COLLABORATIONS AND CURIOSITY

MATCHING scientist mentors and students on projects to advance the Laboratory's mission has proven to be a reliable first step to promote innovation and build a new employee pipeline. Within Lawrence Livermore's Strategic Deterrence organization, a matching model has been successfully implemented by the Academic Collaboration Team (ACT), enabling students and professors to apply their expertise to projects in high-energy-density science, inertial confinement fusion, nuclear and materials physics, and computation that address evolving program needs. Collaborations are intended to promote innovation and advanced perspectives among partners and yield tangible outcomes, such as publications, patents, and new methods, while encouraging students to consider future employment at Lawrence Livermore.

Counter to the practice of collaborating solely with a set list of tenured faculty members, ACT seeks proposals from early career academics to cultivate new research relationships, provide opportunities to respond to changing program needs with greater agility, and build engagement among students who will soon seek employment. Early- and mid-career Livermore researchers benefit from the chance to explore new areas of science without losing focus on their full-time Laboratory work.

Livermore's Rose McCallen and colleagues in the Strategic Deterrence organization initiated ACT in 2019 based on the understanding that Laboratory capabilities combined with a steady supply of doctoral candidates seeking to establish themselves in their respective research fields could strengthen near-term and long-term success for all parties. With Alison Saunders at the program's helm since 2023, ACT continues to galvanize past university relationships while seeking a more diverse range of institutional partnerships. Saunders, who served as a principal investigator (PI) on a past ACT project, understood the program's value in training the next generation of scientists and guiding strategic university engagement even before she took over the leadership role. "Three years of collaboration with a university professor and doctorate student expanded my knowledge of cutting-edge materials research. The university partners broadened their research scope by modeling their experiments with the Laboratory's advanced simulation codes," says Saunders. "Smaller-scale projects such as those selected for ACT allow the Laboratory to bring in new ideas from our university collaborators while, longer term, building ties to grow hiring pipelines and fostering the continued exchange of academic ideas."

Programmed for Success

ACT publishes a call for proposals each year. Livermore researchers respond with project descriptions, proposed milestones and Laboratory deliverables, estimated costs for student participation, and participant resumes. With the goal of enhancing innovation in target research areas, all proposals are initially reviewed with redacted names of PIs and universities to avoid potential bias. The PIs for down-selected proposals are invited to present their projects to the committee, and five or six projects are selected for funding. ACT establishes subcontracts with university partners and funds the efforts of students and professors for up to three years. Livermore staff continue to be funded by their respective programs.

After projects kick off, students find benefits beyond building and contributing expertise as they receive mentorship from a career researcher and access to one-of-a-kind Laboratory facilities. "An ACT partnership serves as the first professional work setting for many of the selected students," says Saunders. "Working with the same Livermore mentor for several consecutive years enables the partnership to grow and evolve."

Rather than dividing elements of a long-term study among a rotation of students, ACT allows the researcher and student to cultivate a body of work. The ongoing working relationship can also yield quicker turnarounds from research output to return on investment and innovation. Over time, partners become more familiar with the Laboratory's specific methods and sensitive work, preparing them for a potential career at Lawrence Livermore and supporting broader Laboratory goals as well. For example, National Ignition Facility (NIF) physicist Hye-Sook Park mentored a University of California at San Diego student who in turn contributed to research Park pursued, studying material properties at Earth's core. "ACT enabled us to produce important results in this fundamental basic research area and led to the student's advancement in practical knowledge and valuable skills for future Laboratory projects," says Park.

Expanding the Partnership Pool

Completed collaborations have led to a number of publications and to the development of enhanced research tools. (See Sidebars "Expanding Iron's Dynamic Strength," "Refining a Fusion Research Model," and "Studying High-velocity Microparticle Impacts.") Teams have also benefitted from NIF shot time through NIF's Discovery Science program.

