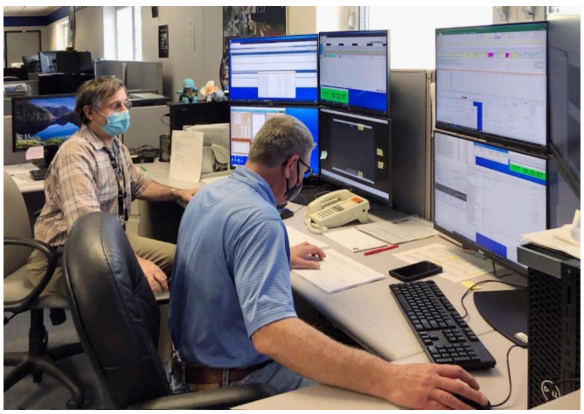
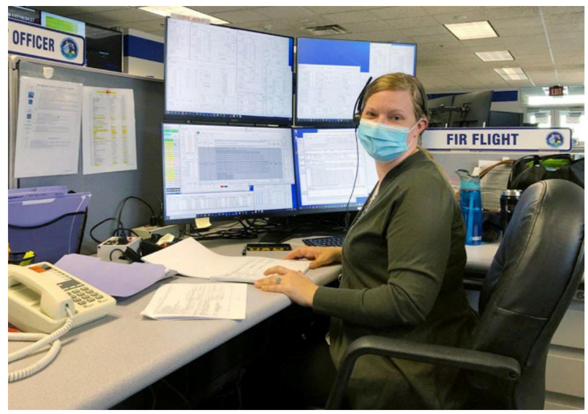
Advanced Colloids Experiments (ACE)

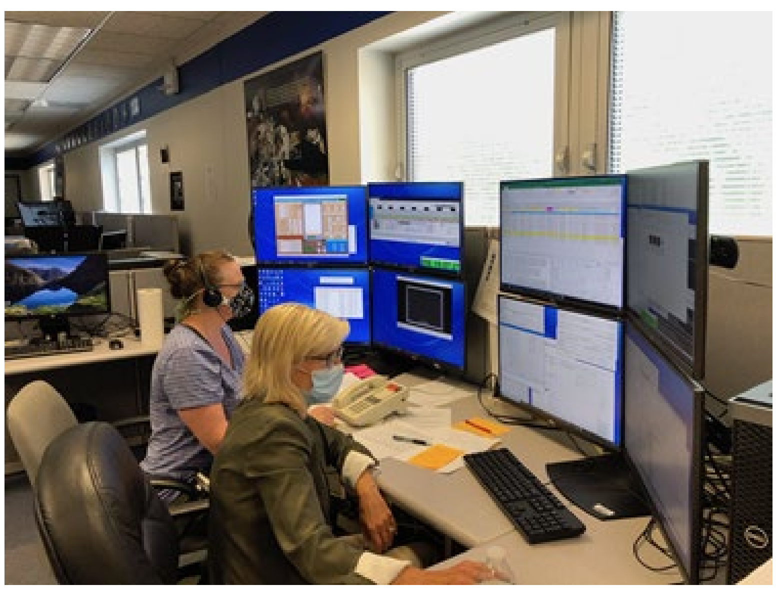
To remove gravitational jamming and sedimentation so that it is possible to observe how order arises out of disorder and to learn to control this process. Small colloidal particles can be used to model atomic systems and to engineer new systems. Colloids are big enough (in comparison to atoms) to be seen and big enough and consequently slow enough that their evolution can be recorded with a camera. With a confocal microscope, templates and grids, we can observe this process in 3-d and learn to control it.



Louis Chestney & Tibor Lorik (l-r), ZIN Technologies, starting ACE-T2-3 science Operations at the GIPOC.



