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

9:00	Introductions and Welcomes: Michael Sipser, Dean of Science; Peter Fisher, Physics Department Head
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	Introductions and Welcomes: Bolek Wyslouch, LNS Director; Washington Taylor, CTP Director
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: The Future of Theoretical Physics

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; former Pappalardo Fellow

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
Abstract: 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.

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

New Ideas About Dark Matter
Abstract: TBA

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 mark 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 it is 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; former Pappalardo 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

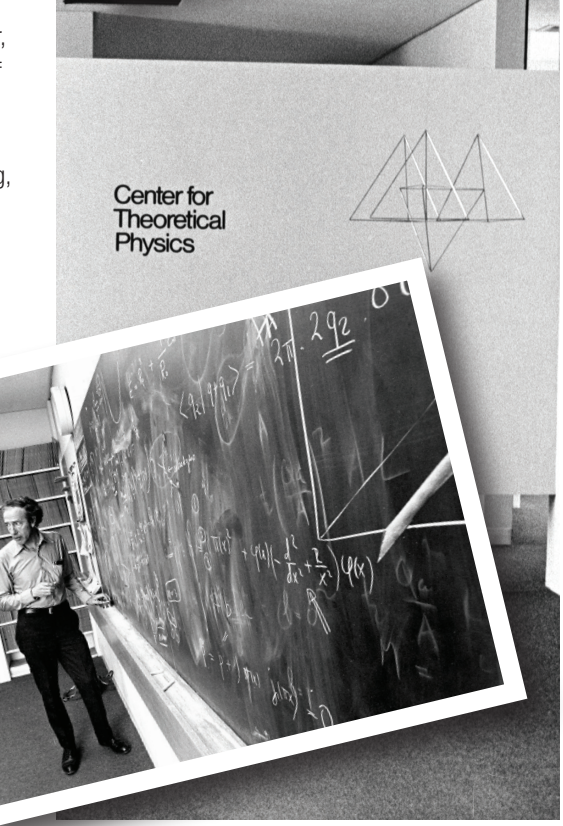
Symmetries of Time
Abstract: Time exhibits regularities that vastly simplify our picture of the world. Yet those regularities provide challenges and opportunities which are expanding the frontiers of physics today, leading us to propose new particles (axions) which could provide the cosmological dark 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.

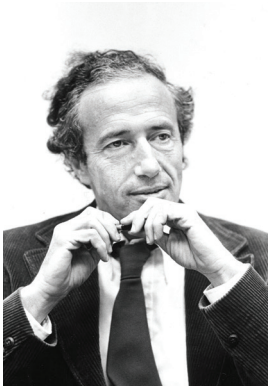
Panel Discussion Participants on The Future of Theoretical Physics
Will Detmold, Associate Professor of Physics, Center for Theoretical Physics
Daniel Harlow, Assistant Professor of Physics, Center for Theoretical Physics
Aram Harrow, Associate Professor of Physics, Center for Theoretical Physics
Tracy Slatyer, Jerrold Zacharias CD Assistant Professor of Physics, Center for Theoretical Physics
Jesse Thaler, Associate Professor of Physics, Center for Theoretical Physics

CTP 50

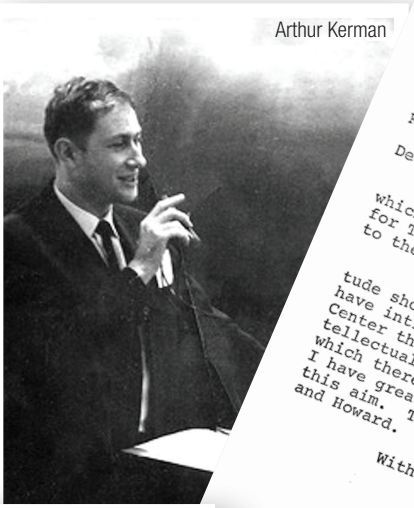
HISTORY

The Center for Theoretical Physics (CTP) is a unified research and teaching center focused on fundamental physics. The CTP was officially launched in March of 1968 as "a section of the Eastman Laboratories wing of the main MIT building, remodeled to provide an abundance of two essentials for scientists in this field– **blackboards and quiet**". 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.





