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Friction and Wear in Light of Elastic Interactions Between Micro Contacts

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ABSTRACT:

It is well known that man-made and natural surfaces are rough, with roughness observed over many length scales. An important consequence is that the real contact area is much smaller than the nominal contact area, and is made of micro contacts that vary in size and shape. It is well known that elastic interactions between nearby micro contacts matter [1,2]. Elastic interactions are felt over long distances, affect the location and average size of micro contacts, and influence the tribological properties. In particular, in the case of adhesive and abrasive wear [3], we show how crack shielding mechanisms between nearby asperities promote the formation of larger debris, thereby providing a mechanistic understanding of the transition for mild to severe wear at a critical load. While these results were initially observed through molecular dynamics simulations, we will discuss our recent efforts at generalizing those early observations with computationally efficient continuum solvers, through the boundary-element method or the finite-element method incorporating phase-field modeling of fracture.Ultimately, elastic interactions help revise the definition of a contact asperity, by incorporating nearby contact junctions into an effective contact area. The presentation will also explore optimization strategies in order to maximize elastic interactions and provide optimal contact shapes for cutting tools technology.

BIOGRAPHY:

Professor J.F. Molinari is the director of the Computational Solid Mechanics Laboratory (http://lsms.epfl.ch) at EPFL, Switzerland. He holds an appointment in the Civil Engineering institute, which he directed from 2013 to 2017, and a joint appointment in the Materials Science institute. He started his tenure at EPFL in 2007, and was promoted to Full Professor in 2012. He is currently an elected member of the Research Council of the Swiss National Science Foundation in Division 2 (Mathematics, Natural and Engineering Sciences). J.F. Molinari graduated from Caltech, USA, in 2001, with a M.S. and Ph.D. in Aeronautics. He held professorships in several countries besides Switzerland, including the United States with a position in Mechanical Engineering at the Johns Hopkins University (2000-2006), and France at Ecole Normale Supérieure Cachan in Mechanics (2005-2007), as well as a Teaching Associate position at the Ecole Polytechnique de Paris (2006-2009).The work conducted by Prof. Molinari and his collaborators takes place at the frontier between traditional disciplines and covers several length scales from atomistic to macroscopic scales. Over the years, Professor Molinari and his group have been developing novel multiscale approaches for a seamless coupling across scales. The activities of the laboratory span the domains of damage mechanics of materials and structures, nano- and microstructural mechanical properties, and tribology.