NASA STTR 2020 Phase I Solicitation

T8.04 Metamaterials and Metasurfaces Technology for Remote Sensing Applications

Lead Center: GSFC

Participating Center(s): JPL

Technology Area: TA8 Science Instruments, Observatories & Sensor Systems

Scope Title
Research and Development Opportunities for Metamaterials

Scope Description

Metamaterials are man-made (synthesized) composite materials whose electromagnetic, acoustic, optical, etc. properties are determined by their constitutive structural materials and their configurations. Metamaterials can be precisely tailored to manipulate electromagnetic waves, including visible light, microwaves, and other parts of the spectrum, in ways that no natural materials can. The development of metamaterials continues to redefine the boundaries of materials science. In the field of electromagnetic research and beyond, these materials offer excellent design flexibility with their customized properties and their tunability under external stimuli. These properties enable Metamaterials to be a game changer for many technologies needing reduced size, weight, and power (SWaP), enhanced tunability and reconfigurability. Topics of interest for NASA's applications are listed below.

1. Beam shaping with metamaterials (at optical as well as microwave wavelengths).
2. Control of emission and absorption with metamaterials (for applications such as tunable lenses).
3. Engineering mid-infrared and optical nonlinearities with metamaterials.
4. Development of microwave and millimeter-wave metamaterials: radar scanning systems, flat panel antennas, mobile communication antennas, novel magnetic materials and high-performance absorbing and shielding materials for electromagnetic compatibility (EMC) and reduction of radio frequency interference (RFI).
5. Thin-film technology incorporated with metamaterial nanocomposites to collect light from wide angles and absorption over wide spectrum.
6. Tunable, reconfigurable metamaterials using liquid crystal medium (Applications: IR and Optical spectrometers).
7. Development of artificial ferrites and artificial dielectrics using metamaterial concepts to design electrically small, lightweight, and efficient RF components.
8. Transformation electromagnetic techniques with advances in fabricating metamaterials (Applications: microwaves and infrared wavelength sensors).

Expected TRL or TRL range at completion of the project: 1 to 3

Desired Deliverables of Phase II

Prototype, Analysis, Hardware, Research

Desired Deliverables Description

It is expected at the end of year one for selected teams to provide a comprehensive feasibility study to address an applicable area of interest within the field of metamaterial technology. Deliverables in subsequent years could involve prototypes and demonstration of performance.

State of the Art and Critical Gaps

Metamaterial research is interdisciplinary and involves such fields as electrical engineering, electromagnetics, classical optics, solid state physics, microwave and antenna engineering, optoelectronics, material sciences, as well as nanoscience and semiconductor engineering.
Potential applications of metamaterials are diverse and include: optical filters, remote aerospace applications, sensor detection, radomes, and lenses for high-gain antennas. Metamaterials also offer the potential to create superlenses, which could allow imaging below the diffraction limit that is the minimum resolution that can be achieved by conventional glass lenses. Transformation optics is a technique that simplifies the modeling of optical devices by altering the coordinate system to control the trajectories of light rays. At microwave frequencies, the first, imperfect invisibility cloak was realized in 2006.

Relevance / Science Traceability

Metamaterial technology has the biggest potential to impact the future of space borne instrumentation by reducing size, weight, and power (SWaP) as well as the overall cost of future space missions. There is especially a need for these improved capabilities in the development of instruments for Planetary and the Earth Science missions to reduce their cost. Due to the nature of metamaterials, there are a multitude of possible applications for this technology. For example, applications of metamaterials for remote sensing include tunability, complex filtering, light channeling/trapping, superbeaming, and determination of optical angular momentum modes via metamaterials. For additional information regarding Science Mission Directorate (SMD) technology needs, please review https://science.nasa.gov/about-us/science-strategy/decadal-surveys.

References

www.centerformetamaterials.org/

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