Francis Low


Arthur Kerman

Provost Jerome Wiesner
Room 3-234, M.I.T.

December 1, 1967

Dear Jerry:

This is only to add a few words to the excellent letter which Herman Fesbach has written to you in regard to the Center for Theoretical Physics. I agree very much with his remarks as to the distribution of credits for the great success of the Center

Let me add that the main portion of thanks and gratitude should go to you Jerry and to the spirit which you and Howard have introduced into M.I.T. We will do what we can to make this Center the symbol of what M.I.T. should be, a place where intellectual activity of the highest degree is carried out and in which there is no place for mediocrity and for personal ambitions. I have great hopes that we will at least partially succeed in this aim. Things are really looking up at M.I.T. thanks to you and Howard.

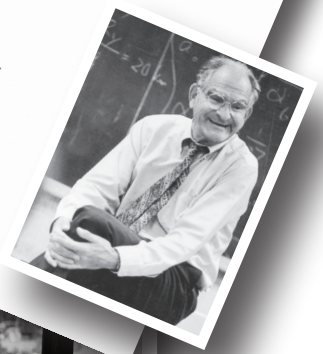
With best regards.

Yours sincerely,

Victor F. Weisskopf

VFW:mtd
cc: H. Feshbach
A. Hill
H. Johnson


Kenneth Johnson



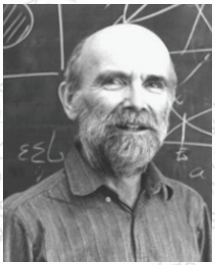

Felix Villars

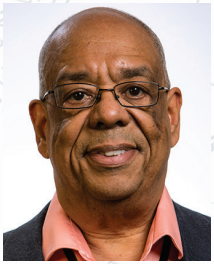
Directors of the Center for Theoretical Physics

Herman Feshbach (1968-1973)
Francis Low (1973-1976)
Arthur Kerman (1976-1983)
Jeffrey Goldstone (1983-1989)
John Negele (1989-1998)
Robert Jaffe (1998-2004)
Edward Farhi (2004-2016)
Washington Taylor (2016-)

Former CTP Faculty

Allan Adams
Michel Baranger
Roger Brooks
Carleton DeTar
Herman Feshbach
Sergio Fubini
Roscoe Giles
Amihay Hanany
Charles Horowitz
Kerson Huang
Xiangdong Ji
Kenneth Johnson
C. Edward Jones
Arthur Kerman
Francis Low
Samir Mathur
Aneesh Manohar
John McGreevy
Ernest Moniz
Janos Polonyi
Lisa Randall
Vigdor Teplitz
Charles Thorn
Gabriele Veneziano
Victor Weisskopf
Felix Villars
Nick Warner
Steven Weinberg
Uwe-Jens Wiese
James Young


