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RPPR Final Report
as of 28-Dec-2018

Agency Code:

Proposal Number: 71599EGCF **Agreement Number: W911NF-17-1-0426**
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STEM Degrees: 0 **STEM Participants:** 0

Major Goals: Metastructures is an emerging research topic that spans several disciplines and that has potentials for impact in a number of engineering systems. These include structures with integrated vibration reduction capabilities, shock absorption, and generally tailored mechanical properties that are derived from the assembly of units at the meso-scale. While some of the concepts rely on, and are inspired by, the abundant literature in the area of metamaterials, there are several aspects in terms of analysis and performance that make metastructures unique. However, the literature on metastructures is at its infancy, and several studies still need to be conducted to fully explore fundamentals as well as areas of application.

A 2.5 day workshop brought together experts from academia, industry and government labs with the goal of identifying key research questions and highlighting new areas of investigation based on the opportunities afforded by metastructures concepts. This report summarizes activities conducted during the ARO-sponsored workshop titled \emph{Metastructures: Dynamics, Topology and Related Opportunities}. The workshop was held on May 16-18, 2018, in Atlanta, GA. The workshop included 7 sessions, with a total of 35 presentations by invited speakers from academia and the government. In addition, a breakout session was devoted to the identification of open research questions, application opportunities, and long-term vision for the field of metastructures. Approximately 60 participants were in attendance and actively participated to the technical exchange during and following the presentations, and the breakout session. Attendees included members of various academic institutions, several students and post-docs, and representatives of government agencies such as the Army Research Office (ARO), the Air Force Office of Scientific Research (AFOSR), the Army Research Laboratory (ARL), the Air Force Research Laboratory (AFRL), National Aeronautics and Space Administration (NASA), National Security Campus (NSC), and Sandia National Laboratory (SNL).

Accomplishments: Accomplishments are included in the uploaded file.

Training Opportunities: The workshop organization was conducted in collaboration with one leading post-doctoral fellow, Dr. Marco Miniaci, supported by several students. These individuals have had the opportunity to be exposed with state-of-the-art presentations, and to meet and interact with leading scientists.

Results Dissemination: Nothing to Report

Honors and Awards: Nothing to Report

RPPR Final Report
as of 28-Dec-2018

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Technology Transfer: Nothing to Report

PARTICIPANTS:

Participant Type: Other Professional
Participant: Bethany L Smith
Person Months Worked: 1.00 **Funding Support:**
Project Contribution:
International Collaboration:
International Travel:
National Academy Member: N
Other Collaborators:

Participant Type: Postdoctoral (scholar, fellow or other postdoctoral position)
Participant: Marco Miniaci
Person Months Worked: 1.00 **Funding Support:**
Project Contribution:
International Collaboration:
International Travel:
National Academy Member: N
Other Collaborators:

Workshop
Meta-structures: Dynamics, Topology and Related Opportunities

Final Report

Contract Number W911NF-17-1-0426

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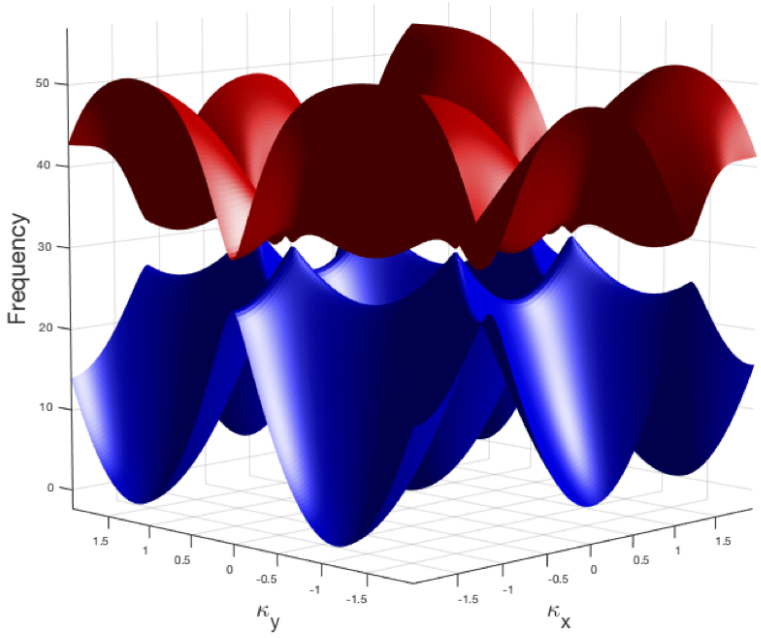
Atlanta - GA

