Title: “Multiphysics at the Exascale: Portable Astrophysical Turbulence, Transport, and Kinetics with Flash-X”

Abstract: Flash-X is a new incarnation of FLASH, which has served both the astrophysics community and others for more than two decades. FLASH has been used on a range of high-end computing platforms, and Flash-X continues that legacy. As part of the United States Department of Energy's Exascale Computing Project, Flash-X was used to run a core-collapse supernova simulation as part of the ExaStar ECP project. The calculation exercised the integrated multi-physics capabilities of the code, including self-gravity, shock-capturing hydrodynamics, nuclear reactions, nuclear equation of state, and spectral neutrino transport. Each of these pieces of physics is necessary to produce simulations of these stellar transients that can be used to confront observations across photons, neutrinos, and gravitational waves.

Computing at scale on exascale platforms is made more challenging due to heterogeneity in both hardware and software. While platform heterogeneity has been in the spotlight for a while, a similar challenge is presented by increasing diversity in solvers that applications need to deploy. Current abstractions do not obviate the need for the developers to know the mapping between application and target hardware. Therefore, for Flash-X we have adopted the approach of co-designing the software architecture with an accompanying toolchain to provide a more enduring solution to performance portability across a wide variety of applications and platforms. The code and the toolchain are both highly composable with building blocks that can be permuted and combined in different ways.

Bio: Bronson Messer is a Distinguished Staff Scientist and Director of Science for the Oak Ridge Leadership Computing Facility (OLCF) at Oak Ridge National Laboratory (ORNL). As Director of Science, his primary job is to ensure that the resources provided through the OLCF's allocation programs are effectively used to produce high-impact science and to communicate those impacts to all stakeholders, including the public. Messer is also Joint Faculty Professor in the Department of Physics & Astronomy at the University of Tennessee. His primary research interests are related to the explosion mechanisms and phenomenology of supernovae (both thermonuclear and core-collapse), especially neutrino transport and signatures, dense matter physics, and the details of turbulent nuclear combustion. In addition, he has worked on the application of machine learning algorithms to the analysis of galaxy merger simulations and on performance modeling and prediction for high-performance computing architectures.

He is a member of the American Astronomical Society and he recently served on the American Physical Society’s Committee on Informing the Public (2018-2020). In 2020, he was awarded the Department of Energy Secretary’s Honor Award for his part in enabling the COVID-19 High Performance Computing Consortium. Dr. Messer holds undergraduate and graduate degrees from the University of Tennessee, earning his PhD in physics in 2000.