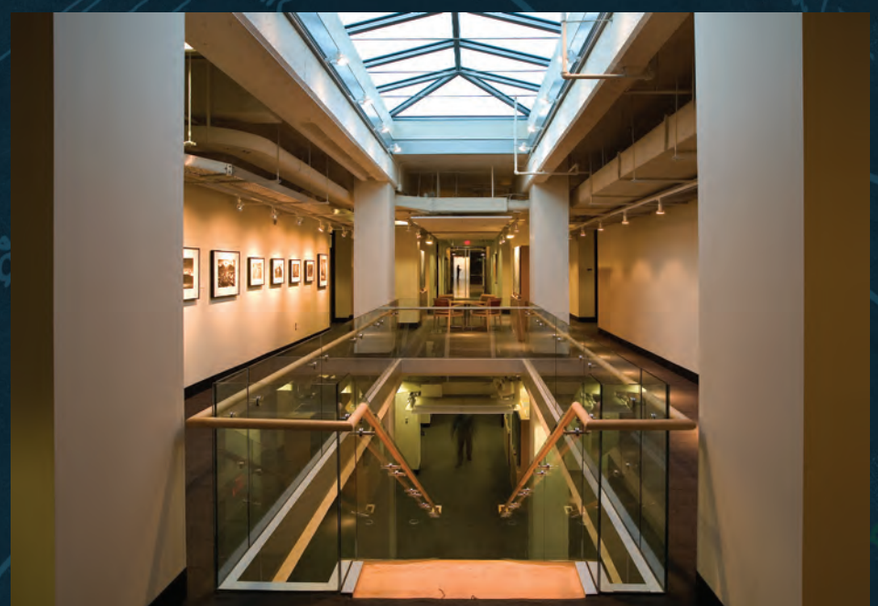
# CTP$^{50}$

## The Center for Theoretical Physics: The First 50 Years


Massachusetts Institute of Technology

Saturday, March 24, 2018



## SPEAKERS

**Andrew Childs**, Co-Director of the Joint Center for Quantum Information and Computer Science and Professor of Computer Science, University of Maryland

**Will Detmold**, Associate Professor of Physics, Center for Theoretical Physics

**Henriette Elvang**, Professor of Physics, University of Michigan, Ann Arbor

**Alan Guth**, Victor Weisskopf Professor of Physics, Center for Theoretical Physics

**Daniel Harlow**, Assistant Professor of Physics, Center for Theoretical Physics

**Aram Harrow**, Associate Professor of Physics, Center for Theoretical Physics

**David Kaiser**, Germeshausen Professor of the History of Science and Professor of Physics

**Chung-Pei Ma**, J. C. Webb Professor of Astronomy and Physics, University of California, Berkeley

**Lisa Randall**, Frank B. Baird, Jr. Professor of Science, Harvard University

**Sanjay Reddy**, Professor of Physics, Institute for Nuclear Theory, University of Washington

**Tracy Slatyer**, Jerrold Zacharias CD Assistant Professor of Physics, Center for Theoretical Physics

**Dam Son**, University Professor, University of Chicago

**Jesse Thaler**, Associate Professor, Center for Theoretical Physics

**David Tong**, Professor of Theoretical Physics, University of Cambridge, England and Trinity College Fellow

**Frank Wilczek**, Herman Feshbach Professor of Physics, Center for Theoretical Physics and 2004 Nobel Laureate

## SCHEDULE

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|---|---|
| 9:00 | Welcomes and Introductions |
| 9:15 | Andrew Childs |
| 9:45 | Henriette Elvang |
| 10:15 | Video |
| 10:20 | Coffee Break |
| 10:45 | Frank Wilczek |
| 11:15 | Dam Son |
| 11:45 | Sanjay Reddy |
| 12:15 | Video |
| 12:20 | Lunch in the CTP |
| 1:30 | Welcome from Bolek |
| 1:40 | David Kaiser |
| 2:10 | Video |
| 2:15 | Lisa Randall |
| 2:45 | David Tong |
| 3:15 | Coffee break |
| 3:45 | Chung-Pei Ma |
| 4:15 | Alan Guth |
| 4:45 | Video |
| 4:50 | Panel Discussion |


## SPEAKERS AND ABSTRACTS

**Andrew Childs**, Co-Director of the Joint Center for Quantum Information and Computer Science and Professor of Computer Science, University of Maryland

**Algorithmic Challenges in Quantum Simulation**

Abstract: Simulating the dynamics of quantum systems is a difficult problem for classical computers. The prospect of solving this problem efficiently with an inherently quantum device provided the original motivation for the idea of a quantum computer and remains one of their most compelling potential applications. In this talk, I will describe some computational challenges that led to new algorithmic ideas for quantum simulation. I will also discuss the prospects for performing quantum simulation with early quantum computers.

