Abstract:

The major organ responsible for our balance sense is the vestibular system. It is part of the labyrinth of the inner ear and consists of two types of sensors: one for linear acceleration, i.e. the otolith organ, and one for angular velocity, i.e. the semicircular canals (SCCs). These are filled by a fluid called endolymph. During a head rotation, the endolymph which fills the SCC lags behind the walls of the canal and displaces a sensory structure which triggers the sensation of motion.

In a first part of the talk, we present a model for the endolymph flow in a healthy SCC and show flow patterns in the proximity of the sensory tissues that had not been discussed in the literature before. The governing equations are solved numerically by the method of fundamental solutions (MFS). The MFS is a special type of boundary method where the source points are positioned outside the flow domain rather than on the boundary. This avoids singular integrals at the boundary and can lead to exponential convergence. However, the stability and the accuracy of the method depend strongly on the positioning of the source points. We will present a multilayer implementation of the MFS (multilayer MFS) which can overcome these numerical difficulties.

In a second part of the talk, we will present a model for canalithiasis. This is a common pathological condition due to the presence of free floating particles in the SCC and is the major cause of vertigo in humans. The particles are modeled by the force coupling method (FCM). This allows to treat clusters of finite size particles. The resulting governing equations are solved by coupling the multilayer MFS with the FCM.
Relevant differences between the flow in healthy and pathological organs will be discussed.

Keywords: Endolymph flow; vestibular system; canalithiasis; Stokes flow with particles; Multilayer Method of Fundamental Solutions (multilayer MFS); Force Coupling Method (FCM).