Newsletter
March 2017

APS Topical Group on Shock Compression of Condensed Matter

2017 APS SCCM Officers:

Chair: Damian Swift
Lawrence Livermore National Laboratory
Phone: (925) 422-6781
email: swift23@llnl.gov

Chair-Elect: Brian Jensen
Los Alamos National Laboratory
Phone: (505) 667-9886
Cell: (505) 500-2802
email: bjjensen@lanl.gov

Vice-Chair: Timothy Germann
Los Alamos National Laboratory
Phone: (505) 665-9772
email: tcg@lanl.gov

Past-Chair: Dan Dolan
Sandia National Laboratories
Phone: (505) 284-8608
email: dhdolan@sandia.gov

Secretary/Treasurer:
Mark Elert
US Naval Academy
Phone: (410) 293-6636
FAX: (410) 293-2218
email: elert@usna.edu

Webmaster: E. Ray Lemar
Energetics Technology Center
Phone: (240) 461-5316
email:elemar@comcast.net

Message from the Chair

I am deeply honored to serve as Chair for this year. I would like to offer congratulations and welcome to our newly-elected officers, Tim Germann as Vice Chair, and Members-at-Large Daniel Hooks and Kit Neel. Thanks to our outgoing Chair Dan Dolan and Members Rick Kraus and Seth Root. And continued thanks for our Secretary/Treasurer Mark Elert for keeping the Group on the rails, and to Sunil Dwivedi for cracking the whip to keep newsletters timely.

While it seems that change is still the new normal for many of us, please be assured that the APS and GSCCM are ready to help anyone contemplating a career change, or seeking career development. The APS sees itself as a global society, and particularly wants to strengthen support for non-U.S. members and physicists in industry. I'm personally keen to find ways in which we might contribute here.

In the GSCCM arena, we are making several tweaks intended to support our community more effectively. We plan to transfer routine maintenance of GSCCM content to the APS web team, consistent with the other APS units. The APS-hosted site should be up in the next few weeks; the Group site at shock-physics.org will operate as usual until the APS site is stable, and will continue at least as an alternative GSCCM landing point for the foreseeable future. We will bring up some new web pages and services in trial form, such as a curated data repository and topic bibliography. I would like to express thanks and appreciation to Ray Lemar for maintaining the GSCCM website so diligently for many years, and I hope for his close involvement and guidance as our web arrangements evolve. I would also like to thank APS web staff Cat Lee and David Ralph for their responsiveness and input.

The early registration deadline with discounts for APS members is coming up – June 12 – for this summer's GSCCM conference in St Louis. Many thanks to the Organizing Committee for all their effort so far. I'm generally in trouble for being slow to publish, but I have always found the GSCCM meeting to be an excellent forum for feedback before submitting results to a journal, as well as a source of ideas and contacts for new research directions.

There is also a deadline for APS Fellowships: nominations through GSCCM must be submitted by April 3.

If you have suggestions for anything else we as a community might do to increase our effectiveness as scientists, please don't hesitate to get in contact. If anyone has advice or is prepared to help in setting up new web site features, that would be wonderful!

Finally, I would like to wish you all a safe and productive 2017.

Sincerely,

Damian Swift
swift23@llnl.gov

Upcoming Meetings

DYMAT's 23rd Technical Meeting

Dynamic Fracture of Ductile Materials

BACKGROUND
Numerical simulations have moved into a leading role in engineering system design due to the pressure towards decreasing the time and cost of bringing products to the market. The success of numerical simulations for innovation and value creation relies among other things on the quality of the material modelling. Constitutive models describe the stress and internal variables as function of the strain, strain rate and temperature. In large-scale simulations of structures, the framework of continuum thermo-mechanics is typically adopted to formulate the constitutive models, while thermo-mechanical testing is used to identify the model parameters. The models have to describe plastic anisotropy, non-linear isotropic and kinematic hardening, strain-rate and temperature dependence, damage evolution and failure. Thus a basic understanding of the physical phenomenon controlling the material response is necessary in large-scale analysis as well as an understanding of how simplifications can be made to still retain sufficient accuracy reliability.

OBJECTIVE
The main objective with this technical meeting is to gather scientists and PhD students to provide state-of-the art knowledge on constitutive models for damage and fracture of ductile materials subjected to dynamic loading. Dynamic loading in this context means materials and structures subjected to loading at elevated rates of strain combined with high and low temperatures and high pressures.

