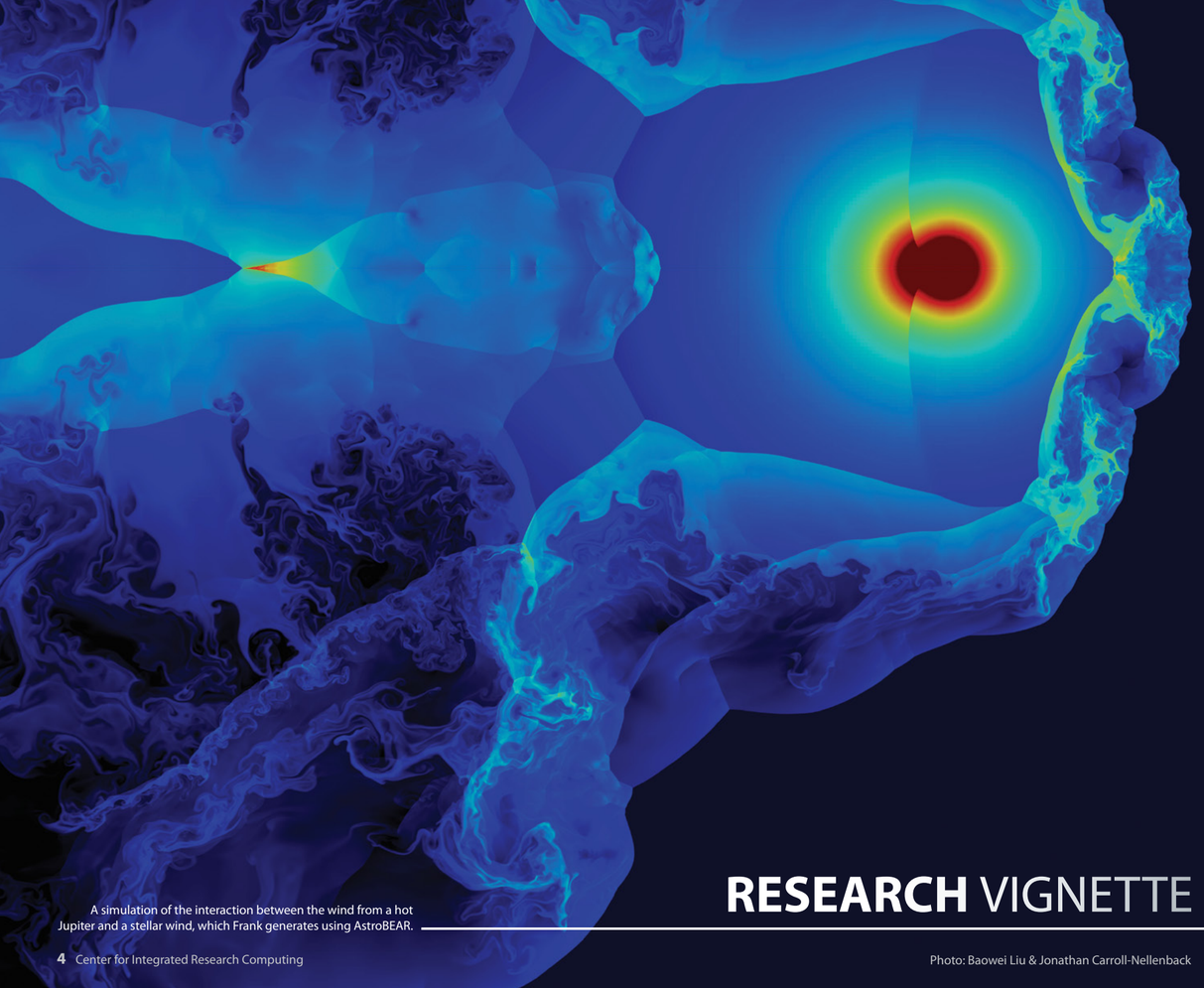


A simulation of the interaction between the wind from a hot Jupiter and a stellar wind, which Frank generates using AstroBEAR.

Photo: Baowei Liu & Jonathan Carroll-Nellenback

RESEARCH VIGNETTE

Simulating the Cosmos

How do you study something that is billions of years old and light years away in a laboratory? That is the challenge facing astrophysicist Adam Frank, Ph.D., who studies the evolution of stars — from the formation of stars within giant molecular clouds to the eventual death of those stars and their expansion into planetary nebulae. To investigate the processes shaping this evolution, Frank needs more than the evidence collected by telescopes; he needs a way to simulate complex theoretical models of astrophysical phenomena.

"To do these kinds of simulations," Frank explained, "you need a code that has the ability to simulate lots of physics all at once, what we call multiphysics. It's a very difficult challenge computationally that really requires massive parallel machines."

Driven by his unique research challenges, Frank has been pivotal in the University's research computing efforts since its nascent stages. He chaired the committee of faculty researchers that convened in 2005 to discuss institutional support for computational research. The committee published a report in 2006 that was the impetus for the creation of the Center and the University's ongoing investment in research computing.

