ENCAPSULATED MICROBUBBLES: FROM ECHOCARDIOGRAPHY TO NONINVASIVE BLOOD PRESSURE MONITORING AND TARGETED DRUG DELIVERY

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Abstract: Micron-size gas bubbles encapsulated by a nanometer layer of proteins, lipids and other surfactants are injected into a patient’s body to improve ultrasound imaging. Currently, two such contrast agents—Optison (GE Healthcare) and Definity (Lantheus Medical Imaging)—are approved by the Food and Drug Administration for echocardiography. They can also be functionalized for molecular imaging and conjugated with drugs for targeted delivery. For the past decade, we have been performing experimental and analytical research on contrast microbubbles. We are the first to propose and subsequently develop an interface model of the encapsulation—that is, a model with an intrinsic surface rheology—addressing the wide disparity of scales between the overall bubble size and that of the encapsulation. In this talk, I will discuss material characterization of these contrast agents that includes determination of rheological properties of a contrast microbubble’s encapsulation using one set of in vitro experiments, followed by model validation using another set. I will offer a hierarchical approach with increasing sophistication in constitutive modeling of the encapsulation as warranted by the determining experiments and underlying physics. I will discuss subharmonic signals used for noninvasive monitoring of organ-level blood pressure, and explain their unusual behaviors in sharp contrast to “plausible expectations” and classical bubble dynamics results. I will also briefly discuss specifically targeted and cytosolic delivery of cancer drugs from “echogenic liposomes”.

Time permitting, I will provide an overview of other research efforts at our lab. It includes direct numerical simulation of multiphase flows—emulsions of deformable viscous and viscoelastic drops, capsules (encapsulated by a hyperelastic membrane), their rheology, adhesion and migration of leukocytes—as well as ultrasound mediated bone fracture healing and cancer therapy.