Michel Baranger

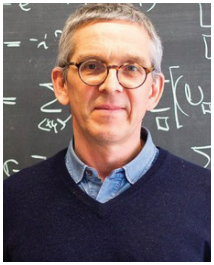

Roscoe Glles

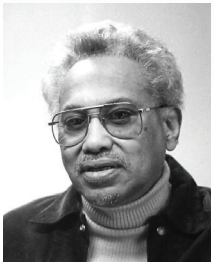

Kerson Huang


Aneesh Manohar


Ernest Moniz


Lisa Randall


Uwe-Jens Wiese

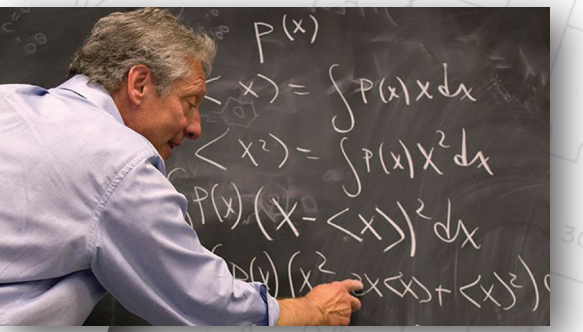

James Young

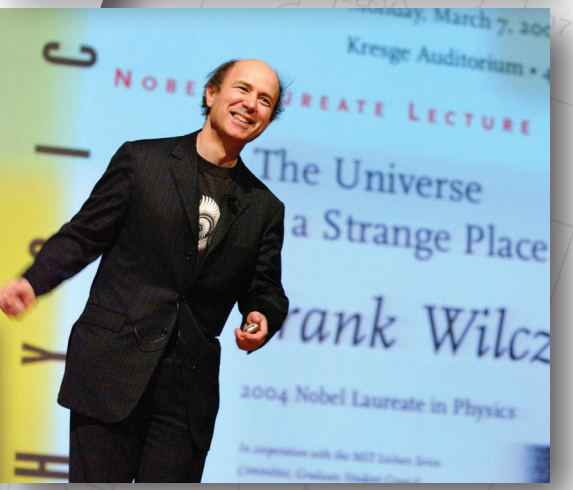

Gabriele Veneziano

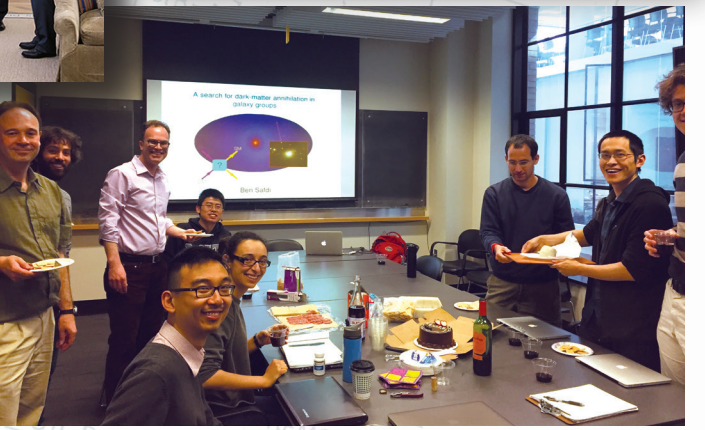

Steven Weinberg

Preamble

In the presentation below we shall propose th
formation of a "Center of Theoretical Physics" at M.I.T.
For the most part our discussion will focus upon the
activities present and future of the theoretical group
of the Laboratory for Nuclear Science. In the long
run a theoretical center cannot and should not be
restricted to the fields of nuclear and particle physics.
owever, at the present time, the L.N.S. theory group is
t only the major theoretical physics group within the
sics Department but also it has had an extensive program
ost-doctoral education and research in operation for
time. This activity forms the natural starting point
formation of a theoretical center. Other research
s can be included when the center is well established
funds become available for an expansion in s







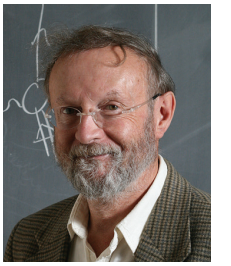
THE VIRGIL ELINGS CENTER FOR THEORETICAL PHYSICS IN THE GREEN CENTER FOR PHYSICS

After years of effort and with the generous support of our alumni and friends, the Virgil Elings Center for Theoretical Physics was dedicated in 2007 as part of the new Green Center for Physics. The design of the new CTP enhances the strong interactions among faculty, students and postdocs. The completion of the renovation also brought us close together with the Condensed Matter Theory Group for the first time, fostering closer research connections with our CMT colleagues. One of the chief goals of the renovation was to create many spaces for researchers to collaborate to further understand the nature of matter and energy, the dynamics of the cosmos and the rapidly expanding field of quantum computing. The architects and builders who designed and constructed this space have given us all an environment where CTP members are invigorated in their explorations.