**Henriette Elvang**, Professor of Physics, University of Michigan, Ann Arbor

**New Approaches to Effective Field Theories**

Abstract: Traditionally physicists start with a theory or model and deduce from it the physical consequences, such as the scattering amplitudes that encode the probabilities of scattering events at collider experiments. Recent years have seen tremendous progress in novel techniques for calculating scattering amplitudes using methods more efficient than Feynman diagrams and this has resulted in new exciting connections to mathematics. In this talk I will discuss
reversing the logic of this approach, namely how we can restrict the possible classes of theories with certain properties using the physical and analytical structure of the amplitudes. In particular, I will discuss applications to low-energy effective theories that arise from spontaneous symmetry breaking.

**Alan Guth**, Victor Weisskopf Professor of Physics, Center for Theoretical Physics

**The Cosmic Bell Experiment: Using Ancient Photons to Test Quantum Theory**

Abstract: Quantum theory tells us that we usually cannot predict the
outcomes of experiments, but instead only the probabilities of different outcomes. But we cannot completely rule out the possibility that there might be some underlying “hidden-variable” mechanism, as-yet undiscovered, which would be completely deterministic. The Cosmic Bell experiment is a test of quantum entanglement, Einstein’s “spooky action at a distance,” which makes use of some of the oldest light in the universe to address a loophole in previous experiments, making the existence of a hidden-variable mechanism more implausible than ever.

**David Kaiser**, Germeshausen Professor of the History of Science and Professor of Physics

**'It was Fifty Years Ago Today …': A Brief Look Back at Physics, MIT, and the World of 1968**
Abstract: MIT's Center for Theoretical Physics (CTP) celebrates its 50th anniversary this year. Though the CTP, like MIT generally, is a forward-looking place, it can be valuable on occasion to consider the curving paths that brought us to our present. What challenges did physicists focus on — or even recognize — half a century ago, and how did they think the new Center at MIT might further their goals? How did theoretical physicists at MIT and elsewhere think about their roles within broader society, and what surprises were in store?

**Chung-Pei Ma**, J. C. Webb Professor of Astronomy and Physics, University of California, Berkeley

**Supermassive Black Holes and Low-Frequency Gravitational Waves**
Supermassive black holes are a fundamental component of galaxies. Residing at the centers of galaxies, these black holes have masses up to 20 billion suns and directly impact the evolution of their host galaxies. I will describe recent progress in discovering new populations of massive black holes, and the implications for the theoretical understanding of the symbiotic relationships between black holes and galaxies. I will discuss the prospects for detecting low-frequency gravitational waves from merging binaries of supermassive black holes in the next decade.

**Sanjay Reddy**, Professor of Physics, Institute for Nuclear Theory, University of Washington

**The Ultimate Collision: Neutron Stars Rattle, Shine, and Spew Gold**
Abstract: Speculation that neutron star collisions produce short gamma-ray bursts, emit intense gravitational waves detectable out to cosmic distances, and synthesize heavy elements such as gold, platinum and uranium have been (largely) confirmed by a spectacular event: GW170817. Its multi-messenger observations, which marks the beginning of a new era in astronomy, provided detail that exceeded expectations. In my talk I will describe how theory, simulations and observations have transformed neutron stars from tiny curios to nature's heavy-metal rock stars. The physics of neutron stars and the astrophysics of their collisions, spans a wide range of length scales and its remarkable that we can model them. I will provide a brief summary of how nuclear physics, neutrinos, and properties of matter at extreme density shape neutron stars and their collisions.