December 21, 2018



Contents

1 Workshop Overview

Metastructures is an emerging research topic that spans several disciplines and that has potentials for impact in a number of engineering systems. These include structures with integrated vibration reduction capabilities, shock absorption, and generally tailored mechanical properties that are derived from the assembly of units at the meso-scale. While some of the concepts rely on, and are inspired by, the abundant literature in the area of metamaterials, there are several aspects in terms of analysis and performance that make metastructures unique. However, the literature on metastructures is at its infancy, and several studies still need to be conducted to fully explore fundamentals as well as areas of application.

A 2.5 day workshop brought together experts from academia, industry and government labs with the goal of identifying key research questions and highlighting new areas of investigation based on the opportunities afforded by metastructures concepts. This report summarizes activities conducted during the ARO-sponsored workshop titled *Metastructures: Dynamics, Topology and Related Opportunities*. The workshop was held on May 16-18, 2018, in Atlanta, GA. The workshop included 7 sessions, with a total of 35 presentations by invited speakers from academia and the government. In addition, a breakout session was devoted to the identification of open research questions, application opportunities, and long-term vision for the field of metastructures. Approximately 60 participants were in attendance and actively participated to the technical exchange during and following the presentations, and the breakout session. Attendees included members of various academic institutions, several students and post-docs, and representatives of government agencies such as the Army Research Office (ARO), the Air Force Office of Scientific Research (AFOSR), the Army Research Laboratory (ARL), the Air Force Research Laboratory (AFRL), National Aeronautics and Space Administration (NASA), National Security Campus (NSC), and Sandia National Laboratory (SNL).

1.1 Introduction

In the last two decades, significant research has been devoted to the study of mechanical *metamaterials*. While related discoveries have significantly energized the research community, and have suggested a variety of implications for engineering applications, most of the concepts rely on small-scale configurations, typically in the nm or μm range. The related findings cannot be directly transferred to larger scale structural components, and are not practical for scaled-up implementation.

Metamaterials are generally investigated by materials and physics communities through studies that focus on fundamental, equivalent material properties. Based on these, overall performance is typically inferred. In contrast, the word *metastructure*, as effectively embraced by the community as a result of this workshop, denotes concepts for which performance is defined not only by the meso-structural configuration, but also by overall dimensions, geometry and boundary conditions imposed to an assembly consisting of a finite number of units (see Fig. 1). As a result, performance needs to be defined more broadly, and specifically in terms, for example, of location of natural frequencies, coincidence frequencies, buckling and structural failure modes, and not solely based on fundamental material properties such as elastic moduli or equivalent constitutive models.

1.2 Motivations

Based on these observations, it is clear that there are a number of outstanding fundamental questions that need to be addressed before metamaterial concepts can be scaled-up, transitioned, and possibly successfully integrated as part of novel structural configurations. Most importantly, several opportunities remain unexplored to provide structural assemblies with unique properties and tailored performance. The transition from a materials perspective, to a structural one is likely to elicit new questions, and stimulate fundamental research in an area that is expected to be fundamentally

different than a simple scale-up extension of metamaterials research. Furthermore, the investigation of metastructures motivates the exploration of new concepts relying on the existence of interfaces and of interactions with the environment. These interactions may be exploited to significantly affect the properties of a structure in an engineered and controllable manner. This remains an area of research that is rich in fundamental questions, one that may hold significant promise for a number of applications relevant to the US Army and beyond.