Sarah Czerwien, ZIN Technologies, Data Management Officer, ACE-T2-3



Mission Operations at the GRC TSC for the ACE-T4-2 Experiment.
Amber Krauss and Cathy Frey, ZIN Technologies

Recent article about FIR/LMM/ACE

[International Space Station Research on Tiny Colloid Particles Yields Big Results]()

ACE-H

ACE-H-1

(Advanced Colloids Experiment-Heated-1)

The Advanced Colloids Experiment-Heated-1 (ACE-H-1) experiment examines densely packed microscopic spheres, or colloidal mixtures, to study their transition from ordered crystals into disordered glass. The particles are fluorescent and change size in different temperatures, so scientists are able to see how they move and change forms as they are heated and cooled. Studying particle interactions without the influence of gravity improves the ability of scientists to understand how increasing disorder in a crystal material affects its freezing, melting, aging and structural integrity.

Principal Investigator(s)

- Arjun Yodh, Ph.D., *University of Pennsylvania, Philadelphia, Pennsylvania, United States*

Co-Investigator(s)/Collaborator(s)

- Mathew Lohr, *University of Pennsylvania, Philadelphia, Pennsylvania, United States*
- Matthew Gratale, Ph.D., *University of Pennsylvania, Philadelphia, Pennsylvania, United States*

ACE-H-2

(Advanced Colloids Experiment-Heated-2)

Small particles suspended in a mixture, known as colloids, can combine to form complex structures and be used in new advanced materials. Colloids are found in a wide range of foods and consumer products, but they can also include particles with unique surface chemistry or electrostatic properties that allow them bind to each other in various ways. The Advanced Colloids Experiment-H-2 (ACE-H-2) investigation studies a technique called nanoparticle haloing, which stabilizes colloidal mixtures and may be important for designing advanced materials for use in medicine, imaging and other fields.

Principal Investigator(s)

- Stuart K. Williams, Ph.D., *The University of Arizona, Tucson, Arizona, United States*
- Suzanne Smith, Ph.D., *University of Kentucky, Lexington, Kentucky, United States*

Co-Investigator(s)/Collaborator(s)

- Gerold Willing, Ph.D., *University of Louisville, Louisville, Kentucky, United States*
- Hemali Rathnayake, Ph.D., *Western Kentucky University, Bowling Green, Kentucky, United States*

ACE-M

ACE-M-1

(Advanced Colloids Experiment-Microscopy-1)

Advanced Colloids Experiment-Microscopy-1 (ACE-M-1) studies the behavior of microscopic particles in gels and creams. Many consumer products are colloidal mixtures with stabilizers added to make them last longer. But eventually, particles still clump together and sink to the bottom in a process known as coarsening which can spoil a product. The International Space Station is an ideal location to study the physics of coarsening which could lead to manufacturing longer lasting products.

Principal Investigator(s)

- Matthew Lynch, Ph.D., *Procter and Gamble, West Chester, Ohio, United States*
- Thomas Kodger, *Harvard University, Cambridge, Massachusetts, United States*

ACE-M-2

(Advanced Colloids Experiment-Microscopy-2)

Sometimes it's hard to tell a gas from a liquid. Advanced Colloids Experiment-Microscopy-2 (ACE-M-2) observes the microscopic behavior of liquids and gases separating from each other. The investigation examines the behavior of model (colloid rich) liquids and model (colloid poor) gases near the critical point, or the point at which there is no distinct boundary between the two phases. ACE-M-2 uses a new microscope to record micro-scale events on short time scales, while previous experiments observed large-scale behavior over many weeks. Liquids and gases of the same material usually have different densities, so they would behave differently under the influence of gravity, making the microgravity environment of the International Space Station ideal for these experiments.

Principal Investigator(s)

- David A. Weitz, Ph.D., *Harvard University, Cambridge, Massachusetts, United States*

Co-Investigator(s)/Collaborator(s)

- Peter J Lu, Ph.D., *Harvard University, Cambridge, Massachusetts, United States*

ACE-M-3

(Advanced Colloids Experiment-Microscopy-3)

The ACE-M-3 experiment involves the design and assembly of complex three-dimensional structures from small particles suspended within a fluid medium. These so-called "self-assembled colloidal structures", are vital to the design of advanced optical materials. In the microgravity environment, insight will be provided into the relation between particle shape, crystal symmetry, and structure: a fundamental issue in condensed matter science.