Contact
Professor Magnus Langseth
Magnus.langseth@ntnu.no
Tlf: +47 93 03 70 02

Mr Peter Karlsaune
Peter.karlsaune@ntnu.no
Tlf: +47 45 00 21 77

Dept. of Structural Engineering
NTNU
Trondheim, Norway

20th Biennial APS Conference on Shock Compression of Condensed Matter

The 20th Biennial International Conference of the APS Topical Group on Shock Compression of Condensed Matter (SCCM-2017)
Hyatt Regency St. Louis at the Arch
July 9-14, 2017

We are pleased to announce that registration is now open for the **20th Biennial APS Shock Compression of Condensed Matter Conference** which will be held in St. Louis, Missouri, on July 9-14, 2017 at the Hyatt Regency St. Louis at the Arch. Registration should be submitted online through the APS website. Online registration will close on Friday, June 30 for pre-conference preparations, and will re-open on Sunday, July 9 for "onsite online" registration using credit cards. Please visit the conference website for more details.

We also would like to remind you of the early registration discount for the APS members who register by June 12, 2017. Abstract submission has closed as of February 24, 2017. Thanks to everyone who have submitted the abstracts to make the conference a success. Again, please visit the conference website for more details.

We look forward to seeing you in St. Louis!

Eric Brown, Marcus Knudson, and Jon Eggert
SCCM-2017 Co-chairs

News and Events

2016 APS Fellow Awards

Richard L. Gustavsen,

Nominated by the Topical Group on Shock Compression of Condensed Matter, Richard L. Gustavsen, of the Explosive Science and Shock Physics Division at Los Alamos National Laboratory, and Suhithi M. Peiris , of Air Force Research Laboratory, earned the prestigious rank of APS Fellow in 2016. Richard L. Gustavsen was recognized for pioneering studies of the dynamic and high-pressure mechanical and chemical behavior of energetic materials, for shock initiation data used to calibrate reactive burn models, for the development and extension of photon Doppler velocimetry and magnetic particle velocity gauge methods, for mentorship of detonation physicists worldwide, and for leadership and service in the shock physics community. Suhithi M. Peiris was recognized for technical leadership in the dynamical and chemical behavior of energetic materials, for technical advances in both static and dynamic high pressure physics methods, and for sustained leadership and service to the American Physical Society and energetic materials community.

Suhithi M. Peiris

2017 APS Fellowship Nomination

Dear GSCCM Members,

We are writing to encourage you to submit nominations for Fellowship in the American Physical Society through the Topical Group on Shock Compression of Condensed Matter. The Fellowship Program provides a way to recognize our GSCCM colleagues who have made outstanding contributions in experimental and theoretical shock physics.

The deadline for nomination is Monday, April 3, 2017. The nominee must be a APS member in good standing for at least one year. Information about the Fellowship program and nomination instructions can be found online on the APS Fellowship webpage. If you have any questions, please contact me at tcg@lanl.gov. In addition, any questions about the nomination website (which is new for this year) may be directed to Janay Oliver at fellowship@aps.org.

Because a primary goal of APS is to attract and serve a diverse and global membership, nominations of women, members of underrepresented minority groups, and scientists from outside the United States are particularly encouraged.

Sincerely,

Tim Germann
2017 GSCCM Vice Chair

Dynamic Compression Summer School

"Understanding Materials at Extreme Conditions"

August 6-10, 2017

Location: The Dynamic Compression Sector at the Advanced Photon Source, Argonne National Laboratory

WASHINGTON STATE UNIVERSITY

For more information about ISP and DCS visit: www.shock.wsu.edu or www.dcs-aps.wsu.edu

Dynamic Compression Summer School

"Understanding Materials at Extreme Conditions"

August 6 – 10, 2017

WASHINGTON STATE UNIVERSITY

Dynamic compression experiments subject materials to unique conditions – very large compressions, high temperatures, and large deformations – on short time scales resulting in a rich array of physical and chemical changes. Understanding the material response at these extreme conditions is of central importance to fundamental science and spans the disciplines of physics, chemistry, materials science, solid mechanics, planetary sciences, and applied mathematics.

Research activities related to the dynamic compression of materials are extremely diverse and challenging. As such, the Institute for Shock Physics aims to strengthen ongoing efforts to enhance the long-term intellectual vitality of this field, which is uniquely suited for studying material response under extreme conditions.

