A viscous two-phase model for contractile actomyosin bundles.

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Abstract:
A mathematical model in one dimension for a dis-ordered non-muscle actomyosin bundle featuring anti-parallel flows of anti-parallel F-Actin is introduced.
The model is able to relate these flows to the effect of cross-linking and bundling proteins, to the forces due to myosin-II filaments and to external forces at the extreme tips of the bundle.

The modeling is based on a coarse graining approach starting with a microscopic model which includes the description of chemical bonds as elastic springs and the force contribution of myosin filaments. In a second step we consider the asymptotic regime where the filament lengths are small compared to the overall bundle length and restrict to the lowest order contributions. There it becomes apparent that myosin filaments generate forces which are partly compensated by drag forces due to cross-linking proteins. The remaining local contractile forces are then propagated to the tips of the bundle by the viscosity effect of bundling proteins in the filament gel.

The model is able to explain how a disordered bundle of comparatively short actin filaments interspersed with myosin filaments can effectively contract the two tips of the actomyosin bundle. It gives a quantitative description of these forces and of the anti-parallel flows of the two phases of anti-parallel F-Actin. An asymptotic version of the model with infinite viscosity can be solved explicitly and yields an upper bound to the contractile force of the bundle.