A mechanism of biological pattern formation through mechanochemical feedback

P. Gross[1,2], K. Vijay Kumar[2,3,4], J. S. Bois[5], C. Hoege[1], N. W. Goehring[6], F. Jülicher[3], S. W. Grill[1,2,3]

[1]MPI-CBG, Dresden, Germany, [2]BIOTEC, TU Dresden, [3]MPI-PKS, Dresden, Germany, [4]ICTS, Bangalore, India, [5]UCLA Department of Chemistry and Biochemistry, Los Angeles, CA, [6]London Research Institute, London, UK

The interplay between biochemistry and cell mechanics is critical for a broad range of morphogenetic changes. A key example is the early embryonic development of the *Caenorhabditis elegans* zygote, where flows of the actomyosin cortex occur simultaneously with the establishment of a polarity pattern in partitioning defective (PAR) proteins. However, how the PAR system interacts with and regulates cortical flow has remained elusive. Here, we identify a novel mechanochemical pattern-generating mechanism, which drives the patterning of the PAR polarity proteins.

Using calibrated, quantitative fluorescence microscopy, we first measured the spatiotemporal evolution of the membrane-associated protein concentration of the posterior PAR-2, the anterior PAR-6 and myosin II as the mechanical force generator, as well as the cortical flow field. Next we show that these dynamics can be quantitatively recapitulated, using a reaction-diffusion-advection theory for the concentration fields (myosin II, PAR-2 PAR-6) in combination with an active-fluids theory for the cortical flow field. Remarkably, our physical theory can, for the first time, fully recapitulate the spatiotemporal evolution of all the measured concentration fields as well as the actomyosin flow field, duting the polarization process. We demonstrate that the function of this mechanochemical feedback is to amplify and stabilize cortical flows and thus to promote a rapid transition to the patterned state of the PAR system.