While many institutions repeatedly receive ACT awards due to the high caliber of their proposals, students, and expertise, the program set an early goal of encouraging proposals from smaller universities and institutions outside California. Recent university partners have included North Carolina State, Mississippi State, and George Mason universities, and the University of South Florida, building institutional networks beyond earlier ACT collaborators at the University of California at Los Angeles, Stanford University, and University of Notre Dame, among others. "The more students we can recruit and the closer the collaboration, the more data we can collect to refine the program and expand our reach even further," says McCallen, ACT's founder. "Tapping into our university relationships for a workforce with refined skills, knowledge, and abilities will come even more easily as we cultivate a more diverse researcher pool." Saunders is dedicated to continuing McCallen's vision of an ACT program that contributes meaningful research and opens channels to exchange knowledge with other research programs in the Department of Energy and National Nuclear Security Administration.

ACT receives more proposals and funds more research projects each year. In 2023, university students submitted 30 proposals leading to six new awards funded by ACT. Saunders is proud to report that at least three recent postdoctoral hires are the direct result of the ACT program. "The connections made definitely draw great talent," says Saunders.

— Gwendelyn Pinkela (additional reporting by Amy Weldon)

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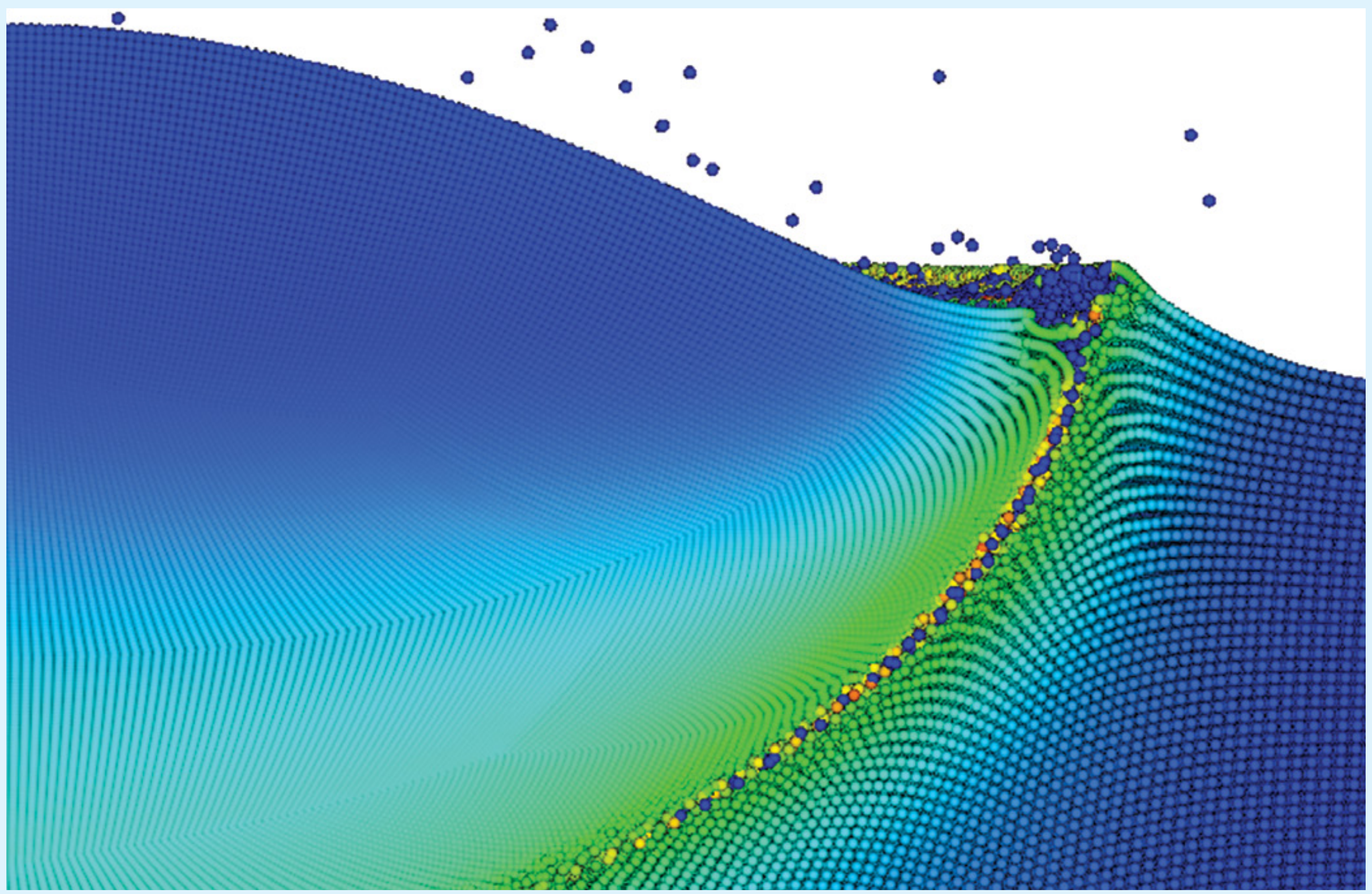
STUDYING HIGH-VELOCITY MICROPARTICLE IMPACTS

