COLLOQUIUM

DEPARTMENT OF MATHEMATICS AND STATISTICS
OAKLAND UNIVERSITY
ROCHESTER, MICHIGAN 48309

Hermann Eberl
University of Guelph

A Spatio-Temporal Continuum Model for Bacterial Biofilms

Abstract: Bacterial biofilms are accumulations of microorganisms on interfaces and surfaces in aqueous systems. Their occurrence is ubiquitous; they develop wherever nutrients are available to bacteria. Depending on the context they are considered beneficial (environmental systems) or harmful (medicine, food technology). Life in biofilm communities offers benefits to the microorganisms that they do not have in a suspended mode of growth, e.g. increased resistance to antimicrobial agents and protection against harmful environmental conditions. Therefore, biofilm bacteria behave differently from their planktonic conspecifics. Consequently, mathematical models formulated for suspended microbial communities cannot be carried over to biofilms but new approaches must be developed, in particular to explicitly take into account physical limitations. The microbial complexity of biofilms is naturally reflected by the mathematical complexity of these models. While the moniker biofilm indicates a flat and homogeneous layer of bacteria, modern microscopy techniques show that these communities grow in highly irregular spatial structures. We derive a density-dependent diffusion-reaction system that is able to predict the spatial heterogeneity. It shows to non-standard diffusion effects: (i) degeneracy as in the porous medium equation, and (ii) a singularity in the diffusion coefficient as the dependent variable approaches its *a priori* known maximum density. Analytical results include existence, uniqueness, boundedness and stability of solutions. Extensions and applications of the proto-type model to systems describing some aspects of biofilm resistance to antibiotics as well as multi-species interactions are presented.

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(Refreshments at 2:30 p.m. in Room 368, Science and Engineering Building)

A native of Bavaria, Germany, Dr. Eberl received his Ph.D. from the Technische Universität München (Munich University of Technology) in 1998. Before becoming an assistant professor at Guelph, he held research positions in Germany, Scotland, and the Netherlands. His research and teaching are mainly concerned with mathematical modeling and numerical simulation in Life Science and Environmental Engineering, typically with differential equations (ordinary or partial) and appropriate numerical techniques.