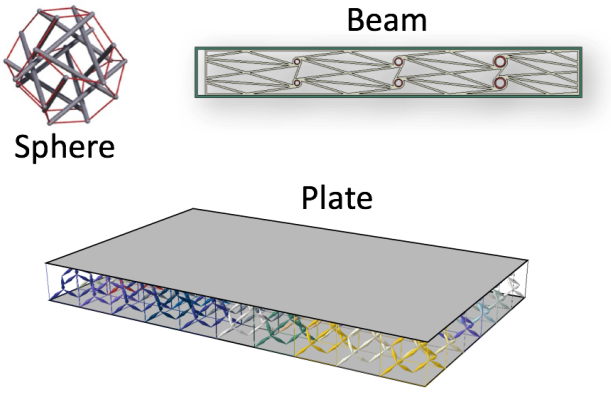


Figure 1: Examples of metastructures.

1.3 Objectives

This focused thematic workshop has directly addressed these fundamental questions, and explored the range of opportunities afforded by the metastructure framework. Specific objectives of the workshop were:

1. To define the concept of metastructures, and to identify opportunities and related research gaps;
2. To identify key challenges related to the study and exploration of metastructures and their performance, with specific reference to meso-scale concepts;
3. To identify emerging ideas, physical principles and analysis techniques that enable the implementation of metastructures with transformative capabilities.

1.4 Summary of outcomes and recommendations

The workshop was successfull in achieving the objectives set, and provided a stimulating technical exchange among researchers of diverse background and expertise, all unified by converging interests in the area of metastructures.

The workshop activities led to the following general outcomes and observations:

- The field of metastructures is extremely broad and rich in opportunities for additional research and the pursuit of novel structural components with superior and unprecedented properties.
- There is a community of researchers that is well equipped to make advances in both fundamental as well as applied aspects.

- There are significant opportunities enabled by novel fabrication techniques, design methodologies and analysis tools to explore an extremely wide design space. Performance of interest may include dynamic response, fracture, structural stability, fluid-structure interaction for drag reduction and aeroelastic performance, lightweight, thermal transport among others.
- The investigation of modular design concepts that rely on multifield interactions is at its infancy. There are unexplored opportunities in the field of chemo-elasticity, along with magneto- and electro-elasticity that may lead to active, adaptive, responsive or tunable structural components.
- The ability to manipulate mechanical and structural properties is expected to transform the way in which we design and build and operate structural components and assemblies.
- There is a grand vision that in a 10-year time frame, researchers will be able to control structural performance across unprecedented frequency ranges, scales, and operational scenarios.
- The pursuit of this vision will require multidisciplinary research and large scale projects that enable interaction of highly diverse teams of investigators.

1.5 Organization, location and logistics

The workshop was organized by the PI, Prof. Massimo Ruzzene, in coordination with Dr. Samuel Stanton of ARO. The workshop organization was also supported by the help of Ms. Bethany Smith, and Dr. Marco Miniaci, both of Georgia Tech. The workshop was held at the JW Marriott in Atlanta over 2.5 days, and included 7 sessions and 1 breakout session. Session 1 was a joint session, while all subsequent sessions were split into two parallel sub-sessions 'A' and 'B'. A total of 4 plenary presentations were delivered by representatives of a government agency.

The workshop detailed agenda is provided in Appendix A of this report, while the list of participants is given in Appendix B. A total of approximately 60 participants were invited to attend and actively participate in discussions following the presentation sessions, and in vision setting exercises conducted during breaks and the breakout session.

2 Technical contents and highlights

The technical content of the sessions can be summarized as follows:

