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Resolvent Estimates for 2D Contact Line Dynamics and Stability Analysis for Active Fluids

SHAKER VERLAG

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Summary: Resolvent Estimates for 2D Contact Line Dynamics and Stability Analysis for Active Fluids
Christiane Anh-Nguyet Bui

In the following thesis we consider two different models known from fluid dynamics which are based on Navier-Stokes equations.
The first model is devoted to the so-called 2D contact line dynamics investigating the contact line between fluid and solid phases. Since the fluid and solid phases are moving within time, it is necessary to transform this model to a fixed domain in order to apply known strategies. This leads to a system of Stokes equations subject to transformed free and partial slip boundary conditions which are considered on the sector. Then linear analysis is performed for the stationary Stokes system leading to the existence of weak solutions which solve the model in the strong sense and fulfilling resolvent estimates. Here, we work in the framework of homogeneous Sobolev spaces with $p = 2$ where we made use of the fact that in the Hilbert space setting elements from functional analysis, e.g. Lax Milgram's theorem, are available. (In)homogeneous Sobolev spaces in sectors are introduced at the beginning of this thesis complemented by various results which are transferred to the setting of (in)homogeneous spaces in sectors, as e.g. trace theorems, elliptic problems and Korn's inequality.
The second model that is considered in this thesis, is an active fluid continuum model which describes the motion of self-propelled organisms of high concentration in fluids. This model is based on generalized Navier-Stokes equations having a leading fourth order term which is responsible for global wellposedness. Here, we consider the active fluid continuum model on a bounded domain subject to periodic boundary conditions in Lebesgue spaces with $p = 2$ in $n = 2, 3$. Two stationary states are considered: the disordered isotropic state and the ordered polar state. In this thesis, we focus on the stability analysis of the ordered polar state which indeed forms a manifold which allows us to apply the generalized principle for normal stability and normal hyperbolicity, respectively. Here, it is essential that we are working on periodic spaces on a bounded domain which allows us to use the Fourier series representation and yields properties for the spectrum which are necessary to apply the theory. At last the existence of a global attractor for the active fluid continuum model is established. Here, we essentially make use of energy estimates and perform bootstrapping arguments to obtain a compact absorbing set of arbitrary high regularity which yields the existence of such an attractor. Then, several properties of the global attractor are proved, to be precise we show injectivity and finite dimensionality of the global attractor. At last we even prove the existence of an inertial manifold for $n = 2$ which has even the stronger property of attracting solutions exponentially.