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Resolving lubrication layers in immersed boundary method simulations of vesicular transport in dendritic spines THOMAS FAI, Harvard University, REMY KUSTERS, Eindhoven University of Technology, CHRIS RYCROFT, Harvard University — Our understanding of how neuronal connections in the brain are maintained and reorganized is being revolutionized by new experimental and computational techniques. Existing high-resolution 3D images show that neuronal axons often terminate onto micron-sized structures known as dendritic spines, which are characterized by their thin necks and bulbous heads. Vesicles containing membrane receptors must deform significantly to squeeze into the bulbous heads of the spines, but more quantitative estimates of the force and energy required are still lacking. We have used three-dimensional immersed boundary method simulations to capture the fluid dynamics of vesicle transport into spines. We vary the applied force and neck geometry to identify the region in phase space in which the vesicle can squeeze into the spine. These results are compared to pass-stuck diagrams computed previously in the case of vesicles squeezing through open channels with rigid walls. The resulting force estimates are found to be consistent with the physiological density of motor proteins. Resolving the thin lubricating layers between the vesicles and spine poses significant numerical challenges, and we have used elements from lubrication theory to help resolve these boundary layers.

Thomas Fai
Harvard University

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