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The equivalent thermal properties of a single fracture

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The major objective of this communication is to determine in a steady state the equivalent thermal resistance of a fracture embedded in a conducting medium when a constant temperature gradient is imposed far away from the fracture. This gradient is either perpendicular or parallel to the fracture plane. In the first situation, the fracture corresponds roughly to a layer of conductivity lambda_f in between two blocks with the same conductivity lambda; it is equivalent to an additional resistance (which can be negative) in series with the two solid blocks. In the second situation, the fracture corresponds to an element in parallel with the two solid blocks; therefore, it is more straightforward to study the tangential conductivity rather than the tangential resistance. These two quantities are systematically addressed. Of course, the thermal resistance is the inverse of the thermal conductivity and these quantities can be easily derived one from another.

It is important to notice that this work is not limited to thermal problems, but to problems which are governed by Laplace equations in the fracture and in the surrounding solid. For instance, consider a fracture filled by debris embedded in a porous medium; the flow on the Darcy scale in these two media are governed by elliptic equations with different coefficients. Therefore, all the methodology and results apply to this case as well.

The normal resistance and the tangential conductivity of a single fracture with Gaussian or self affine surfaces are systematically studied as functions of the nature of the materials in contact and of the geometrical parameters. Analytical formulae are provided in the lubrication limit for fractures with sinusoidal apertures; these formulae are used to substantiate empirical formulae for resistance and conductivity.

Other approximations based on the combination of series and parallel formulae are tested.