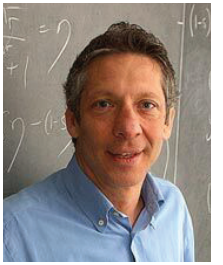
CURRENT FACULTY

The current CTP faculty, postdocs, students and staff carry the vision of its founders onward; discovering, nurturing, navigating and defining the future of theoretical physics — as our predecessors have done over its first fifty years.

William Detmold

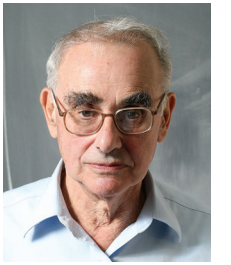


T. William Donnelly



Edward Farhi

Daniel Freedman



Jeffrey Goldstone


Alan Guth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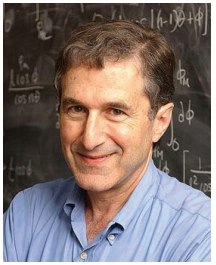
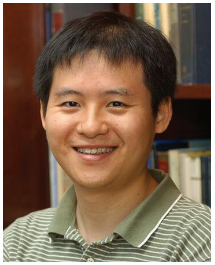
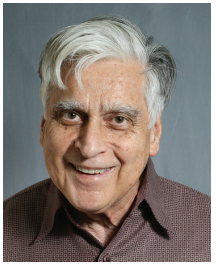
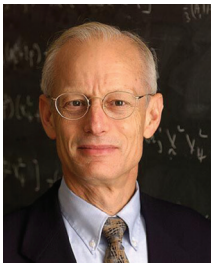

Robert Jaffe


David Kaiser


Roman Jackiw


Hong Liu

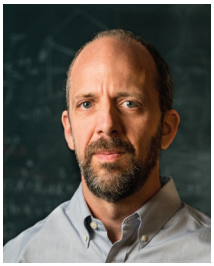

Earle Lomon


John Negele


Krishna Rajagopal


Tracy Slatyer


Iain Stewart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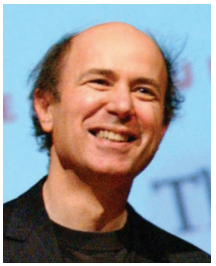
Frank Wilczek


Barton Zwiebach

SPECIAL THANKS

We are grateful to the Office of Science of the United States Department of Energy for their many decades of steadfast support.

We are immensely grateful to Virgil Elings, whose generous gift helped make possible the new space that houses the Virgil Elings Center for Theoretical Physics, and to Neil Pappalardo for his ongoing support of the Physics Department, the CTP, and MIT. Many thanks to all of our alumni and friends whose generosity supports the physics that we do.

We are also grateful to the School of Science, the Department of Physics and the Laboratory for Nuclear Physics for their support for this event.

CTP 50 Organizing Committee: Krishna Rajagopal (Chair), Robert Jaffe, David Kaiser, Richard Milner, Iain Stewart, Washington Taylor, Barton Zwiebach and, most important, Scott Morley whom we thank for his leadership in every aspect of the organization of this event.

Thanks also to Jules Catering
Event Website & Program Photos: Peter Vanderwarker,
Back Cover and Poster Photo: Adrianne Mathiowetz
Overall Event Design: Christopher Dearborn, New Frontiers Design
Website Layout: Charles Suggs
CTP50 Videos: Harry Bechkes, Bill Lattanzi, Joe McMaster, Lillie Paquette

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 long-term fundamental research in theoretical physics. Contributions from organizations and individuals to the CTP and to the MIT Department of Physics 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

Massachusetts Institute of Technology