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Supervisor Expression of Interest
MSCA-IF Marie Sklodowska Curie Action-Individual Fellowship 2019

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Department Name: Research topic: (https://www.polimi.it/en/scientific-research/research-at-the-politecnico/departments/)	Department of Mathematics Francesco Brioschi (DMAT) **Polyhedral discretization methods for fluid flow and crack propagation in fractured poroelastic media** PE1_17 Numerical Analysis PE6_12 Scientific computing, simulation and modelling tools
MSCA-IF Research Area Panels	☐ CHE_Chemistry ☐ ECO_Economic Sciences ☐ ENG_Information Science and Engineering ☐ ENV_Environmental and Geosciences ☐ LIF_Life Sciences X MAT_Mathematics ☐ PHY_Physics ☐ SOC_Social Sciences and Humanities
Politecnico di Milano Areas:	☐ Cultural Heritage ☐ Smart Cities X Territorial Fragilities ☐ Health ☐ Industry 4.0
Brief description of the Department and Research Group (including URL if applicable):	The project will be carried out at the **Laboratory for Modeling and Scientific Computing MOX**, which is part of the **Department of Mathematics DMAT**. Researchers activities at the DMAT aims at expanding the mathematical knowledge and supporting its application to engeneering, physical, and industrial problems. The MOX gathers researchers in numerical analysis, mathematical physics and statistics. Its mission is to create and consolidate a centre of excellence in the field of mathematical modelling and scientific computing. The areas of expertise include fluid mechanics, geophysics, seismic and acoustic phenomena, and biomechanics. The complementary attitude of MOX researchers towards the solution of complex engineering problems and their expertise in numerical modeling will provide an ideal environment for the development of the project. Specif existing resources of the host institution will be employed to achieve the goals of the project: DMAT clusters for parallel CPU (up to 160 cores) and GPU computations; and the resources of CINECA, the Italian largest supercomputing centre.

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Brief project description: (max 1 page)	Propagating cracks in response to poroelastic stresses occur frequently in a large number of geomechanical applications, such as: tensile failure induced by pressurization of a borehole, waste disposal, earthquake triggering due to pressure induced rupture or reactivation of faults, injection-production cycles in geothermal fields, and geologic storage of carbon dioxide. Recent concerns over induced seismicity and groundwater contamination due to the loss of rock integrity underscore the need to quantify the risk of harmful events associated with subsurface flow and deformation. The key to successful assessment of these phenomena is the ability to perform accurate numerical simulations. Modeling a fluid-driven crack growth in porous media is a challenging problem. Since porous materials comprise a great number of interconnected pores allowing for fluid flow, this process involves coupled deformation and pressure diffusion. Nevertheless, most of the numerical models in hydraulic fracturing propagation have been developed assuming an elastic behavior of the rock and neglecting the pore pressure effect. Moreover, the complexity of the problem often restricts to consider simple fracture geometries. In recent years, a large effort has been devoted to the development of numerical schemes (e.g., discontinuous Galerkin, Virtual Element, and Hybrid High-Order methods), that apply to more general meshes than simplicial or Cartesian ones. In the context of poromechanics and crack propagation, discretization methods supporting general polyhedral meshes can be useful in order to treat complex geometry arising from the presence of various layers and fractures. Indeed, the discretization of the spatial domain may also include degenerate elements, hanging nodes, and nonconforming interfaces accounting for the presence of cracks or resulting from local mesh refinement or coarsening procedures. Envisioned project activities will be focused on the design and the analysis of efficient polyhedral discretization methods for simulating fluid flow, crack propagation, and fault slip in fractured poroelastic media. We expect that the use of these schemes will provide a greater robustness with respect to mesh fracture and distortion. The method should also be able to circumvent the main issues that have to be accounted for in poromechanical modeling: the coupling between the flow and the mechanics and the possible rough variations of the physical coefficients. The research will target the investigation of the models describing the interaction between the propagating cracks and the fluid flow and the analysis of the mathematical formulation of the problem. The computational performances of the proposed discretization will be assessed and compared to other algorithms considered in the literature.