Principal Investigator(s)

- Paul M. Chaikin, Ph.D., *New York University, New York City, New York, United States*

Co-Investigator(s)/Collaborator(s)

- Stefano Sacanna, Ph.D., *New York University, New York, New York, United State*s
- Andrew D. Hollingsworth, Ph.D., *New York University, New York City, New York, United States*

ACE-T

ACE-T-1

(Advanced Colloids Experiment-Temperature control-1)

Advanced Colloids Experiment-Temperature control-1 (ACE-T-1) studies tiny suspended particles which have been designed by scientists to connect themselves in a specific way to form organized structures within water. Materials having complex structures and unique properties potentially can be made with more knowledge of how these particles are joined together and the conditions which control their behaviors. The particular type of particles used in ACE-T-1 are referred to as Janus particles, named after the two faced Roman god Janus because these particles may be said to have "two faces" since they possess two distinct types of properties. The Janus particles being studied have one half of their surface composed of hydrophilic groups (which interact with water) and the other half of hydrophobic groups (which are repelled from water). The microgravity environment on the International Space Station (ISS) provides researchers insight into the fundamental physics of micro particle self-assembly and the kinds of colloidal structures that are possible to fabricate. This in turn helps manufacturers on Earth in choosing which high-value material is worth investigating.

Principal Investigator(s)

- Chang-Soo Lee, Ph.D., *Chungnam National University, Daejeon, South Korea*

ACE-T-2

(Advanced Colloids Experiment-Temperature-2)

The Advanced Colloids Experiment-Temperature-2 (ACE-T-2) experiment looks at the assembly of complex structures from micron-scale colloidal particles interacting via tunable attractive interactions. The samples contain suspensions of trifluoroethyl methacrylate (FEMA) colloidal particles (10%vol) of type A and B in binary solvents composed of water (H2O, 68%mass) and lutidine (32%mass), that upon nearing the critical solvent temperature (Tc~32°C) give rise to critical Casimir interactions between the particles. Regulating the temperature enables control of the particle interactions, which for these mixtures of particles A and B are different, leading to the growth of complex structures, and provide a better understanding of how complex interactions lead to complex structures, and to understand the dynamics of growth of these structures.

Principal Investigator(s)

- Peter Schall, Ph.D., *University of Amsterdam, Institute of Physics, Amsterdam, Netherlands*

Co-Investigator(s)/Collaborator(s)

- Gerard Wegdam, Ph.D., *University of Amsterdam, Institute of Physics, Amsterdam, Netherlands*
- Simon Stuij, *University of Amsterdam, Institute of Physics, Amsterdam, Netherlands*
- Piet Swinkels, *University of Amsterdam, Institute of Physics, Amsterdam, Netherlands*
- Marco A. C. Potenza, Ph.D., *University of Milan, Milan, Italy*

ACE-T-4

(Advanced Colloids Experiment-Temperature-4)

Introducing disorder to a crystalline system in a controlled way can form glass. Advanced Colloids Experiment-Temperature-4 (ACE-T-4) examines the transition of an ordered crystal to a disordered glass to determine how increasing disorder affects structural and dynamic properties. The investigation controls disorder by controlling temperature in a series of samples and observes the microscopic transition in three dimensions.

Principal Investigator(s)

- Arjun Yodh, Ph.D., *University of Pennsylvania, Philadelphia, Pennsylvania, United States*

Co-Investigator(s)/Collaborator(s)

- Chandan Mishra Kumar, *University of Pennsylvania, Philadelphia, Pennsylvania, United States*
- Xiaoguang Ma, *University of Pennsylvania, Philadelphia, Pennsylvania, United States*

ACE-T-5

(Advanced Colloids Experiment-Temperature-5)

Advanced Colloids Experiment-Temperature-5 (ACE-T-5) examines the physical and chemical characteristics of a new class of soft materials, bicontinuous interfacially jammed emulsion gels, or bijels. Bijels have a unique structure of two liquid phases separated by a layer of small particles or colloids, which has significant potential for the design and synthesis of composite materials. A more thorough understanding of the factors that influence their mechanical stability and processing will advance this potential.

https://www.youtube.com/embed/8VFwBv4Ikhc

ACE-T5 Video – Bijels for Improved Battery and Biomedical Applications

Principal Investigator(s)

