KERATIN DYNAMICS: SOLVING PDES INSIDE MOVING DOMAINS USING PHASE FIELD METHODS

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ABSTRACT

The cell's structural integrity is assured by its cytoskeleton, which is constituted by a complex network of filaments in the region between its nucleus and cellular membrane. Keratin is one of these filaments and it is one of the main constituent of hair fibers and the outer layer of the skin, in humans, as well as the horns and hooves of animals. Keratin can be present inside the cell in one of two forms: either as monomers diffusing in the cytoplasm (disassembled state) or forming chains that migrate towards the nucleus (assembled state). This system can be modeled as two coupled reaction-advection-diffusion equations for the concentration of keratin in each state. To study the dynamics of keratin inside a cell, we developed a phase field model to describe the cell's outer and nuclear membrane, enabling us to confine the relevant processes in space, while applying the corresponding boundary conditions at the interface. Using a phase field model also allows us to solve the equations while the boundaries of the cell and nucleus are evolving due, for example, to external forces. With this model we are able simulate the movement of assembled keratin towards the nucleus, a phenomenon that is observed in experimental results, drawing conclusions regarding the cell's dynamic mechanical response and stiffness. This success validates the use of phase field models to deal with PDEs in evolving, moving geometries without the need for complex grids.

References

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