Chemo-hydrodynamic instabilities in porous media

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Traveling waves are known to occur in many non-linear reaction diffusion systems. These waves serve primarily to transport species faster than what can be achieved purely by molecular diffusion and in particular are not associated with convection. These waves are characterized by a constant shape and velocity. They can explain several phenomena occurring in nature as waves of chemical species on surfaces of an egg, propagation of epidemics. The waves can be observed when the reaction systems are autocatalytic and admit multiple solutions. These waves can be viewed as trajectories connecting an unstable state to a stable state. We can obtain an estimate of the velocity exhibited by the wave from a linear stability analysis and investigating the eigen-values of the singular points.

Viscous fingering in purely hydrodynamic systems has been analysed extensively in view of its implications in oil recovery. Here we investigate a problem where in one fluid displaces another fluid present in a porous medium. The front between the two phases is determined by the properties of the two fluids. Extensive studies on miscible as well as immiscible flow systems have been carried out and a good understanding of the physical properties which influence the onset of finger formation flow behavior exists. The physical conditions i.e., the variation of the properties like density and viscosity etc. have been well understood. In particular we are interested in analyzing the conditions when the interface between the two fluids remains flat or becomes deformed in the form of fingers.

In this talk we will analyze chemically reacting systems such as polymerization or combustion where in the progress of the reaction introduces the change in the property as viscosity or density. Both horizontal and vertical configurations will be discussed and we will analyze the Iodate Arsenous Acid reaction system theoretically to determine conditions under which the reaction front will propagate as a flat interface. We take into account the exothermicity of the reaction and the termperature change associated with it. For the horizontal flow conditions we analyze a situation where the viscosity is assumed to be a function of the concentration and the temperature. For the vertical geometry we analyze the situation where the density is assumed to be a function of the concentration and temperature. The behavior of the reacting system in a porous medium is analysed under the Bouissenessq approximation. A linear stability analysis is carried out to determine the onset of fingering and its predictions in turn are verified by detailed non-linear simulations of the governing equations.