6th European Conference on Computational Mechanics (ECCM 6)
7th European Conference on Computational Fluid Dynamics (ECFD 7)
11-15 June 2018, Glasgow, UK

Models for Tear Break Up Dynamics and Imaging

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Keywords: *Tear film, dry eye, tear breakup, thin fluid film*

The tear film coats the ocular surface after a blink; it protects the eye and enables clear vision. Tear film breakup (TBU) is when the tear film fails to cover the eye surface; this is important to dry eye syndrome and may involve many physical effects. We study two modes of TBU: evaporative (Case I) and polar-lipid-driven Marangoni effect (Case II). The physical effects combine differently in each. In vivo, tear films of subjects were simultaneously recorded using either: (1) fluorescein (FL) and retroillumination (RI) methods or (2) FL and lipid microscopy (LM) for lipid layer thickness [1]. In some experiments, the initial FL concentration is estimated [2], facilitating comparison with theory. Using these images for comparison, thin fluid film models were solved for the tear film thickness, insoluble surfactant concentration (polar lipid) on the film's free surface, and osmolarity and fluorescein concentrations inside the tear film. Fluorescent intensity can be computed from these quantities [3]. Case I: Experimental FL+LM images show a practically stationary lipid layer, and TBU develops over a period of seconds through holes in the lipid layer with elevated osmolarity there. Case II: FL+RI or FL+LM experiments show sub-second spreading of the lipid layer and tear film, and leading to much faster TBU with larger extent than in Case I. Osmolarity changes litte in this case. FL intensity results from the math models is consistent with, and helps interpret, the experiments.

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