

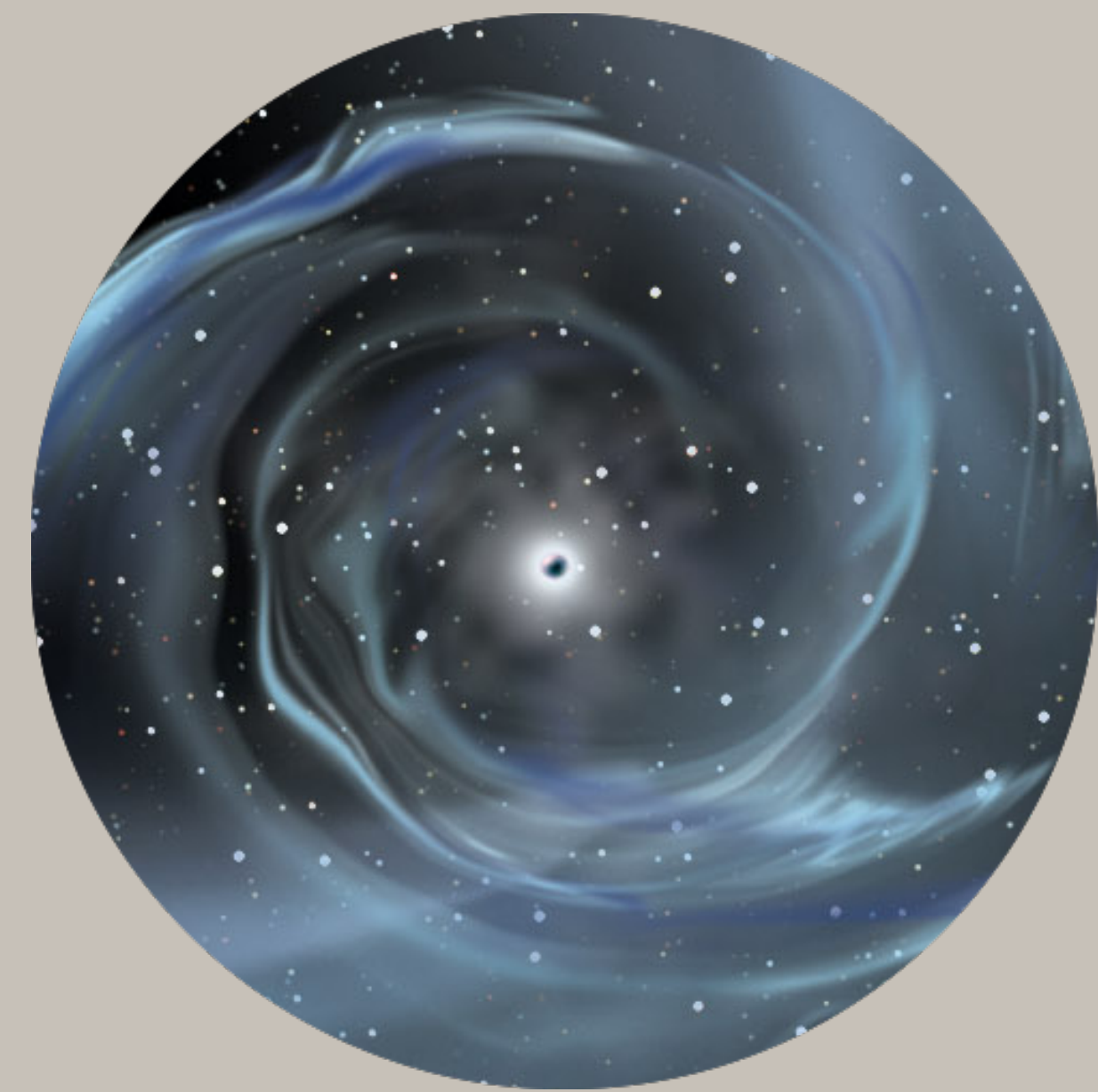


QMAP: Center for Quantum Mathematics and Physics



We seek to understand the wheels within wheels of our Universe.

This entails many different areas of research:

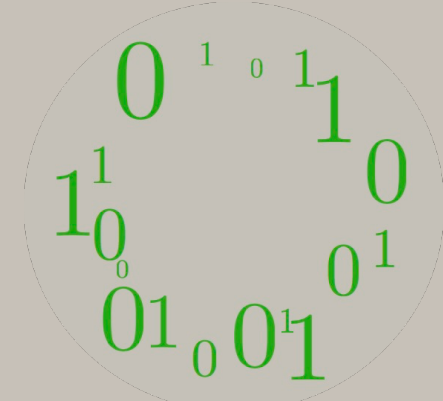


Black Holes & Cosmology:

- * Cosmology seeks to unravel the dynamics of our universe as a whole.
- * Black holes are fascinating astrophysical objects in our universe, but they are also much, much more:
- * Their mathematically elegant structure renders them powerful theoretical laboratories, through which we have uncovered many deep principles of nature.
- * Indeed, black holes may hold the key to Quantum Gravity.

