



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

## RESEARCH VIGNETTE

Photo: Baowei Liu & Jonathan Carroll-Nellenback

# 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.