Biomimetic model systems of rigid hair beds: Part I - Theory
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Crustaceans - such as lobsters, crabs, and stomapods - have hairy appendages that
they use to recognize and track odorants in the surrounding fluid. An array of rigid
hairs impedes flow at different rates depending on the spacing between hairs and the
Reynolds number, Re. At larger Reynolds numbers (Re >1), fluid travels through
the hairs rather than around them, a phenomenon called leakiness. Crustaceans flick
their appendages at different speeds in order to manipulate the leakiness between
the hairs, allowing the hairs to either detect odors in a sample of fluid or collect a
new sample. A single hair can be represented as a slender body attached at one end
to a wall. Using both slender body theory and numerical methods, we observe that
there is a region of flow around the hair that speeds up relative to the unobstructed
flow. As the Reynolds number increases, this fast flow region moves closer to the
hair. Using this model, we predict that an array of hairs can be engineered to have
a desired leakiness profile.

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