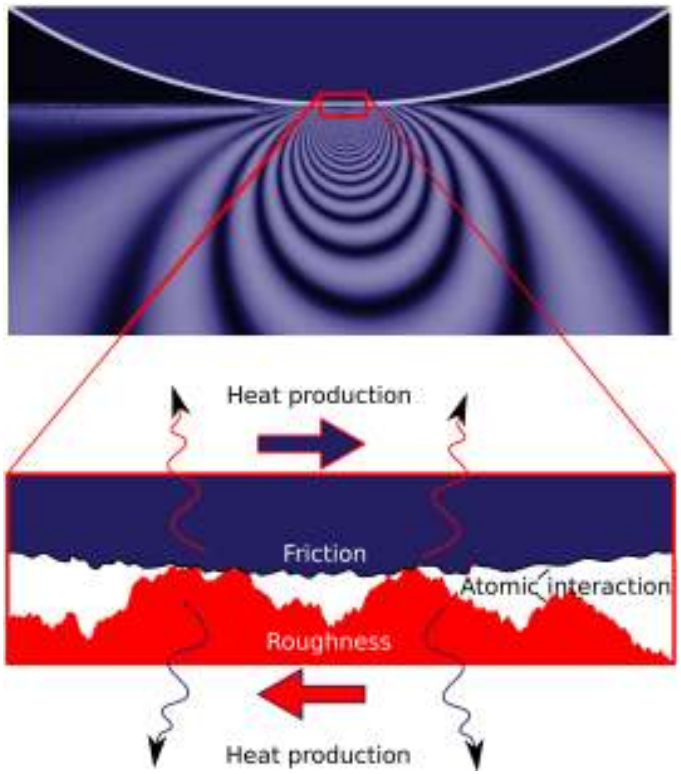
Exam and notes

- On Friday, February 23 right after lunch at 14h00.
- 20-25 questions on lectures of the first four days (Monday-Thursday) and on a paper you need to read by Friday:
  [1] K.L. Johnson, K. Kendall, A.D. Roberts. *"Surface Energy and the Contact of Elastic Solids"*, Proc. R. Soc. Lond. A. 324, 301-313 (1971)
- Duration: 2 hours.
- Type of questions: technical questions which generally require some algebra
- As there is no lecture notes, you shall be attentive during the classes and take notes on your own.
- You will be allowed to use your notes and printed lectures during the exam.
- Notes are essential for DMS participants to validate the course.
- Right answers will be announced right after the exam.

Contact complexity: physics and mathematics

Particular difficulties related to contact problems:
multiphysical aspects, mathematical aspects

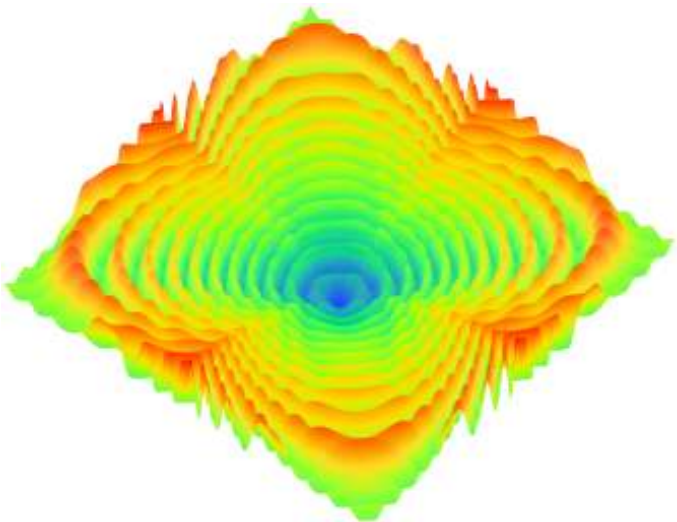
- Fractality of surfaces
- Interface chemistry
- Hardly accessible contact interface for measurements
- Generation and diffusion of heat
- Multiscale and multiphysical nature of friction



Contact complexity: physics and mathematics

Particular difficulties related to contact problems:
multiphysical aspects, **mathematical aspects**

- One of the most hard problems in mechanics
- Lack of standard optimization problem
- Non-convexity and non-differentiability
- Non-continuous character
- Bad scalability



Notations

Vectors and tensors

- a, α scalars
- $\underline{b}$ vectors
- $\underline{\underline{C}}, \underline{\underline{\beta}}$ 2nd order tensors
- $\overset{4}{\underline{\underline{D}}}$ 4th order tensors
- $\nabla \underline{a} = \underline{\underline{B}}$ gradient operator
- $\nabla \times \underline{a} = \underline{\underline{B}}$ rotor operator
- $\underline{a} \cdot \underline{b} = c$ scalar (dot) product
- $\underline{a} \times \underline{b} = \underline{c}$ vector (cross) product
- $\underline{a} \otimes \underline{b} = \underline{\underline{C}}$ tensor product
- $\underline{\underline{A}}^T$ transposition
- $\nabla \cdot \underline{a} = c$ divergence operator
- $\underline{\underline{I}} = \underline{e}_i \otimes \underline{e}_i$ unitary 2nd order tensor

Mechanics

- $\underline{\underline{\sigma}}$ Cauchy stress tensor
- g, g_n gap, normal gap
- ϵ penalty parameter
- $\lambda, \lambda_n, \lambda_t$ lagrange multipliers
- $\sigma_n = (\underline{\underline{\sigma}} \cdot \underline{n}) \cdot \underline{n}$ contact pressure
- $\underline{\underline{\varepsilon}}$ Small strain tensor
- $\underset{\sim}{\xi}$ position vector in parent space
- $\underline{n}$ outward unit normal vector
- $\frac{\partial \underline{\underline{\varrho}}}{\partial \xi_1}, \frac{\partial \underline{\underline{\varrho}}}{\partial \xi_2}$ surface tangent vectors
- f, μ Coefficient of friction

☺ Welcome to CMET course!