Quest for Quantum Gravity:

- * Our world is quantum mechanical, but gravity does not fit into this paradigm.
- * We need to develop a complete and consistent quantum theory of gravity, which will allow us to answer such basic questions as:
 - * What is the underlying nature of spacetime? How does it emerge from a more fundamental description?
 - * For example, why do we see 3 spatial and 1 time dimension (at least on macroscopic scales)?
 - * How did the Universe originate, and what will be its ultimate fate?



Quantum Information:

- * Recent hint: spacetime emerges from quantum entanglement

String Theory:

- * Powerful framework describing a quantum theory that contains gravity as well as the other fundamental forces of nature. All particles and forces are manifested as excitations of a string.
- * This elegant structure provides a vast edifice in theoretical physics and mathematics, linking previously disconnected concepts and uncovering new ones. Much more still remains to be explored and understood!

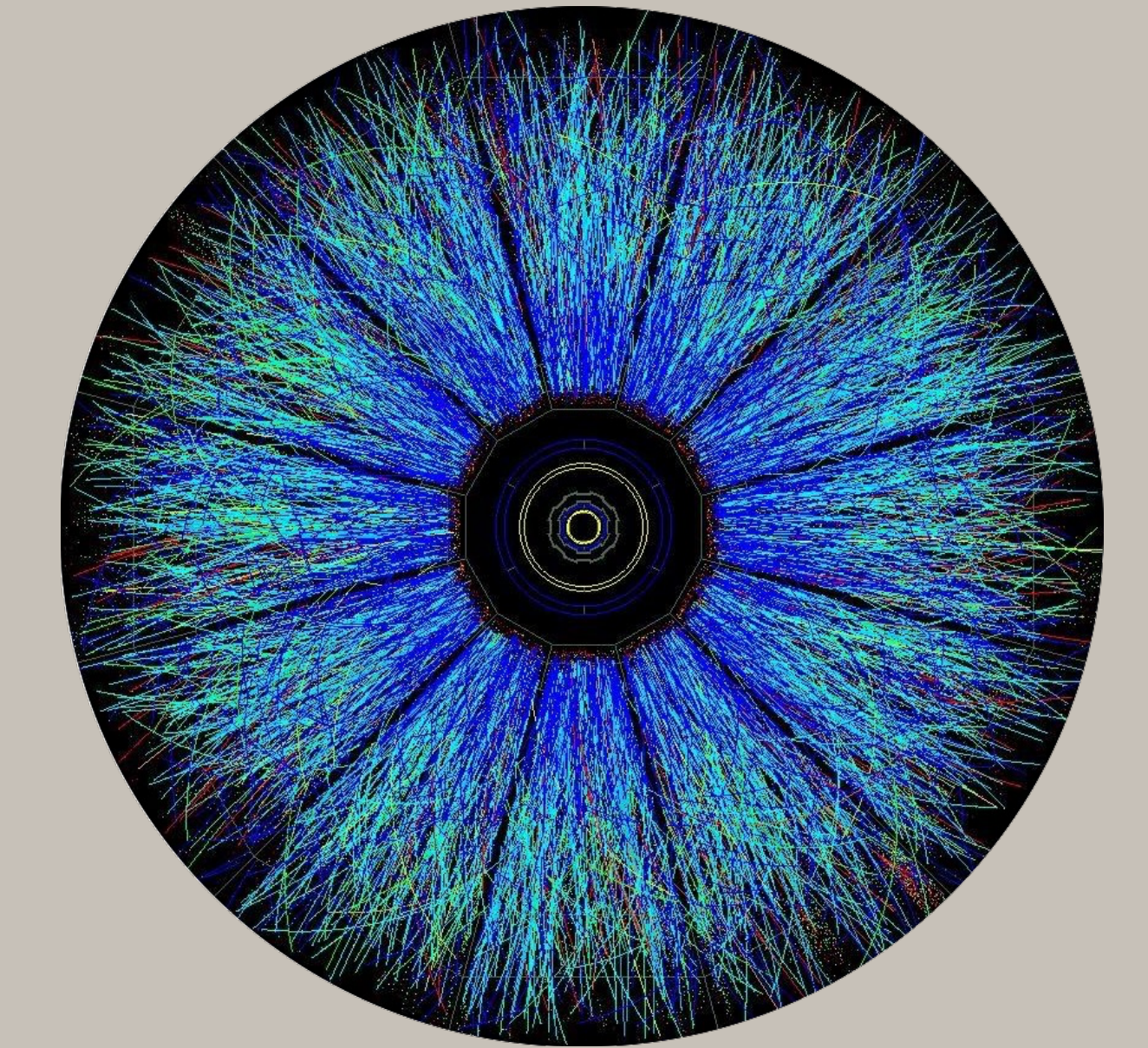


AdS/CFT Correspondence:

- * Duality which relates string theory (in higher dimensional AdS=Anti-deSitter spacetime) to a non-gravitational quantum field theory (CFT=conformal field theory).
- * The two sides live in different dimensions! Hence we call the correspondence *holographic*.
- * We can think of the entire universe as living inside the bulk of AdS. Its dual description is given by the CFT on boundary.

