Abstract Submitted
for the MAR17 Meeting of
The American Physical Society

Pattern formation in mass conserving reaction-diffusion systems
FRIDTJOF BRAUNS, JACOB HALATEK, ERWIN FREY, LMU Munich — We present a rigorous theoretical framework able to generalize and unify pattern formation for quantitative mass conserving reaction-diffusion models. Mass redistribution controls chemical equilibria locally. Separation of diffusive mass redistribution on the level of conserved species provides a general mathematical procedure to decompose complex reaction-diffusion systems into effectively independent functional units, and to reveal the general underlying bifurcation scenarios. We apply this framework to Min protein pattern formation and identify the mechanistic roles of both involved protein species. MinD generates polarity through phase separation, whereas MinE takes the role of a control variable regulating the existence of MinD phases. Hence, polarization and not oscillations is the generic core dynamics of Min proteins in vivo. This establishes an intrinsic mechanistic link between the Min system and a broad class of intracellular pattern forming systems based on bistability and phase separation (wave-pinning). Oscillations are facilitated by MinE redistribution and can be understood mechanistically as relaxation oscillations of the polarization direction.

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Date submitted: 09 Nov 2016 Electronic form version 1.4