Over the past decade, Frank's research group has gone from scrounging for compute cycles at peer institutions to running 3-D simulations of multiphysics on supercomputers right here in Rochester.

"Before the advent of CIRC, I had to go to my collaborators who had supercomputing centers and beg for computer time. But now, they're coming to us because we have this enormous computing capacity," Frank said. "Through that, we've been able to build collaborations with other groups on other campuses. So it really has been a fundamental change for us having these resources and this program here."

With thousands of compute cores at his disposal and the assistance of computational scientists at CIRC, Frank is now able to investigate astrophysical problems that have been too difficult to simulate before. Frank's research group and CIRC — with funding from the National Science Foundation, the National Aeronautics and Space Administration, and the Department of Energy — have developed AstroBEAR, an advanced computational tool for simulating multiphysics that is available to researchers worldwide.

"We're getting to open up completely new windows in astrophysics using AstroBEAR," Frank said, "and now we have collaborations with groups across the world. It's wonderful to see other people using the code to do their own research and taking it in entirely different directions. We're looking forward to more collaborations and being able to facilitate studies of astronomy that go in directions we hadn't thought of ourselves."

The Center continues to assist with code development, testing, and performance tuning to further improve AstroBEAR for future releases and push the code to new limits. "The development of this code and the advances we've been able to make wouldn't have been possible without the collaboration with CIRC," Frank added.

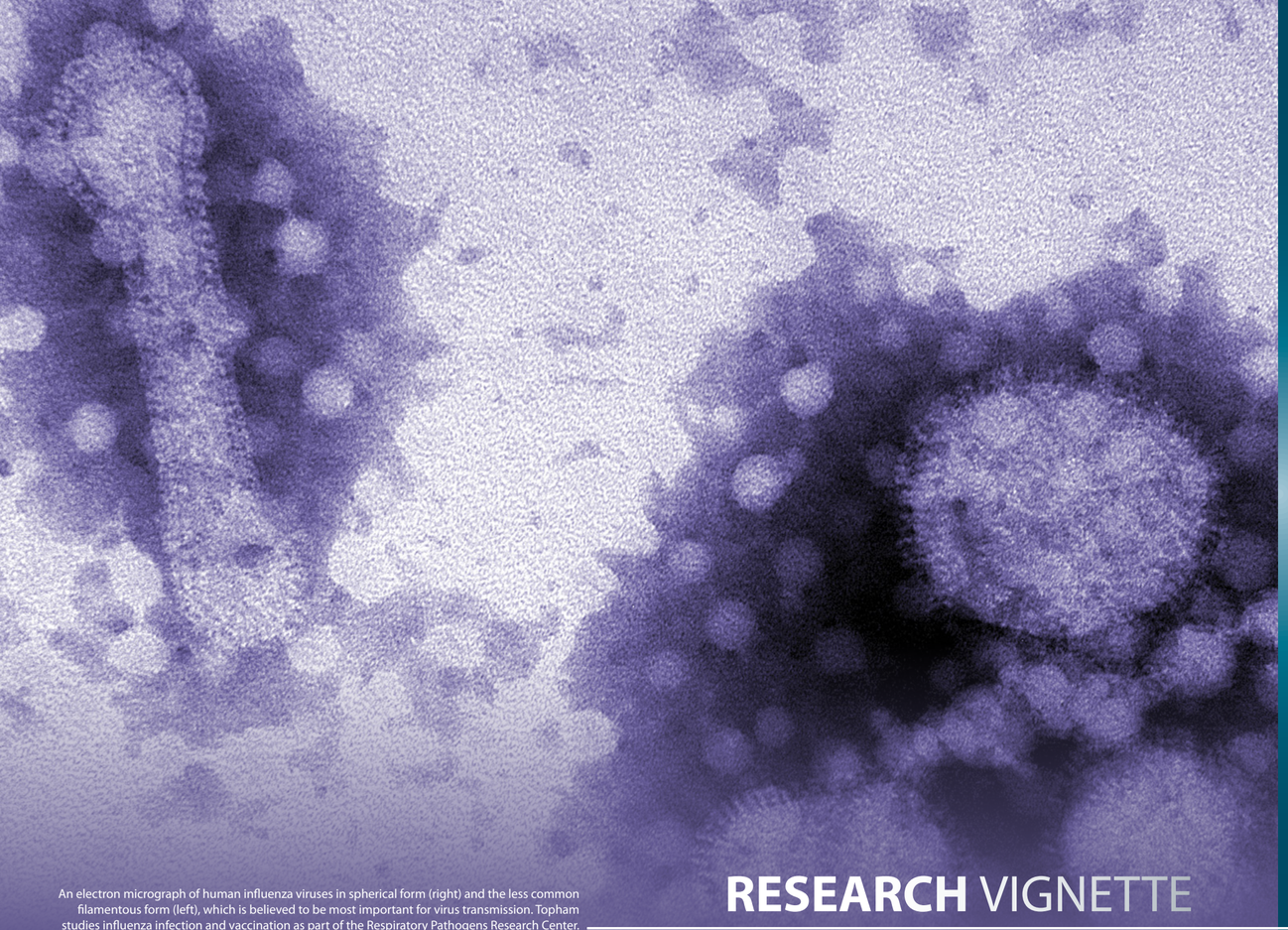
"The future of research is going to involve massive data sets and figuring out how to move around through them. I think CIRC is well positioned to lead the University into the future."