- Ali Mohraz, Ph.D., *University of California, Irvine, Irvine, California, United States*

ACE-T-6

(Advanced Colloids Experiment-Temperature-6)

Colloids are suspensions of microscopic particles in a liquid, and they are found in products ranging from milk to fabric softener. Consumer products often use colloidal gels to distribute specialized ingredients, for instance droplets that soften fabrics, but the gels must serve two opposite purposes: they have to disperse the active ingredient so it can work, yet maintain an even distribution so the product does not spoil. Advanced Colloids Experiment-Temperature-6 (ACE-T-6) studies the microscopic behavior of colloids in gels and creams, providing new insight into fundamental interactions that can improve product shelf life.

Principal Investigator(s)

- Matthew Lynch, Ph.D., *Procter and Gamble, West Chester, Ohio, United States*

Co-Investigator(s)/Collaborator(s)

- Thomas Kodger, *Harvard University, Cambridge, Massachusetts, United States*

ACE-T-7

(Advanced Colloids Experiment-Temperature-7)

The Advanced Colloids Experiment-Temperature-7 (ACE-T-7) experiment involves the design and assembly of complex three-dimensional structures from small particles suspended within a fluid medium. These so-called "self-assembled colloidal structures", are vital to the design of advanced optical materials and active devices. In the microgravity environment, insight is provided into the relation between particle shape and interparticle interactions on assembly structure and dynamics: fundamental issues in condensed matter science.

Principal Investigator(s)

- Paul M. Chaikin, Ph.D., *New York University, New York City, New York, United States*

Co-Investigator(s)/Collaborator(s)

- Andrew D. Hollingsworth, Ph.D., *New York University, New York City, New York, United States*
- Stefano Sacanna, Ph.D., *New York University, New York, New York, United States*

ACE-T-9

(Advanced Imaging, Folding, and Assembly of Colloidal Molecules)

The Advanced Imaging, Folding, and Assembly of Colloidal Molecules (ACE-T-9) experiment involves the imaging, folding, and assembly of complex colloidal molecules within a fluid medium. This set of experiments not only prepares for future colloidal studies, but also provides insight into the relationship between particle shape, colloidal interaction, and structure. These so-called "colloidal molecules" are vital to the design of new and more stable product mixtures.

Principal Investigator(s)

- David Marr, Ph.D., *Colorado School of Mines, Golden, Colorado, United States*

Co-Investigator(s)/Collaborator(s)

- Ning Wu, Ph.D., *Colorado School of Mines, Golden, Colorado, United States*
- Michael Solomon, Ph.D., *University of Michigan, Ann Arbor, Michigan, United States*

ACE-T-10

(Advanced Colloidal Experiment-Temperature-10)

Advanced Colloids Experiment-Temperature-10 (ACE-T-10) investigates the growth kinetics, microscopic dynamics, and restructuring processes in ordered and disordered structures such as colloidal crystals, glasses and gels. The investigation studies crystal nucleation in colloidal fluids, the origin of ageing in glasses and gels, as well as the heterogeneous nature of the microscopic dynamics in these structures. The study must be conducted in microgravity, as gravitational stresses affect the structure and growth of these solids from colloids.

Principal Investigator(s)

- Roberto Piazza, Ph.D., *Politecnico di Milano, Milano, Italy*

Co-Investigator(s)/Collaborator(s)

- Luca Cipelletti, Ph.D., *Universite Monpellier II, Montpellier, France*
- Stefano Buzzaccaro, Ph.D., *Politecnico di Milano, Milano, Italy*

ACE-T-11

(Advanced Colloids Experiment-Temperature Control and Gradient Sample-11)

Advanced Colloids Experiment-Temperature Control and Gradient Sample-11 (ACE-T-11) involves the design and assembly of complex three-dimensional (3D) structures from colloids, or small particles suspended within a fluid medium, and control of particle density and phase behavior. Such structures are vital to the design of advanced optical materials and important for 3D printing and additive manufacturing. Assembling structures in microgravity provides insight into the relation between particle shape, crystal symmetry, density, and other fundamental factors.