- *Session 1*: The workshop was opened by introductory remarks delivered by the workshop organizer, Dr. Massimo Ruzzene (Georgia Tech). The goal was to set the tone of the workshop, provide a tentative definition and context to the *metastructure* concept, and to give an overview of the workshop, its organization, and its objectives. Next, Dr. Sam Stanton of ARO delivered a talk titles "Can we even do this? Metastructures Ideas from the Ordinary to the Outlandish", where he provided his programmatic perspective, along with a vision for the field, highlighting potential challenges, and the potential relevance to the Army ongoing research and development efforts. US Army perspectives were also presented in the presentation on "Novel Investigation of High Frequency Multiaxial Vibration" by Dr. Jaret Riddick, Director of the Vehicle Technology Directorate of ARL. The talk illustrated novel capabilities available at ARL in terms of multiaxial vibration testing, ongoing research activities and the open campus initiative that is intended to facilitate collaboration with the academic community and provide access to ARL facilities on collaborative projects. The session also included talks by members of the academic community, from aerospace (Prof. D. Inman, University of Michigan), mechanical (Prof. K.W. Wang, University of Michigan), electrical engineering (Prof. A. Alù, CUNY) and physics (Prof. V. Vitelli, University of Chicago) departments, which showed the highly interdisciplinary nature of the metastructures area.

- *Session 2*: The session was opened by the an overview of the research portfolio of Dr. J. Tiley of AFOSR, who discussed ongoing areas of emphasis, and potential interests in the general topic of the workshop. The session was then split into two parallel sessions each including four talks.

  - *Session 2A* was devoted to the emerging topic of *topological mechanics*, which is one that holds particular promise towards the pursuit of novel structural configurations that have unique properties in relation to their ability to conduct elastic waves along boundaries and interfaces, to feature diffraction-free propagation, and to potentially lead to robust energy transfer in modalities that challenge generally accepted notions of mechanical and acoustic reciprocity.
  - *Session 2B*: addressed challenges and opportunities afforded by new fabrication methods that are currently enabling the conception of novel ideas for complex structural configurations that include novel architectures, that can act as waveguides, that have superior properties and that can be used for manipulation of objects (tweezers).

- *Session 3* include the following two sub-sessions:

  - *Session 3A* continued the series of presentations in the area of topological mechanics and addressed opportunities provided by band dispersion engineering, tunability, and by the implementation of topological concepts to affect the energy flow in thin-walled structural components such as plates and shells. The opportunities afforded by harnessing nonlinearities and multi-stable components were common themes emerging from the technical briefings.
  - *Session 3B*: included 3 presentations that discussed novel structural components such as patterned plate with waveguiding characteristics, along with the application of Origami and Tensegrity design for the implementation of new metamaterials and metrastructures

that are lightweight, are deployable, and feature overall tunable mechanical characteristics. This session also discussed structural topology optimization techniques devoted for the design of aerospace structures and inverse design approaches for vibration control.

- *Session 4*: was opened by a plenary presentation by Dr. Abby Juhl from the Materials Directorate of AFRL. The presentation highlighted ongoing activities in the Lab, with specific emphasis on the area of programmable structures and additive manufacturing of active structural components. Ongoing research was placed in the context of Air Force relevant applications related to vibration and sound mitigation, and in terms of overall capabilities of tailoring the mechanical properties, such as the Poisson's ratio, of structural components on-demand. The session continued with the following parallel tracks:

  - *Session 4A*: focused on multiphysics interactions and specifically on metamaterials concepts for flow control, stress induced transformation as a mechanism to achieve phase changing structural components, on space-time periodic modulations for non-reciprocity, and most notably on electro?chemical?mechanical interactions for energy storage in structural components.
  - *Session 4B*: continued the investigation of nonlinear mechanisms to achieve non-reciprocal wave motion, and unique structural characteristics in general, and the potential implications in terms of shock and vibration absorption, as well as to achieve extreme control of the programmable properties of structural components through electro-mechanical interactions.

- *Breakout*: The breakout session was held as a closure to the workshop. The session was conducted as an open exchange among all workshop attendees. The tone was set by workshop coordinators, Dr.s Ruzzene and Stanton, who set the tone for the open through preliminary remarks. Examples of observations and topics addressed during the discussion are summarized in the following section of this report.

