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Coupled chemotaxis-fluid models

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We consider coupled chemotaxis-fluid models aimed to describe swimming bacteria, which show bio-convective flow patterns on length scales much larger than the bacteria size. This behaviour can be modelled by a system consisting of chemotaxis equations coupled with viscous incompressible fluid equations through transport and external forcing. The authors in [2] proposed the following model:

$$\begin{cases} c_t + u\cdot\nabla c = \Delta c - nf(c), \\ n_t + u\cdot\nabla n = \Delta n - \nabla\cdot(n\chi(c)\nabla c), \\ u_t + u\cdot\nabla u + \nabla p - \eta\Delta u + n\nabla\phi = 0, \\ \nabla\cdot u = 0 \end{cases} \tag{1}$$

The global-in-time existence of solutions to the Cauchy problem in two and three space dimensions is established. Precisely, for the chemotaxis-Navier-Stokes system (1), we obtain global existence and convergence rates of classical solutions near constant states. When the fluid motion is described by Stokes equations, we derive some free energy functionals to prove global-in-time existence of weak solutions for cell density with finite mass, first-order spatial moment and entropy provided that the potential is weak or the substrate concentration is small cf. [1]. Moreover, with nonlinear diffusion for the bacteria, we give global-in-time existence of weak solutions in two space dimensions.

[1] R.-J. DUAN, A. LORZ, P. MARKOWICH: Global Solutions to the Coupled Chemotaxis-Fluid Equations, preprint (2009).

[2] I. TUVAL, L. CISNEROS, C. DOMBROWSKI, C. W. WOLGEMUTH, J.O. KESSLER, R.E. GOLDSTEIN: Bacterial swimming and oxygen transport near contact lines. *Proceedings of the National Academy of Sciences* **102** (2005), 2277–2282.