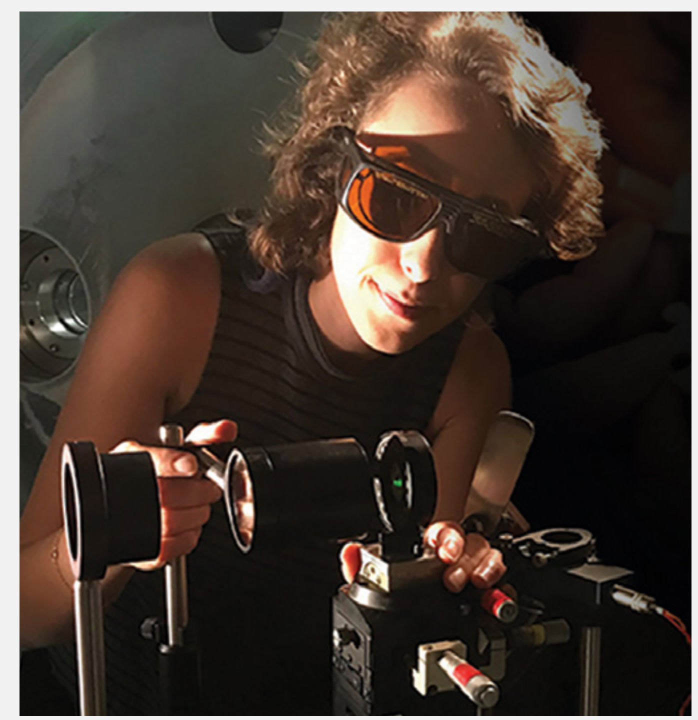
Livermore's hydrocodes, such as ALE3D, predict dynamic material response, providing key particle impact behavior for applications from improving cold spray welding to determining micrometeoroid impacts on spacecraft. Led by Livermore researcher Alison Saunders, a Laboratory team collaborated with Massachusetts Institute of Technology (MIT) student Tyler Lucas and professors Chris Schuh and Keith Nelson to benchmark the constitutive models in such a high strain-rate regime. The MIT group developed the Laser-Induced Particle Impact Test, which uses a table-top laser to accelerate metallic microparticles beyond velocities of 1 kilometer per second. As particles collide with substrates, a high-speed camera with nanosecond temporal resolution captures the impact event. Depending on material and impact velocity, many different phenomena can occur, including rebound, adhesion, hydrodynamic penetration, and melt-driven substrate erosion. Experimental results inform Livermore's ALE3D code to further refine material models. "ACT provided the opportunity to implement Livermore hydrocodes and leverage supercomputers to produce essential data unattainable through other means," says Lucas. "I collaborated with some of the best materials experts and code developers in the field, and they were eager to help me implement my ideas."