3 Summary of breakout session

The workshop highlighted several research themes that could emerge and materialize in terms of research initiatives. Multi-disciplinary funding vehicles, such as MURIs, are clear vehicles to support multidisciplinary research in several topics relevant to metastructures. However, the community should not solely focus MURIs and should consider other funding mechanisms to pursue research that will enable advances in several subtopics. In addition, researchers are encouraged to leverage unfunded collaboration opportunities with government labs, that could provide access to shared resources, and lead to common projects with significant opportunities for technology transition. For example, ARL's open campus initiative offers access to facilities, that are unique, and that would be otherwise hard to procure in university settings. Compelling objectives for future research that emerged include, for example, the investigation of mathematical tools for the analysis of wave propagation in tunable, multi-field/multi-domain structural components, the formulation of compelling research questions beyond, for example, the formation of bandgaps, and the sole investigation of nonlinearities as an interesting fundamental topic, along with the articulation of specific technological implications that will highlight the importance of the investigations beyond simple scientific curiosity.

The tone of the discussion was also set by posing a number of questions which are highlighted in the slides used to introduce the session, here reported in Fig. 2. The slides list key questions

in regards to the timeliness of the topic of metastructures, in terms of the potential applications that could benefit from research in this area, and on the areas of fundamental research that could enable a leap forward in terms of discovery and related capabilities. A first point that was discussed addresses the "why now?" question, which was further elaborated into the following queries. Points made by the workshop participants in relation to each of the questions are given in what follows.

Figure 2: Slides used in the opening of the breakout session.

- *Are we reinventing/re-branding or innovating?* In response to this question, the group quickly agreed that the topic of metastructures, driven by exciting innovations in theories related to topology, design methodologies, and fabrication techniques, is poised to provide numerous research questions that are novel and compelling. The perceived implications in terms of technological development build on results that have mostly considered vibration-related performance, by focusing primarily on bandgap formation. However, the consensus is that this only scratches the surface of what is feasible and achievable.

  It is envisioned that in the near future, research will be devoted to active metastructures that have the ability to tailor their mechanical properties on demand, to affect the properties of interfaces, to modulate properties in space and time to break reciprocity principles, to store, absorb and convert mechanical and other forms of energy, to reconfigure shape and overall geometry, and to achieve emergent behaviors from the control of selected components

- *Is there a critical mass?* The workshop gathered a diverse group of researchers, that are driven by common interests and goals. As a result, there are ample opportunities for interdisciplinary collaboration. It was generally agreed that there is a community that is forming which is gathering scientists and engineers with expertise in physics, mechanical, aerospace, electrical and civil engineering, material science, chemistry and control theory. The multidisciplinary nature of this community is likely to lead to desired advances in the areas of metastructures. The involvement of students, and their active participation, indicates that there is a pipeline

of expertise that is being developed, which indicates that activities will be sustained for years to come.

- *Is it too early?* As indicated above, the topic is considered highly timely given the convergent advances in a variety of areas that are enabling innovation and discovery in metastructures. These include analysis techniques with multi-physics capabilities, design methodologies, fabrication capabilities that allow assembly of units of unprecedented complexity, and the ever evolving knowledge on the properties of materials at the constitutive level. In addition, advances in self-assembling concepts, combined with the improved knowledge of novel structural configurations could lead the way to a modular approach, described by some during the discussion as a "Lego"-like approach to modern design of structural components.

- *What are the research areas/questions?* Specifically, the issues to be addressed as (1) "is research curiosity driven, application driven or both?", and (2) "is there a breakthrough at the horizon?" The group believed that there are a significant opportunities for the exploration of new physics, mathematics and engineering related to the ability to fully control the properties of metastructures at the constituent level, at the unit-cell level, or at selected limited locations. While mostly curiosity-driven at the moment, there is broad agreement that involvement of practical considerations, and specific goals in terms of structural performance will stimulate further research and will lead to significant breakthroughs in terms of technological development. From this point of view the active parcitipation of government labs such as ARL, AFRL, SnL, and NSC was seen as particularly promising. It is envisioned that areas that could benefit from advances in metastructures research include, but are not limited to, flexible and modular robotics, programmable matter, chemically activated and controlled structures, new modalities of locomotion and actuation based on interface wave modes, new geometrical concepts that go beyond the periodic arrangement of units, and include potentially chaotic assemblies and that are inspired by novel network topologies and geometrical/topological mapping principles.