The Dynamic Compression Summer School has been established to provide an overview of dynamic compression science appropriate for undergraduate students. The four-days of lectures, discussions, and a tour will introduce students to the scientific fundamentals, broad scientific applications, and career opportunities within this vital, diverse and challenging field.

Schedule of Events

Day 1 Introduces dynamic compression science and the fundamentals of matter at high pressure, followed by a tour of the state-of-the-art facilities at the Dynamic Compression Sector at the Advanced Photon Source, Argonne National Laboratory.

Day 2 Continues with the foundations of dynamic compression, followed by an introduction to the opportunities available in dynamic compression science at the Institute for Shock Physics (ISP) at Washington State University – including a talk by a current ISP graduate student.

Day 3 Builds upon the foundations laid during the first two days and focuses on applications of dynamic compression to address scientific problems in various areas including: materials science, geophysics and planetary physics, phase transformations, and mechanical engineering.

Day 4 Provides an overview of career opportunities in dynamic compression science, with perspectives by speakers from each of the three major National Laboratories.

Location

The Dynamic Compression Sector at the Advanced Photon Source, Argonne National Laboratory

Enrollment and Support Details

- Enrollment is limited to 30 students.
- Lodging and meals provided.
- Travel support up to $500 is available.

How to Apply

Application forms and further information can be found at:

shock.wsu.edu/dynamic-compression-summer-school

For questions, please contact Sheila Heyns at (509) 335-5345 or email shockphysics@wsu.edu

shock.wsu.edu ♦ dcs-aps.wsu.edu

For more information about ISP and DCS visit: www.shock.wsu.edu or www.dcs-aps.wsu.edu.

APS SCCM-2017 Early Career and Student Symposium

We are proud to announce that SCCM-2017 will feature an Early Career and Student Symposium, to be held on Sunday, July 9, 2017, just before the start of the main meeting. The symposium will feature a full-day scientific program, including talks and posters from graduate students, postdocs and early career researchers. There will also be a networking lunch, which will be attended by invited researchers from the national labs and academia (lunch provided), as well as an informal evening social outing to allow the younger members of GSCCM to meet each other in a casual setting (attendees will be responsible for their own costs for this event).

A limited number of travel awards are available to cover the cost of conference registration and partial travel costs for students and early career researchers. A conference registration fee waiver and up to $500 for travel costs will be awarded per person, as funding permits. To apply, participants should fill out an application and request a letter of recommendation from their supervisor.

Applications for the Early Career and Student Symposium and travel awards will continue to be accepted through Friday, March 3, 2017. Please see the Early Career and Student Symposium website for more details and application instructions.

U.S. - India Travel Grant Program Application Deadline: February 28, 2017

APS and the Indo-U.S. Science and Technology Forum (IUSSTF) are pleased to announce that applications are now open for professorship/lectureship awards for the U.S.-India Travel Grant Program.

Physics Ph.D.s from the United States and India are invited to apply for funding to collaborate with scientists to deliver short courses or a lecture series at an Indian or U.S. institution.

Applicants must submit a joint proposal from the proposed visitor and their counterpart/collaborator from the host institution.

2017 George E. Duvall Shock Compression Science Award Recipient

Marc André Meyers
University of California at San Diego

Citation:
"*For pioneering contributions to understanding extreme behavior in a wide range of materials undergoing shock-compression, including deformation, fracture, phase transformations, and chemical reactions.*"

Background:

