Seminario de Análisis Numérico y Modelación Matemática

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Mathematical Models of Sedimentation Processes: Theory, Numerics and Applications

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Resumen

The settling of suspensions of small particles dispersed in a viscous fluid is a fundamental unit operation that arises in a diversity of applications such as mineral processing, wastewater treatment, medicine, geophysics and volcanology. Mathematical models for the design, simulation and control of sedimentation processes are therefore of high theoretical and practical interest. This talk summarizes some recent contribution to theory, numerics and applications of such models that are based on time-dependent partial differential equations (PDEs). The simplest model of this kind goes back to Kynch. It describes the batch settling of a strongly idealized solid-liquid suspension by a scalar conservation law. More recent extensions of this model to continuously operated clarifier-thickener units treating flocculated suspensions give rise to convection-diffusion PDEs whose coefficients vary discontinuously with spatial position, in combination with a strongly degenerate diffusion term that models sediment compressibility. Some recent approaches to handle the challenges posed by these properties for the mathematical and numerical analysis as well as their applications are reviewed.While the description by one scalar, spatially one-dimensional equation is sufficient for many practical purposes, more complicated vessel geometries and advanced applications call for two- or three-dimensional formulations that invariably involve coupled flow-transport models, for instance a convection-diffusion equation for the solids concentration coupled with a version of the Stokes or Navier-Stokes system for the mixture flow field. Such coupled problems can be handled by several variants of a new class of finite volume element method, which is presented along with a partial analysis and numerical examples. To further underline that sedimentation processes provide intriguing problems of applied mathematics, we conclude the talk by briefly reviewing some topics of current research including advances in efficient time discretization of clarifier-thickener simulators, models of polydisperse sedimentation giving rise to systems of conservation laws, and simplified multilayer shallow-water-type descriptions of flow-transport models.

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