**Dam Son**, University Professor, University of Chicago

**Fractional Quantum Hall Effect as a Window to New Field-theoretic Dualities**
Abstract: The fractional quantum Hall fluid is a paradigmatic topological state of matter. This fluid exhibits a new type of quasiparticle - the composite fermion. I will describe new theoretical developments under the name of the "Dirac composite fermion" theory, which has provided a simple solution to some puzzles that have vexed theorists for two decades, and led to testable experimental predictions. Surprisingly, this theory is also connected to developments in other fields of modern condensed matter physics and has stimulated the discovery of new dualities in quantum field theory.

**David Tong**, Professor of Theoretical Physics, University of Cambridge, England and Trinity College Fellow

**Dualities, Old and New**
Abstract: I'll explain how various ideas from condensed matter physics, high energy physics, and string theory have converged to give us a new, surprising insights into quantum field theory.

**Frank Wilczek**, Herman Feshbach Professor of Physics, Center for Theoretical Physics and 2004 Nobel Laureate

**Symmetries of Time**
Abstract: Time exhibits regularities that vastly simplify our picture of the world. Yet those regularities provide challenges and opportunities which are expanding the frontiers of physics today, leading us to propose new particles (axions) which could provide the cosmological dark matter, and new states of matter (time crystals) which may lead to new kinds of precision sensors. I will survey the past, present, and future of the symmetries of time.

**Panel Discussion Participants**
Will Detmold, Associate Professor of Physics, Center for Theoretical Physics
Daniel Harlow, Assistant Professor of Physics, Center for Theoretical Physics
Aram Harrow, Associate Professor of Physics, Center for Theoretical Physics
Lisa Randall, Frank B. Baird, Jr. Professor of Science, Harvard University
Tracy Slatyer, Jerrold Zacharias CD Assistant Professor of Physics, Center for Theoretical Physics
Jesse Thaler, Associate Professor, Center for Theoretical Physics

## HISTORY

The Center for Theoretical Physics (CTP) is a unified research and teaching center focused on fundamental physics. Founded in ??? by ???. CTP activities range from string theory and cosmology at the highest energies down through unification and beyond-the-standard-model physics, through the standard model, to QCD, hadrons, quark matter, and nuclei at the low energy scale.

Members of the CTP are also currently working on quantum computation and on energy policy. The breadth and depth of research in nuclear, particle, string, and gravitational physics at the CTP makes it a unique environment for researchers in these fields.