Adam Frank, Ph.D.

Professor of Physics and Astronomy

Publications:

- Carroll-Nellenback JJ, Shroyer B, Frank A, Ding C. 2013. Efficient parallelization for AMR MHD multiphysics calculations; Implementation in AstroBEAR. J. Comput. Phys. 236:461-476. doi:10.1016/j.jcp.2012.10.004.
- Balick B, Huarte-Espinosa M, Frank A, Gomez T, Alcolea J, Corradi RLM, Vinkovic D. 2013. Outflows from evolved stars: The rapidly changing fingers of CRL 618. Astrophys. J. 772:20-31. doi:10.1088/0004-637X/772/1/20.



An electron micrograph of human influenza viruses in spherical form (right) and the less common filamentous form (left), which is believed to be most important for virus transmission. Topham studies influenza infection and vaccination as part of the Respiratory Pathogens Research Center.

RESEARCH VIGNETTE

Photo: Karen Bentley / URMC Electron Microscopy Research Core

Building an Edge

David Topham, Ph.D., credits serendipity for bringing him to the University of Rochester in 1999, yet he says the interdisciplinary and computational research he has been able to conduct here is anything but happenstance.

As Executive Director of the Health Sciences Center for Computational Innovation (HSCCI), Topham facilitates access to high-performance computing for biomedical research and fosters collaborations among University researchers, computational scientists, government agencies, and corporate partners. Established in 2009, HSCCI is a multimillion-dollar partnership between the University, IBM, and New York State whose goal is to use supercomputing to solve health care's most complex problems.

In 2008-09, IBM gifted the University its first supercomputer and CIRC was founded to provide the necessary computational expertise. "CIRC is what makes it all work," Topham said. "You can have a great idea, but if you can't reduce it to practice to actually make it go, then it's not worth anything. CIRC reduces the projects to practice."

Topham's own immunology research forayed into computational biology as government interest in biodefense research increased in the wake of September 11, 2001. He joined Hulin Wu, Ph.D., Professor of Biostatistics and Computational Biology, and Martin S. Zand, Ph.D., Professor of Nephrology, in applying for funding from the National Institutes of Health (NIH) to create mathematical models of the biology of bioweapons. This set the stage to compete for one of two Respiratory Pathogens Research Centers. NIH ultimately granted Rochester both available centers because "we had the edge in information technology, and NIH knew the type of studies we were going to be doing were going to require substantial infrastructure," Topham explained.

Even more interdisciplinary research has emerged since the construction of the VISTA Collaboratory — a lab custom-built for collaboration and data visualization across fields. Following an impromptu discussion at the VISTA, Topham and Jannick Rolland, Ph.D., Professor of Optics, are combining their distinct expertise to improve tissue-imaging techniques. They have since co-authored a publication in a top optics journal.

"It seems like serendipity again, but it's not. We brought people together for a reason," Topham said. "We had this idea that people from disparate domains would find ways to work together to develop new technologies and novel approaches. And they have."

Topham sees team science and big data as the future of research. Now, with the creation of the University's Institute for Data Science, that vision is being codified with the development of new curricula and degree programs where interactions between data science and research domains are the norm, not the exception.

"We have the edge," Topham said. "And I think we're going to continue to build that edge and stand out from our competitors on a national if not international level, especially in the application of data science-driven approaches to our research."

"It's all about doing good research in the end," Topham concluded. "We can do really cool stuff and work on important questions that have major impact on society that I don't think we would have ever had the opportunity to do if we hadn't taken that risk to invest in research computing."

David Topham, Ph.D.

Executive Director of
Health Sciences Center for Computational Innovation

Professor of Microbiology & Immunology

Publications:

- Tankam P, He Z, Chu YJ, Won J, Canavesi C, Lepine T, Hindman HB, Topham DJ, Gain P, Thuret G, Rolland JP. 2015. Assessing microstructures of the cornea with Gabor-domain optical coherence microscopy: pathway for corneal physiology and diseases. Opt. Lett. 40(6):1113-16. doi:10.1364/OL.40.001113.
- Lee HY, Topham DJ, Park SY, Hollenbaugh J, Treanor J, Mosmann TR, Jin X, Ward B, Miao H, Holden-Wiltse J, Perelson AS, Zand M, Wu H. 2009. Simulation and prediction of the adaptive immune response to influenza A virus infection. J. Virol. 83(14):7151-65. doi:10.1128/JVI.00098-09.