A Workshop agenda

Workshop - Meta-structures: Dynamics, Topology and Related Opportunities
May 16-18, 2018 - Atlanta GA

From	To	Day 1 May 16, 2018
12:00 PM	**2:00 PM**	**CHECK IN AND REGISTRATION**
		Session 1 **Chair**: M. Ruzzene – Room Tallahassee
1:45 PM	2:00 PM	*Workshop Introduction* **M. Ruzzene** - Georgia Tech
2:00 PM	2:30 PM	*Can we even do this? Metastructures Ideas from the Ordinary to the Outlandish* **S. Stanton** - Army Research Office
2:30 PM	3:00 PM	*Reconfigurable Modular Metastructures for Multifunctional Adaptation* **K.W. Wang** - University of Michigan
3:00 PM	3:30 PM	*Soft Self-Assembly Of Weyl Materials For Light And Sound* **V. Vitelli** - University of Chicago
3:30 PM	3:45 PM	**DISCUSSION**
3:45 PM	4:00 PM	**BREAK**
4:00 PM	4:30 PM	*Novel Investigation of High Frequency Multiaxial Vibration* **J. Riddick** - Army Research Laboratory
4:30 PM	5:00 PM	*New Frontiers for Sound Manipulation Using Metamaterials* **A. Alu'** – City University of New York
5:00 PM	5:30 PM	*Issues Facing Meta-Structure Performance* **D. Inman** - University of Michigan
5:30 PM	6:00 PM	**DISCUSSION**
	6:00 PM	**ADJOURN**

Workshop - Meta-structures: Dynamics, Topology and Related Opportunities
May 16-18, 2018 - Atlanta GA

From	To	Day 2 May 17, 2018	
		Session 2 **Chair**: M. Ruzzene – Room: Tallahassee	
9:00 AM	9.30 AM	*AFOSR Overview* **J. Tiley** – Air Force Office of Scientific Research	
9:30 AM	10:00 AM	**BREAK**	
		Session 2A: Topological Mechanics I **Chair**: A. Alu' - Room: Tallahassee	**Session 2B**: Fabrication **Chair**: A. Erturk - Room: Richmond
10:00 AM	10:30 AM	*A Phononic Quadrupole Insulator* **S. Huber** - ETH Zurich	*Tailoring the Flow of Acoustic Waves by Architectured Metamaterials* **N. Fang** - MIT
10:30 AM	11:00 AM	*Opportunities And Challenges With Topological Mechanical Systems* **E. Prodan** – Yeshiva University	*Multimaterial 3D Printing for Meta-Structure Applications* **J. Qi** – Georgia Tech
11:00 AM	11:15 AM	**DISCUSSION**	
11:15 AM	11:30 AM	**BREAK**	
11:30 AM	12:00 AM	*Topological Edge and Corner States in Acoustic Kagome Meta-Structures* **A. Khanikaev** – City Univ. of New York	*Dynamic Properties of Engineered Micro-granular Crystals via Optical Tweezers Fabrication* **J. Hopkins** - UCLA
12:00 AM	12:30 AM	*Controlling the Deformation of Metamaterials: Corner Modes via Topology* **Z. Rocklin** – Georgia Tech	*Fabrication of Multi-Material and Multi-Scale Metastructures: Challenges and Opportunities* **L. Valdevit** – UC Irvine
12:30 AM	2:00 PM	**LUNCH BREAK**	
		Session 3A: Topological Mechanics II **Chair**: M. Leamy - Room: Tallahassee	**Session 3B:** Novel Structures **Chair**: R.K. Pal- Room: Richmond
2:00 PM	2:30 PM	*Tunable Systems For Topological Dynamics* **C. Prodan** – New Jersey Institute of Tech.	*Experimental observation of topologically protected helical edge modes in Kagome elastic plates* **M. Miniaci** – Georgia Tech
2:30 PM	3:00 PM	*Topological Elastic Metastructures: exploiting topological transitions to control the mechanical energy flow in thin-walled structures* **F. Semperlotti** – Purdue University	*Origami inspired structures and configurational metamaterials* **G. Paulino** – Georgia Tech
3:00 PM	3:30 PM	*Opportunities In Meta-Structures: Band Engineering And Discrete Models* **K. Matlack** – University of Illinois UC	*Topology Matters: Expanding The Design Space Of Lightweight Mechanical Metamaterials* **J. Rimoli** – Georgia Tech
3:30 PM	3:45 PM	**DISCUSSION**	
3:45 PM	4:00 PM	**BREAK**	

