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Coupled Hydro-thermal Lattice boltzmann model

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We aim to model hydro-thermal coupling for fluid flowing inside a rough fracture in a rock at a temperature that differs from that of the fluid. In particular, we wish to model the fully three-dimensional flow in the well-developed topography of fracture boundaries, i.e. we wish to go beyond the classical lubrication limit. Lattice-Boltzmann methods appear to be very suitable to implement this problem. Indeed, by requering only local operations, this method allows very steep and complex boundaries between the fluid and the rock.

We develop an algorithm which is based on two coupled lattice boltzmann methods, allowing us to get both the velocity and temperature evolving with time and space (especially, temperature changes in the rock). The implementation of this coupled Lattice Boltzmann model and its first applications will be presented: the first Lattice Boltzmann model describes the fluid mass transport and the Navier-Stokes equation, the second one describes the heat transport, i.e. effectively solves the advection-diffusion equation governing the temperature.

As first step towards a more complex morphology, we study the effect of one indentation in an otherwise flat surface, on the hydraulic and thermal behavior. For instance, eddies may appear inside the corner, depending on how sharp and deep the corner is, and this may change the temperature field if suitable velocity amplitudes are applied on the boundaries.

These kinds of hydro-thermal variation may have practical consequences in several types of situations: e.g. the choice of the imposed flux in geothermal systems for the calibration of the energy pumping in geothermal application. Also, in situations where heat is generated by friction in a saturated interface, the fluid temperature can be modified by its flow in a complex geometry: this type of effect can modify the pore pressurization mechanisms, which in some contexts can play an important role in fault rupture.