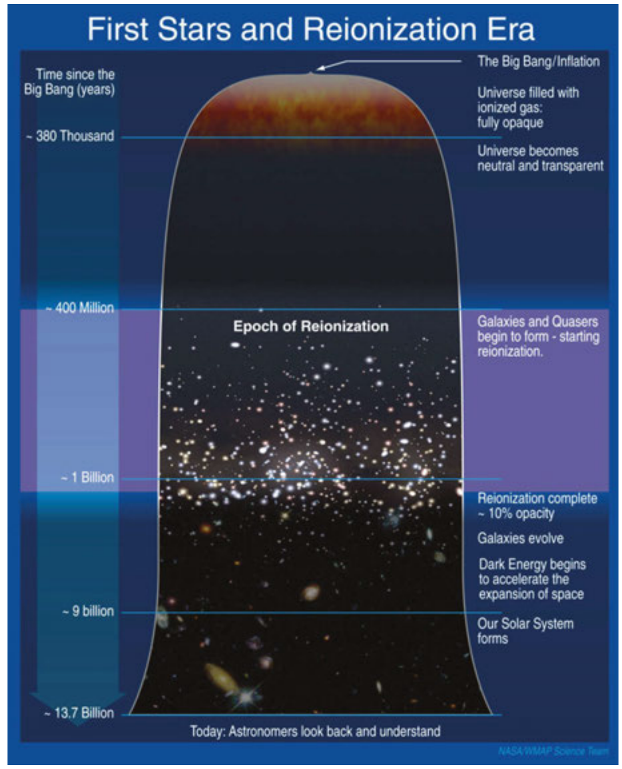
Marc André Meyers, Ph.D., has explored the science of shock waves for 44 years. He is the founder of the first laboratory in all of Latin America dedicated to the study of shock-wave irregularities and interactions with grain boundaries. Dr. Meyers completed his undergraduate studies in mechanical engineering at the Federal University of Minas (Gerais, Brazil) in 1969. He received his M.S. in materials science in 1972 from the University of Denver (Colo.), where in 1974 he also received his Ph.D. in physical metallurgy with the thesis, "Thermomechanical Processing of a Nickel-Base Superalloy by Shock-Wave Deformation" specifically applying to jet turbines. In 1979, while a professor at the South Dakota School of Mines and Technology (Rapid City), Dr. Meyers published the classic paper, "A Mechanism for Homogeneous Dislocation Generation in Shock Compression". Later, as a professor at the New Mexico Institute of Mining and Technology (Socorro), Dr. Meyers co-founded the Center for Explosives Technology Research, which enabled collaborations with the Los Alamos and Sandia National Laboratories (N.M.), and several international laboratories. With Lawrence E. Murr, The University of Texas at El Paso's Materials Research & Technology Institute, Dr. Meyers co-founded the EXPLOMET conference series. At the University of California, San Diego, where Dr. Meyers is a distinguished professor of physics, he investigated shock and dynamic effects in brittle and ductile materials for armor, and developed extensive collaborations with Bruce Remington and others at the Lawrence Livermore National Laboratory in Berkeley, California, on laser shock loading. Thanks to Dr. Meyers' pioneering studies, there have been significant advances in the understanding of shock-induced defects, spallation in ductile metals and brittle rocks, shear banding, tensile-pulse induced martensitic transformations, high temperature shock consolidation reaction-assisted consolidation of metal and ceramic powders, shock synthesis, and shock amorphization. Dr. Meyers has played a leadership role in unifying the "materials science" aspects of shock compression with the "shock physics" aspects of material behavior. He is a fellow of the American Physical Society, the American Society of Microbiology (ASM), and the Minerals, Metals, and Materials Society (TMS), and the recipient of numerous American society awards, including the ASM White, Sauveur Award; the Cohen, Educator, Distinguished Engineer/Scientist, and Service awards from the TMS; and the Acta Materialia Holloman Materials & Society Award. Internationally, Dr. Meyers has been recognized with the Alexander von Humboldt Foundation's Humboldt Prize, the Heyn Commemorative Medal from the German Society for Materials Science, the DYMAT Rinehart Award in Europe, and the Lee Hsung Award from China's Institute of Metal Research. A member of the Brazilian Academy of Sciences and the Institut Grand Ducal in Luxembourg, Dr. Meyers is also the author of 400 papers and the textbook, "Dynamic Behavior of Materials" which has been cited more than 2,500 times and translated into Chinese.

After our universe's cosmic dawn, what happened to all its original hydrogen?

By Aaron Parsons, Associate Professor of Astronomy, University of California, Berkeley/The Conversation

When our universe first blasted into existence with a Big Bang almost 14 billion years ago, it looked much different than it does today. Instead of planets, stars and galaxies, there was an inflating ball of hot plasma.

The universe cooled as it expanded, and over time the different ingredients of our universe froze out as temperatures plummeted. Quarks froze out first, then protons and neutrons, followed by electrons. Finally, after about



Timeline of the universe. NASA, CC BY

380,000 years, hydrogen – the first atoms – started to form. Some of these atoms were pulled together into stars, where they fused into carbon, oxygen, nitrogen, iron and all of the other elements from which planets and life are built.

However, when our universe was about one billion years old, it appears that nine out of every 10 of those original hydrogen atoms were destroyed before they ever found their way into galaxies. Exactly when and how were those first atoms in the universe destroyed? Astronomers have puzzled over these questions for decades. I'm leading a new experiment – known as the Hydrogen Epoch of Reionization Array (HERA) – that we hope will help answer what happened.