Massachusetts Institute of Technology and Livermore teams simulated microparticle impacts with ALE3D hydrocode for insights into physical mechanisms governing experimentally observed particle response. This image captures the simulated impact of a 12-micrometer copper particle (blue dome) striking a copper substrate at 770 meters per second before the particle rebounds. Orange, yellow, and green areas represent regions of elevated strain and, therefore, impact-induced deformation.

EXAMINING IRON'S DYNAMIC STRENGTH

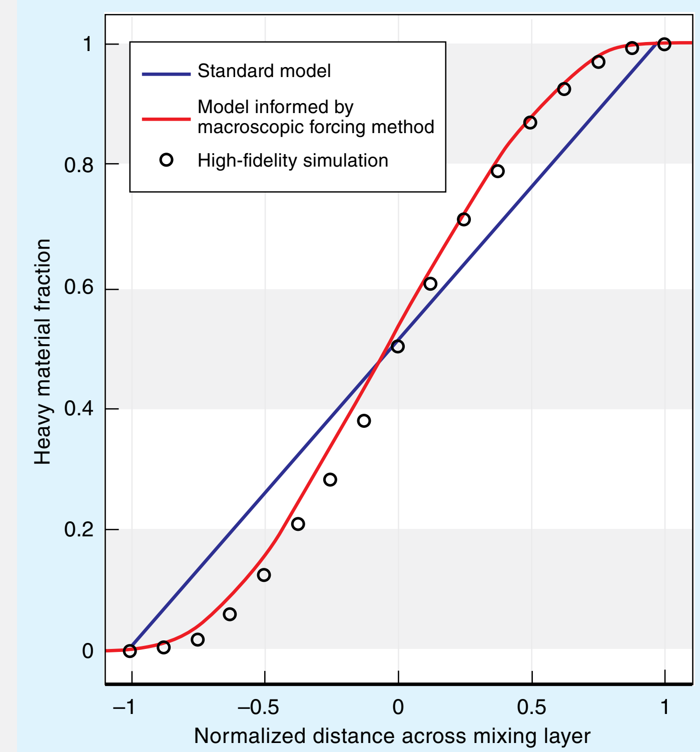
Earth's core is made of iron and nickel, churning deep under 3.5 million atmospheres of pressure. Lawrence Livermore researcher Hye-Sook Park examined the behavior of Earth's high-energy-density iron in collaboration with University of California at San Diego professor Marc Meyers and graduate student Gaia Righi to better understand dynamic failure of iron and iron strength at extreme pressures. Park and Righi implemented laser shock experiments on iron with different initial crystalline lattices and microstructures and then compared results with simulations and models designed to predict the outcomes. Their work, which supports stockpile stewardship, has resulted in three publications and ongoing experimentation. Righi, now the first Harold Brown Postdoctoral Fellow at Lawrence Livermore, says, "ACT gave me the resources to perform laser experiments and simulations and helped me become well connected within the Laboratory. The program contributed to a seamless transition from collaborator to employee."



As a University of California at San Diego student, Gaia Righi worked on an ACT project studying the characteristics of iron at Livermore's Jupiter Laser Facility. Righi is now the Laboratory's Harold Brown Postdoctoral Fellow.

REFINING A FUSION RESEARCH MODEL

In collaboration with Stanford University professor Ali Mani and graduate students Dana Lavacot and Jessie Liu, Livermore's Brandon Morgan addressed the modeling of turbulent mixing, which contributes to degraded target performance in inertial confinement fusion applications. The standard simulation approach, Reynolds-averaged Navier–Stokes (RANS) calculations, can only approximate solutions. Morgan's team sought to develop more predictive RANS models by applying a macroscopic forcing method (MFM) to determine exact differential operators governing the average flow field. "Over the past two years of collaboration, the team has uncovered important factors in modeling flow and developed a new RANS model based on the findings," says Morgan. "ACT helped us develop a promising new modeling technique while also fostering a fruitful hiring pipeline with Stanford University." Future research could be used in National Ignition Facility capsule design simulations.



An ACT-funded collaboration between Livermore and Stanford University yielded a model that better predicts turbulent flow in fusion experiments.