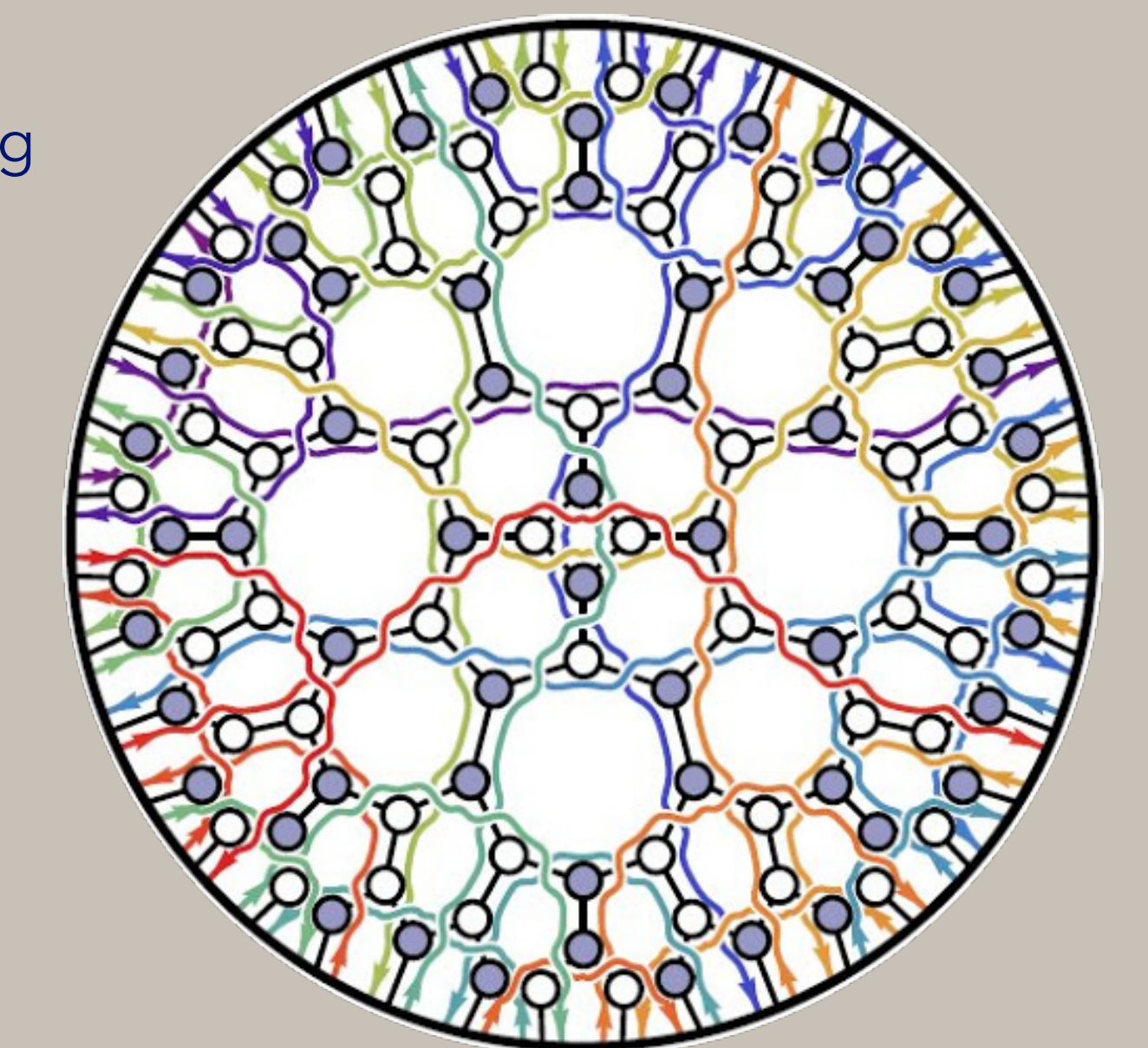
Quantum Field Theory and Elementary Particles:

- * The Standard Model of particle physics unifies three of the four fundamental forces of nature within the framework of Quantum Field Theory.
- * This can be accessed experimentally in particle accelerators.
- * These systems share many universal features with the CFT that lives on the boundary of AdS, holographically dual to string theory. (In fact, certain systems in condensed matter and atomic physics likewise share same universal features.)
- * But, there are aspects of Quantum Field Theories which we still do not fully understand.



Amplituhedron:

- * The QFT language for describing quantum dynamics can be reformulated in terms of simpler building blocks.
- * The recently-developed mathematical structure known as the amplituhedron provides an intriguing overarching framework.
- * In this picture, not only spacetime geometry, but string theory and field theory are themselves emergent quantities.



Mathematics:

- * Underlying all of these investigations is an intricate mathematical structure.
- * From a theorist's viewpoint these provide valuable clues on how to best represent the phenomena encountered in an elegant framework.

Part of the goal of the QMAP program is to exploit developments in modern mathematics to further our understanding of the physical phenomena.

And of course, all this is being done right here at UC Davis! Join the fun!

To learn more about our research and mission, visit us at qmap.ucdavis.edu

