Boulder Fluid and Thermal Sciences Seminar Series

Tuesday, February 6, 2018
3:30pm-4:30pm (refreshments at 3:15pm)
Bechtel Collaboratory in the Discovery Learning Center
University of Colorado, Boulder

Discovery of a "Magenstrasse" and other Gastric Curiosities with a Lattice Boltzmann Model of the Human Stomach

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Mechanically, the stomach is a controlled pump that empties viscous heterogeneous liquid content from a bag (the fundus) through a sphincteric valve (the pylorus) by slow squeeze of fundic muscle. In addition, however, periodic peristaltic contraction waves travel towards the pylorus in the lower stomach (antrum), elevating pressure locally, presumably to periodically enhance emptying. My medical collaborators measured antral contractions with concurrent manometry and MRI *in vivo*; we analyzed the data to show that, as each antral contraction wave approaches the pylorus the pylorus momentarily closes, right when an open pylorus would have allowed a surge of fluid flow into the intestines! This is a curiosity. To study in more detail the consequences of the curious phasic relationship between the passage of antral contraction waves and pyloric opening, we applied a lattice Boltzmann computational fluid dynamics model with moving boundary conditions and a stomach geometry model parameterized using time-resolved MRI. Analysis lead to the discovery of a second curiosity: the antral contraction waves produce a narrow path of emptying, or "Magenstrasse" (German for "stomach road") that directs content from the top of the stomach to the pylorus in relatively short time with little mixing. This discovery might explain a well-known observation in pharmaceutics, that the response time of a drug after ingestion is extremely variable. (If a drug capsule opened in the stomach off the Magenstrasse, it would take over an hour for drug particles to empty into the intestine and drug to enter the circulatory system, while if release occurred on the Magenstrasse, activation time would be quick!) The fluid dynamics underlying this seemingly simple organ turns out to be surprisingly interesting.

Biography: James Brasseur (Jim) is currently Research Professor of Aerospace Engineering Sciences at the University of Colorado Boulder after 27 years as Professor of Mechanical Engineering, Biomedical Engineering and Mathematics at the Pennsylvania State University, where he retains Emeritus and Adjunct Professor status. Dr. Brasseur is a fluid dynamist with extensive expertise in the integrated fluid/solid mechanics and physiology of the gastro-intestinal tract, and with separate expertise in turbulence physics, turbulence simulation and turbulent flows. Over his academic career, he has lead a wide range of research programs in GI physio-mechanics aimed at normal vs. abnormal physiology and function of the esophagus, stomach, intestines, and anal-rectal unit, as well as the complex physio-mechanical mechanisms underlying sphincter function. Dr. Brasseur has also evolved a related research track on release, transport, and absorption from drug particles within the upper GI tract. Professor Brasseur's turbulence programs have applied primarily computational and mathematical methods. Recently he lead major NSF and DOE programs focused on the interactions between atmospheric turbulence and wind turbines and currently he focuses on advanced large-eddy simulation modeling strategies for premixed turbulent combustion prediction. Dr. Brasseur has served on governing boards of the American Physical Society (APS) and APS Division of Fluid Dynamics, was past president of a medical society and on the governing board of another; he was founding Chair of the APS Topical Group on the Physics of Climate. Dr. Brasseur is a member of the Johns Hopkins Society of Scholars and is Fellow of the American Physical Society.