Workshop - Meta-structures: Dynamics, Topology and Related Opportunities
May 16-18, 2018 - Atlanta GA

From	To	Day 2 May 17, 2018	
		Session 3A: **Chair**: M. Leamy - Room: Tallahassee	**Session 3B**: **Chair**: R.K. Pal - Room: Richmond
4:00 PM	4:30 PM	*Metamaterials With Locally Addressable Properties: From Self-Folding To Autonomous Propulsion* **C. Daraio** - Caltech	*Wave Dynamics in Origami-based Mechanical Metamaterials* **J. K. Yang** – U. of Washington
4:30 PM	5:00 PM	*Metastructures with Tunable Rod-Like Resonators Towards A Unitary Testbed to Understand Disorder and Symmetry?* **S. Gonella**- U. of Minnesota	*High-Resolution Topology Optimization Algorithms For Aerospace Structures* **G. Kennedy** – Georgia Tech
5:00 PM	5:30 PM	*Exploiting Bistability For Reconfigurable Tuning And Control Of Elastic Wave Propagation In Metamaterials And Metastructures* **J. Meaud** – Georgia Tech	*PDE-Constrained Optimization Framework For Inverse Design Of Mechanical Metamaterials For Vibration Control* **T. Walsh** – Sandia National Laboratory
5:30 PM	6:00 PM	**DISCUSSION**	
	6:00 PM	**ADJOURN**	

Workshop - Meta-structures: Dynamics, Topology and Related Opportunities
May 16-18, 2018 - Atlanta GA

From	To	Day 3 May 18, 2018	
		Session 4 **Chair**: M. Ruzzene - Room: Tallahassee	
9:00 AM	9.30 AM	*Dynamic Tuning Of Poisson's Ratios Using Shunted Piezoelectrics* **A . Juhl** – Air Force Research Laboratory	
9:30 AM	10:00 AM	**BREAK**	
		Session 4A: Multiphysics Interactions **Chair**: J. Rimoli - Room: Tallahassee	**Session 4B**: Nonlinear interactions **Chair**: G. Kennedy- Room: Richmond
10:00 AM	10:30 AM	*Flow Control By Passive Interfacing With Phononic Materials* **M. Hussein** – University of Colorado Boulder	*Non-reciprocal Acoustic Systems with Nonlinear Hierarchical Internal Structure and Asymmetry* **A. Vakakis** – University of Illinois UC
10:30 AM	11:00 AM	*Non-Reciprocal Wave Phenomena Through Pump-Signal Wave Interaction In Discrete And Continuous Systems* **M. Haberman** – University of Texas at Austin	*Meta-Structures: Novel Devices and Reciprocity Breaking* **M. Leamy** – Georgia Tech
11:00 AM	11:15 AM	**DISCUSSION**	
11:15 AM	11:30 AM	**BREAK**	
11:30 AM	12:00 AM	*Electro-Chemo-Mechanical Meta-Materials For Energy Storage. Harnessing Buckling For Improved Electrochemical Performance* **C. Di Leo** – Georgia Tech	*Dynamic Behavior of Elastomeric Metastructures and Metamaterials Subjected to Shock and Vibration* **R. Harne** – Ohio State University
12:00 AM	12:30 AM	*Stress- and Temperature-Induced Phase Transformation in Architectured Metastructures* **N. Mankame** – General Motors	*Toward Active Piezoelectric Metastructures For Programmable Tasks And Information Processing* **A . Erturk** – Georgia Tech
12:30 AM	2:00 PM	**LUNCH BREAK**	
2:00 PM	3:30 PM	BREAK OUTS Room: Tallahassee	
3:30 PM	4:00 PM	**DISCUSSION**	
	4:00 PM	**ADJOURN**	

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