Hydrogen everywhere, then cosmic dawn

With the formation of those first hydrogen atoms – each made of one negatively charged electron and one positively charged proton – the universe entered a period cosmologists call the Dark Ages. During this time, the universe quietly waited for clouds of hydrogen to obey the influence of gravity and collapse into the very first stars and galaxies. The ignition of the first stars marks the end of the Dark Ages and the beginning of our "Cosmic Dawn," some 100 million years after the Big Bang. For the first time, our universe began shining with a light other than the afterglow of the Big Bang.

Leading up to our Cosmic Dawn, the entire universe was filled with hydrogen. However, starlight consists of photons with enough energy to split hydrogen apart, reionizing it back into protons and electrons. As more and more stars lit up, larger and larger holes of ionization got carved out of the primordial hydrogen clouds.

Other, more exotic objects also began forming inside galaxies. As stars exhausted their hydrogen fuel, they'd explode in spectacular supernovae. Some stars left behind black holes that devoured nearby stars and generated powerful x-ray jets. In the centers of galaxies, supermassive black holes were growing, with the masses of millions of suns.

These events injected huge amounts of energy into the surrounding hydrogen clouds, heating and ionizing them, until, as we look out today, we see that all of the intergalactic hydrogen has been destroyed – reionized into its component particles, protons and electrons.

Mapping the hydrogen itself

We astronomers are still struggling to disentangle all of the complex processes that led to the formation of stars and galaxies and the simultaneous destruction of the universe's hydrogen.

Using our most powerful optical telescopes, we are finding galaxies so far away that their light, emitted when the universe was only one billion years old, is just now getting to us. The glimpse we get of these galaxies in the final throes of reionization is as the last remnants of intergalactic hydrogen are being burned away. Yet as we try to look deeper, the hydrogen itself confounds us. It absorbs the very starlight that we use to observe distant galaxies, acting as a blanketing fog that conceals the chaos behind it.

To solve this problem, my colleagues and I designed a new kind of telescope: an array of radio dishes that, instead of searching for distant galaxies, maps the inter-

The start of construction on the HERA array. SKA South Africa, CC BY

galactic hydrogen itself throughout the process of being heated and reionized. Our Hydrogen Epoch of Reionization Array combines cutting-edge supercomputing hardware with low-cost antenna construction in a unique design that gives it both the sensitivity and precision to create what will be the largest maps in the universe.

HERA is sensitive to a specific kind of radio wave produced when the magnetic fields of the proton and electron inside of hydrogen switch their north-south polarity with respect to each other. Just as two oppositely aligned bar magnets attract each other and release energy in the process, the switching polarity of the electron and proton causes hydrogen to release a small amount of energy. This hyperfine transition produces radio waves with a characteristic wavelength of 21 centimeters.

As a result of the continuing expansion of the universe since the Big Bang, 21-cm radio waves from intergalactic hydrogen have been stretched by different amounts, depending on how old the universe was when they were originally emitted. For example, when the universe was 770 million years old, it was eight times smaller than it is today. A 21-cm radio wave emitted by hydrogen at this time in the history of our universe would be stretched by a factor of eight on its way to us; we would see it with a wavelength of 168 cm. On the other hand, the same radio wave emitted when the universe was 940 million years old would be be stretched only by a factor of seven, appearing to us with a wavelength of 147 cm. By measuring the wavelength of the light, we can know exactly when and where in the universe it was emitted.

Computer simulations predict how clouds of hydrogen glowed with 21-cm emission as they were heated and ionized by early galaxies.

By mapping the sky at many wavelengths between 150 and 350 cm, HERA can produce a series of images from the early childhood of our universe. We will be able to watch step by step as the light of the first stars and galaxies destroys the clouds out of which they formed. We expect to see large clouds of hydrogen glowing with 21-cm emission, with dark pinpricks of ionization sprinkled in. As we move to parts of the universe that are closer to us and where more time has elapsed, we should see larger and larger voids where 21-cm emission is missing, until finally, these voids swallow everything and the 21-cm signal that signifies the presence of hydrogen is gone.

Building our new kind of array

Our HERA team was recently awarded US$9.5 million from the National Science Foundation. We'll use the funds to construct a hexagonal array of 240 14-meter radio dishes in Karoo Radio Reserve of South Africa over the next three years. Our collaborators hail from 16 institutions from around the world. The plan is to work in parallel to conduct the observations that will be used to produce HERA's groundbreaking results.

