



News

[Press Releases](#)
[Event Announcements](#)
[CCT Weekly](#)
[Grants and Funding](#)
[Student News](#)
[Archived News](#)

NSF Awards LSU Computer Scientist and Physicist a Cyberinfrastructure Grant

[LSU Media Center](#)

Enabling fundamental research in the era of multi-messenger astrophysics

BATON ROUGE –The National Science Foundation, or NSF, has awarded more than \$427,000 to LSU and the Center for Computation & Technology to improve the cyberinfrastructure framework used by the Einstein Toolkit, an accessible community-driven open source ecosystem that provides computational tools to advance research in relativistic astrophysics and gravitational physics. At LSU, the project is led by Steven R. Brandt and Peter Diener. Brandt serves as the assistant director for computational science at the LSU Center for Computation & Technology, or CCT; also, he is an adjunct professor in the Division of Computer Science & Engineering. Diener is a research assistant professor in the LSU Department of Physics & Astronomy and holds a joint appointment with CCT.

"The Einstein Toolkit has not only been successful in studying the most energetic processes in the Universe, such as black hole and neutron star collisions as well as supernovae, but it has been an important driver for computational science," Brandt said. "In addition, it has been used as the basis of courses in computational science at LSU and elsewhere."

To simulate the complexities of black hole collisions, the Einstein Toolkit code must evaluate mathematical expressions that would occupy hundreds of pages if typed out in human readable format. Because this code provides unique stresses on computers, it has twice been accepted as a Standard Performance Evaluation Corporation, or SPEC, benchmark. In 2012, the ACM International Symposium on High-Performance Parallel and Distributed Computing gave the Einstein Toolkit researchers a Top Paper award for their research in grid computing using Cactus, the computational infrastructure used by the toolkit. In 2006, CCT founding director Ed Seidel won the Sydney Fernbach award, a prestigious award from the IEEE Computer Society named in honor of Sydney Fernbach, a pioneer in high performance computing, for his work on Cactus.

This four-year grant is part of a \$2.3 million collaborative effort between the University of Illinois Urbana-Champaign, Georgia Institute of Technology, Rochester Institute of Technology, West Virginia University and LSU awarded through NSF's Cyberinfrastructure for Sustained Scientific Innovations program. The research team aims to address current and future challenges in gravitational-wave source modeling, improve the scalability of the code base and support an expanded scientific and user community. The project stems from a previous NSF grant for collaborative research in community planning for scalable cyberinfrastructure to support multi-messenger astrophysics, which was awarded in 2018 to former LSU Computer Science and CCT Professor Gabrielle Allen, who is now at the University of Illinois.

"With the near future prospects of further multi-messenger events like GW170817, it is very important to continue to improve computational tools like the Einstein Toolkit, as they are essential in order to make sense of simultaneous electromagnetic, gravitational wave and neutrino observations of an event," said Diener, who is a co-principal investigator on this project.

The Einstein Toolkit is utilized by many groups, spanning all continents, except Antarctica, and is developed and supported in a distributed, collaborative manner. Its focus on community-based development has resulted in a large user base – 282 registered users from 194 different groups and 40 countries to-date. In addition, the toolkit supports simulations providing information on gravitational waveforms for the Laser Interferometer Gravitational-Wave Observatory, or LIGO.

"[NSF's Office of Advanced Cyberinfrastructure, or OAC,] is pleased to support community-driven software platforms that advance research in relativistic astrophysics that are relevant to Multi-Messenger Astrophysics," said Manish Parashar, OAC director.

Additional Link:

The Einstein Toolkit Ecosystem: Enabling Fundamental Research in the Era of Multi-Messenger Astrophysics: <https://einstein toolkit.org/>

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