Principal Investigator(s)

- Boris Khusid, Ph.D., *New Jersey Institute of Technology, Newark, New Jersey, United States*

Co-Investigator(s)/Collaborator(s)

- Paul M. Chaikin, Ph.D., *New York University, New York City, New York, United States*
- Andrew D. Hollingsworth, Ph.D., *New York University, New York City, New York, United States*

ACE-T-12

(Advanced Colloids Experiment-Nanoparticle Haloing)

Advanced Colloids Experiment-Nanoparticle Haloing (ACE-T-12) involves design and assembly of complex three-dimensional (3D) structures from colloids, or particles of different sizes suspended in a fluid. It employs a recently discovered technique, Nanoparticle Haloing (NPH), which uses highly charged nanoparticles to stabilize much larger, non-charged particles. Allowing these structures to form in microgravity provides insight into the relationship between shape, surface charge, and concentration of particles and particle interactions.

Principal Investigator(s)

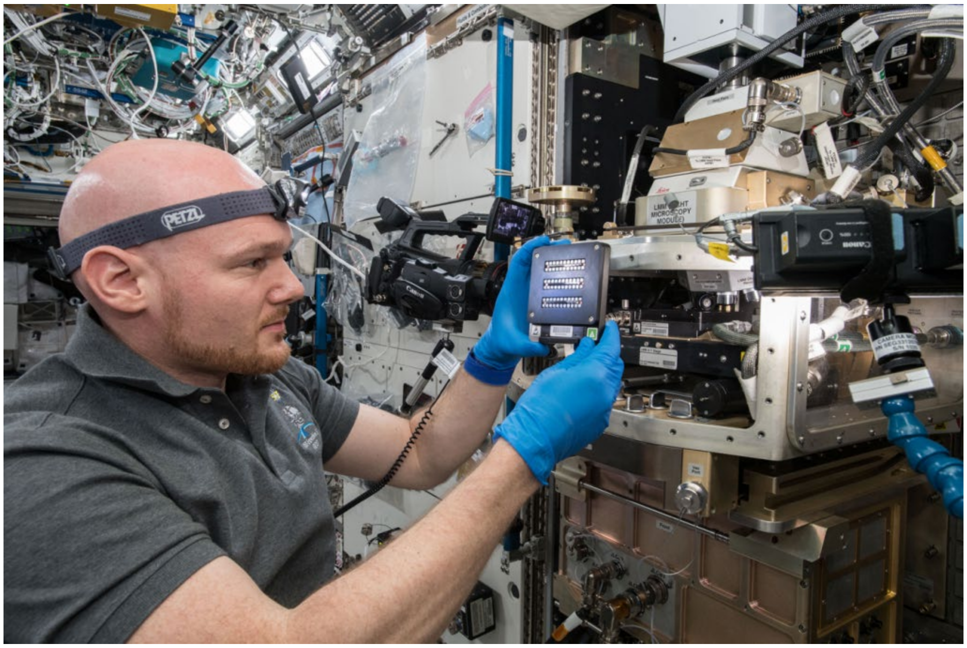
- Stuart J. Williams, Ph.D., *University of Louisville, Louisville, Kentucky, United States*
- Suzanne Smith, Ph.D., *University of Kentucky, Lexington, Kentucky, United States*

Co-Investigator(s)/Collaborator(s)

