WPI Mathematical Sciences Grants and Awards 2022

CAREER: Numerical Methods and Biomechanical Models for Sperm Motility

National Science Foundation

Olson, S.

2015-2022

Mammalian sperm must navigate the female reproductive tract, swimming a distance greater than 1000 times their own length to reach and fertilize the egg. In order to aid in the treatment of reduced sperm motility, it is important to understand interactions of the sperm flagellum with different regions of the reproductive tract. In particular, fluid flow helps bring the egg to the uterus (in the opposite direction of sperm progression). Recent experiments have shown that a large percentage of sperm exhibit positive rheotaxis, the ability to reorient and swim against a background flow. Additionally, sperm will bind and unbind to the oviductal wall and the role of a background flow on sperm detachment is not known. The main scientific goals of this project include further analyzing existing experimental data (through image processing techniques) and developing new computational models to understand the clinical importance of migration through the female reproductive tract and sperm binding and detachment from walls in a background flow. Several new computational modeling frameworks will be developed to allow simulations of sperm in the presence of a background flow and a wall. The PI will provide interdisciplinary training for several students (undergraduate and graduate) as well as one postdoc in the areas of computational biofluids, image processing of experimental movies, and model development. In addition, the PI will work to develop image processing and modeling modules to be used in area High Schools and at summer programs for High School students at WPI. Learn more about the grant.

Zheyang Wu Receives NSF Award for Work Related to ALS

Zheyang Wu, associate professor of mathematical sciences, has received a three-year, $150,000 award from the National Science Foundation for a project titles, "Optimal and Adaptive p-Value Combination Methods with Application to ALS Exome Sequencing Study." The project is focused on developing tests that will give scientists a better understanding of which DNA segments are related to ALS susceptibility. Using ALS exome-sequence data, researchers will develop better data analysis methodology to paint a clearer picture of how genes influence ALS.

ALS, or amyotrophic lateral sclerosis, is a progressive neurodegenerative disease that affects nerve cells in the brain and spinal cord, affecting one's speech and ability to swallow and to control the muscles. Ultimately, it causes paralysis and death. Each year, more than 5,000 people in the United States are diagnosed with ALS, which is also known as Lou Gehrig's disease.

Genetics plays a critical role in ALS. Despite numerous advances in recent years, doctors still cannot trace the genetic cause of a significant amount of ALS cases. This research project is taking on the "missing heritability" problem, using innovative genetic data analysis algorithms and more powerful p-value combination tests to analyze large exome sequencing data for detecting novel ALS genes. The methodology being developed in this project has broad applications and could be used to better understand other diseases, as well. A WPI graduate student will work on this research with Wu. For more information on this grant please visit https://www.nsf.gov/awardsearch/showAward?AWD_ID=1812082

Total award period: July 1, 2018 - June 30, 2022

Christopher Larsen receives $250,000 award from the Division of Mathematical Sciences (DMS) at the National Science Foundation "New Mathematical Methods for Dynamic Fracture Evolution"

In Professor Larsen's own words: *"For a large range of applications, from civil infrastructure to national defense, understanding the failure of materials is critical. Yet, our ability to predict this failure is limited by both modeling, which is somewhat ad hoc, and the mathematics available to formulate and analyze models, as well as to justify numerical methods. These issues are most severe in dynamic problems, such as impacts, when loading changes quickly. The main goal of this project is the development of new mathematical methods for dynamic fracture evolution. In particular, the principal investigator (PI) will extend methods for regular crack paths to more realistic paths, with kinking and branching. A second goal is to address fundamental mathematical issues that are necessary for further progress in completely general settings. Finally, the PI will study phase-field approximations of fracture, which have become very popular tools in the engineering community but remain poorly understood.*

The ability to accurately predict failure depends on the quality of the underlying mathematical models of defects as well as on understanding fundamental properties of solutions. When crack paths are regular, mathematical methods are available to study these evolutions. However, when they are not, the only methods so far involve considering the paths to be limits of more regular paths. The main technical issue here is that strong convergence of the corresponding elastodynamics is necessary for energy balance, as well as for other properties of solutions, but this convergence remains open in many situations. Another fundamental issue is uniqueness of elastodynamic solutions for a given crack path. The investigator will show uniqueness in certain settings, and explore general consequences, such as bounds on crack speed.

The final goal of the project is to analyze phase-field models for fracture. While very popular in the engineering community, a number of properties, including whether they approximate the correct surface energy, or satisfy a maximal dissipation condition, remain open questions."

For more information please see https://www.nsf.gov/awardsearch/showAward?AWD_ID=1909991&HistoricalAwards=false
Total award period: 2019-2022 Award Amount: $250,000