The High Energy Theory group at UMass

From Particles to Gravity

Lorenzo Sorbo

Introduction to Research Symposium, 11/07/2011
People

Faculty

John Donoghue, Webpage, Brief research summary, Papers
Eugene Golowich, Webpage, Brief research summary, Papers
Barry Holstein, Webpage, Brief research summary, Papers
David Kastor, Webpage, Brief research summary, Papers
Lorenzo Sorbo, Webpage, Brief research summary, Papers
Jennie Traschen, Webpage, Brief research summary, Papers

Postdoc

Minjoon Park, Webpage, Brief research summary, Papers

Grad students

Ufuk Aydemir, Webpage, Papers
T.J. Blackburn, Webpage
Jessica Cook, Webpage, Papers
Basem El-Manoufi, Webpage
Benjamin Ett, Webpage, Papers
Max Lakin, Webpage
Jared Vanesse, Webpage
QCD controls strong interactions

At low (interesting) energies QCD is strongly coupled and very difficult to compute

Use tricks (such as new effective degrees of freedom, pions and hadrons) to make predictions.

Two main tools (the fundamental ones) in Quantum Field Theory: symmetries and a lot of calculations

with Ufuk Aydemir, Max Lakin
Strong interactions at low energies behave very differently from strong interactions at high energies
Still, we can learn many things without knowing all the details of the “full” theory
Can we apply the same tricks to other theories?
Gravity can be treated as an effective field theory
Symmetries play a fundamental role in QFT and in our understanding of the world

But are they really fundamental?

How can we use observations to constrain a possible breaking of “fundamental” symmetries?

with Ufuk Aydemir
Cosmology

The Universe as the largest, oldest particle physics experiment
↓
Accurate description of the evolution of the Universe from age=1 second to age=$1.4 \times 10^{10}$ years
↓
What happened during the first second? Inflation
↓
Main tools: intensive use of the rules of Quantum Field Theory (and symmetries) to make predictions and compare them to observations

with Jessica Cook, Ufuk Aydemir
The Universe is large - can be used to test behavior of theories at low energies

Could Einstein gravity be modified at very large distances?

Even just theoretically, very difficult task!
Black holes are the “fundamental particles” of gravity

↓

Useful to study General Relativity+quantum mechanics,
General Relativity+singularities

↓

Black hole thermodynamics

with Basem el-Manoufi, Ben Ett
GR is a beautiful, mathematically constrained theory

\[ \Downarrow \]

Integral constraints (i.e., relations between quantities defined on entire spacetime) can be proven

\[ \Downarrow \]

These constraints can be used to determine whether some phenomenon is allowed/forbidden

with *Basem el-Manoufi, Ben Ett*
Gravity in higher dimensions

David Kastor

More dimensions suggested by many unified theories
  ↓
GR in more than four dimensions is a richer theory
  (more than one “Newton’s constant”)
  ↓
Very rich black hole zoology - what is special about four dimensions?

with Ben Ett
Gravity in higher dimensions

Solution-generating techniques

Few exact solutions in GR

↓

New exact solutions useful

↓

Special effort to discover new solutions in theories of gravity in higher dimensions - relation of higher dimensional gravity with thermodynamics?

with Ben Ett
Gene Golowich

- Hadron Physics
- Physics Beyond the Standard Model
Barry Holstein

Hadron Physics

Effective Field Theories

Effective Field Theory of Gravity

with TJ Blackburn, Jared Vanasse