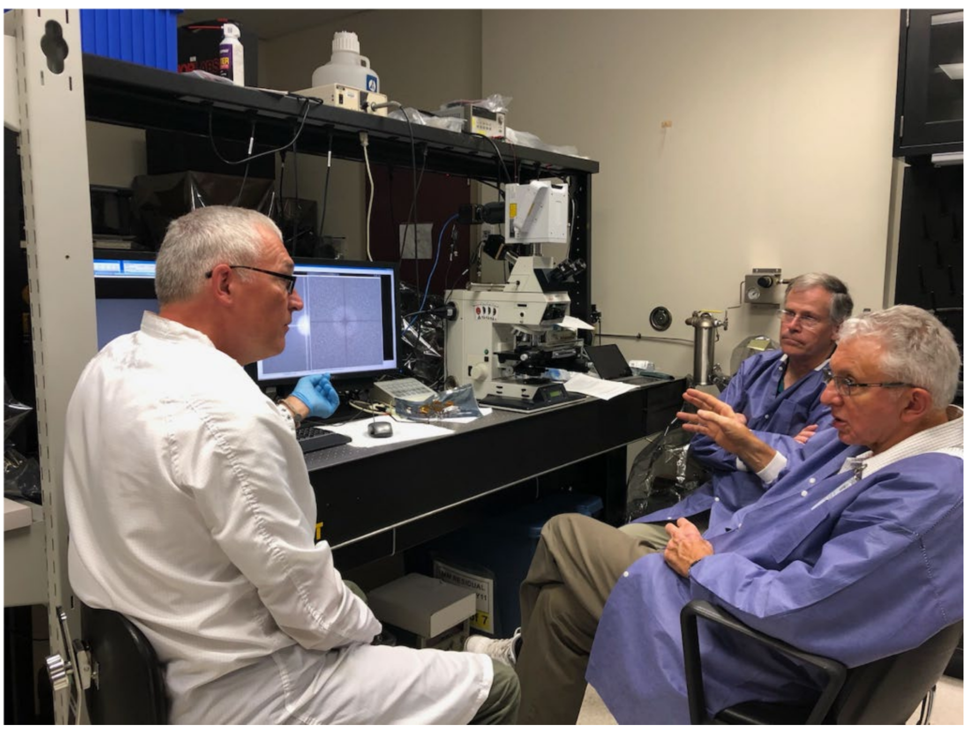
- Gerold Willing, Ph.D., *University of Louisville, Louisville, Kentucky, United States*

Image Gallery

Kate Rubins installing ACE-T sample module on ISS



European Space Agency (ESA) astronaut Alexander Gerst holds up an ACE cartridge as he configures the Light Microscopy Module (LMM) for Advanced Colloids Experiment-Temperature-7 (ACE-T-7).



Chris Lant (Zin Technologies), Boris Khusid (NJIT) and Andy Hollingsworth (NYU) during Grounding testing of ACE-T-11 flight samples, August 5-6, 2019

Mike Kardohly, Louis Chestney (ZIN Technologies), Professor Ali Mohraz, Herman Ching (UC-Irvine), Andrea Marchica (NASA). ACE-T5 Experiment Site visit and ground simulation with Science Team from the University of California-Irvine, August 13-14, 2019.

Mike Kardohly, Louis Chestney (ZIN Technologies), Professor Ali Mohraz, Herman Ching (UC-Irvine), Andrea Marchica (NASA). ACE-T5 Experiment Site visit and ground simulation with Science Team from the University of California-Irvine, August 13-14, 2019.

Matt Lorik (ZIN Technologies) and Stefano Buzzaccaro University of Milan, Italy

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Contact Information

Principal Investigator Team:

- Dr. Paul Chaikin, *New York University, New York City, New York, United States*
- Dr. David Weitz, *Harvard University, Cambridge, Massachusetts, United States*
- Dr. Arjun Yodh, *University of Pennsylvania, Philadelphia, Pennsylvania, United States*
- Dr. Matthew Lynch, *Procter and Gamble, West Chester, Ohio, United States*
- Dr. David Marr, *Colorado School of Mines, Golden, Colorado, United States*

Co-Investigators:

- Dr. Michael Solomon, *University of Michigan, Ann Arbor, Michigan, United States*
- Dr. Ali Mohraz, *University of California, Irvine, Irvine, California, United States*
- Dr. Stefano Buzzaccaro, *Politecnico di Milano, Milano, Italy*
- Dr. Roberto Piazza, *Politecnico di Milano, Milano, Italy*
- Dr. Luca Cipelletti, *Universite Monpellier II, Montpellier, France*
- Dr. Peter Schall, *University of Amsterdam, Institute of Physics, Amsterdam, Netherlands*
- Dr. Marco Potenza, *University of Milan, Milan, Italy*
- Dr. Chang-Soo Lee, *Chungnam National University, Daejeon, South Korea*

Project Manager: Ronald Sicker, NASA GRC

Project Scientist: William V. Meyer/USRA; Dave Chao/LTZ

Engineering Lead: Mike Bohurjak, ZIN Technologies, Inc.