Observations with the new facilities in the next several years are poised to transform our understanding of the first stars, galaxies and black holes, and their role in driving reionization at the end of cosmic dawn. HERA's observations of neutral hydrogen will provide unique insights into this formative period in our universe. Indeed, in the early universe, 21-cm emission provides the only direct way to probe the complex interplay between the first luminous structures and their surroundings. To trace the story of the first atoms in the universe, stay tuned as HERA begins observing over the next few years.

Researchers 'watch' crystal structure change in real time

PULLMAN, Wash. – Washington State University researchers have met the long-standing scientific challenge of watching a material change its crystal structure in real time.

While exposing a sample of silicon to intense pressure – due to the impact of a nearly 12,000 mph plastic projectile – they documented the transformation from its common cubic diamond structure to a simple hexagonal structure. At one point, they could see both structures as the shock wave traveled through the sample in less than half a millionth of a second.

Their discovery is a dramatic proof of concept for a new way of discerning the makeups of various materials, from impacted meteors to body armor to iron in the center of the Earth.

Until now, researchers have had to rely on computer simulations to follow the atomic-level changes of a structural transformation under pressure, said Yogendra Gupta, Regents professor and director of the WSU Institute of Shock Physics. The new method provides a way to actually measure the physical changes and to see if the simulations are valid.

"For the first time, we can determine the structure," Gupta said. "We've been assuming some things but we had never measured it."

Writing in *Physical Review Letters*, one of the leading physics journals, the researchers say their findings already suggest that several long-standing assumptions about the pathways of silicon's transformation "need to be re-examined."

The discovery was made possible by a new facility, the Dynamic Compression Sector at the Advanced Photon Source located at the Argonne National Laboratory. Designed and developed by WSU, the sector is sponsored by the U.S. Department of Energy's National Nuclear Security Administration, whose national security research mission includes fundamental dynamic compression science.

The Advanced Photon Source synchrotron, funded by the Department of Energy's Office of Science, provided high-brilliance x-ray beams that pass through the test material and create diffraction patterns that the researchers use to decode a crystal changing its structure in as little as 5 billionths of a second.

"We're making movies," said Gupta. "We're watching them in real time. We're making nanosecond movies." Stefan Turneaure, lead author of the *Physical Review Letters* paper and a senior scientist at the WSU Institute for Shock Physics, said the researchers exposed silicon to 19 gigapascals, nearly 200,000 times atmospheric pressure. They accomplished this by firing a half-inch plastic projectile into a thin piece of silicon on a Lexan backing. While x-rays hit the sample in pulses, a detector captured images of the diffracted rays every 153.4 nanoseconds – the equivalent of a camera shutter speed of a few millionths of a second.

"People haven't used x-rays like this before," said Turneaure. "Getting these multiple snapshots in a single impact experiment is new."

"What I'm very excited about is we are showing how the crystal lattice, how this diamond structure that silicon starts out with, is related to this ending structure, this hexagonal structure," said Gupta. "We can see which crystal direction becomes which crystal direction. Stefan has done a great job. He has mastered that. We were able to show how the two structures are linked in real time."

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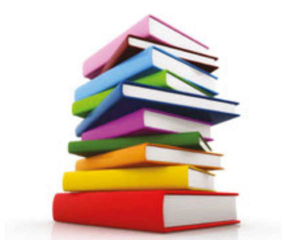
Bookshelf

Books and Proceedings



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Journal of Engineering Physics and Thermophysics, Vol. 89, No. 4, July, 2016
(Paper of Interest Contributed by Stephen Walley)

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American Physical Society
One Physics Ellipse
College Park, MD 20740
www.aps.org

APS GSCCM
www.shockphysics.org

Editorial Staff

Eric Chisolm, Descartes Labs, Inc.
(echisolm@lanl.gov, eric@descarteslabs.com)

Sunil Dwivedi,*
(dwivedis001@yahoo.com)

Eric Herbold, Lawrence Livermore National Laboratory
(herbold1@llnl.gov)

*Lead for this and next issues

Please send any questions or comments about the newsletter to any of the editors.

Special thanks to Nancy Bennett-Karasik of APS Special Publications.

The APS Topical Group on Shock Compression of Condensed Matter (GSCCM) was founded in 1984 to promote the development and exchange of information on the dynamic high-pressure properties of materials. The Topical Group sponsors biennial technical meetings on shock compression and detonation physics research, including experimental, theoretical and computational studies, and new experimental methods and developments