Kenneth Johnson


Felix Villars


Amihay Hanany


James Young


Charles Thorn

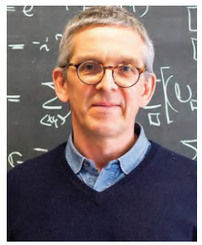

Aneesh Manohar


Ernest Moniz


John McGreevy


Janos Polonyi




Uwe-Jens JWiese


Allan Adams

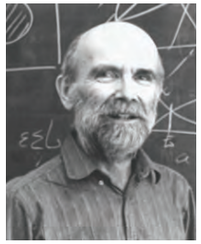

Charles Horowitz


Samir Mathur

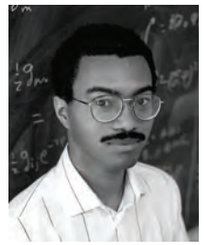

Sergio Fubini


Xiandong Ji


Roscoe Glles


Michel Baranger


Steven Weinberg


Roger Brooks


Nick Warner


Lisa Randall


Kerson Huang


Gabriele Veneziano


Carleton DeTar


Arthur Keman

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Frank Wilczek

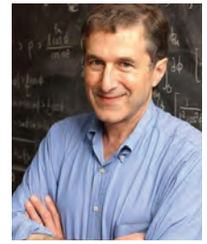
Jesse Thaler

Krishna Rajagopal

Jeffrey Goldstone

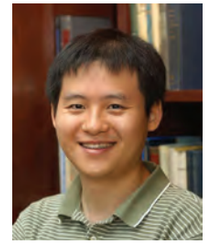
Daniel Harlow

Daniel Freedman



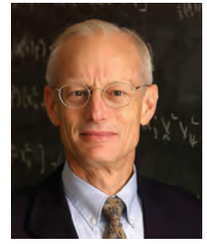
Robert Jaffe

Alan Guth

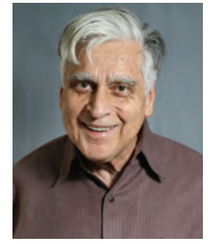


Hong Liu

Edward Farhi



John Negele

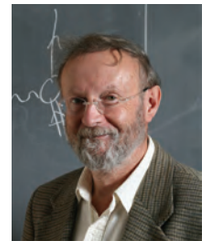


Earle Lomon

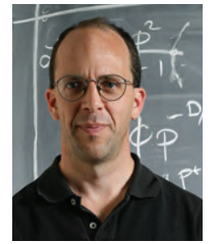
Aram Harrow

Barton Zwiebach

Tracy Slatyer

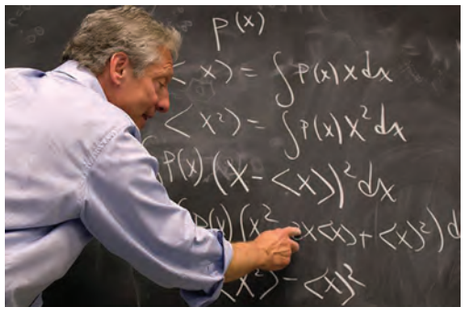


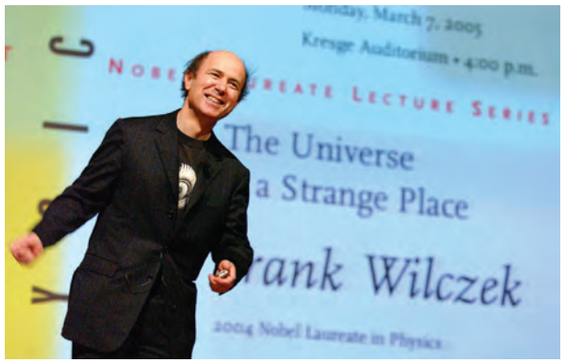
T. William Donnelly

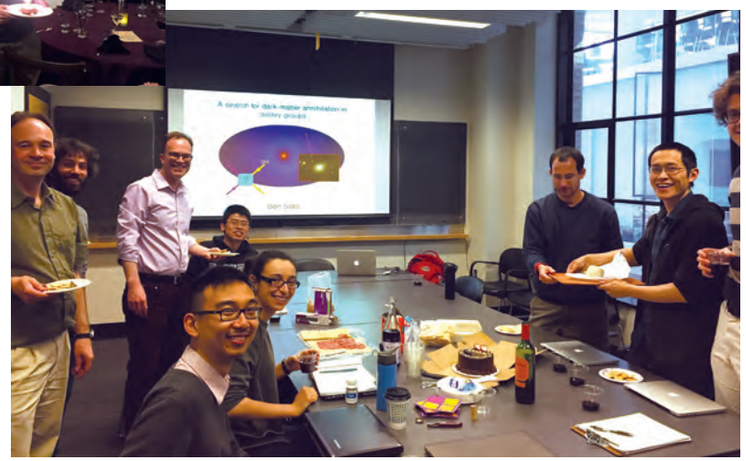


Washington Taylor

Roman Jackiw




Krouse Auditorium • 4:00 p.m.
The Universe
a Strange Place
2004 Nobel Laureate in Physics



## SPECIAL THANKS

We are grateful to The Dean of Science Office, The Department of Physics and the Laboratory for Nuclear Physics for their support for this event.

Thank you always to Virgil Elings whose generous gift helped make possible the new space that houses the Virgil Elings Center for Theoretical Physics

Thanks also to Jules Catering
Event Website, Program and Poster Photos: Peter Vanderwarker
Design: Christopher Dearborn, New Frontiers Design
Website and Program Layout: Charles Suggs

## SUPPORT

The Center for Theoretical Physics at MIT is supported by a combination of public funding from the US Department of Energy, the National Science Foundation and other organizations, and private funding from foundations and individuals.

Private funding plays an increasingly large role in supporting fundamental long-term research in theoretical physics. Contributions from organizations and individuals to the CTP and MIT's physics department play a key role in supporting the work and careers of outstanding young faculty, students and postdocs at the CTP.

For information about supporting the people and research activities at the CTP, please contact Erin McGrath at 617-452-2807 or emcgrath@MIT.edu or you may contribute directly at: http://ctp.lns.mit.edu/support.html

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