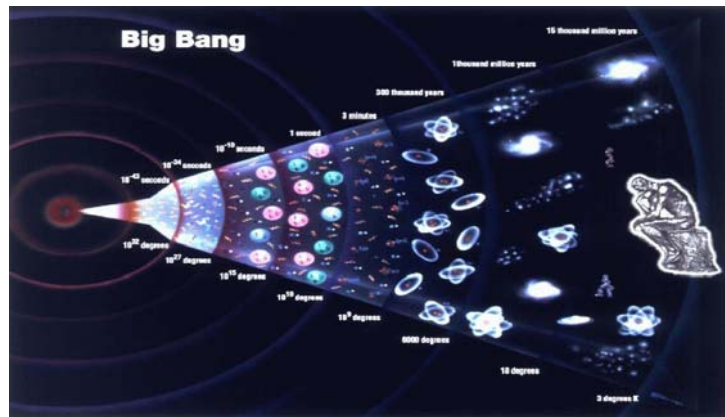


Institute for Gravitation and the Cosmos

For over a decade, the Institute for Gravitational Physics and Geometry has played a leading role at the interface of physics, mathematics and astronomy. The Institute for Gravitation and the Cosmos builds on these strong foundations by making use of the unique strengths in particle astrophysics that Penn State now enjoys. From quantum cosmology to new observational windows, the new Institute will seek greater understanding of the physical universe and its extreme events.

Vision

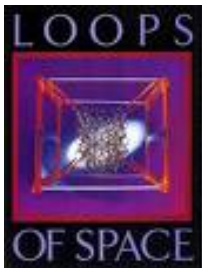
The Institute for Gravitation and the Cosmos will be dedicated to fostering the highest quality education and research in cosmology, general relativity, gravitational wave astronomy, particle astrophysics, quantum gravity and string theory, focusing on high energy phenomena and fundamental issues in the Science of the Cosmos. It will have synergistic interactions with the Schreyer Honors College, the College of Information Science and Technology, the World University Network and four departments in the Eberly College of Science.



Abhay Ashtekar, holder of the Eberly Chair in Physics and the Director of the current Institute for Gravitational Physics and Geometry, will serve as the Director of the new Institute and Paul Sommers, Professor of Physics, will serve as the Associate Director. The Institute will integrate the theoretical and observational research carried out in its three centers: the *Center for Fundamental Theory*, headed by Murat Gunaydin, Professor of Physics; the *Center for Gravitational Wave Physics*, by Sam Finn, Professor of Physics and Astronomy and Astrophysics; and the *Center for Particle Astrophysics* by Peter Mészáros, the Eberly Professor of Astronomy and Astrophysics and the Chief Theorist for the Swift GRBE mission.

Centers

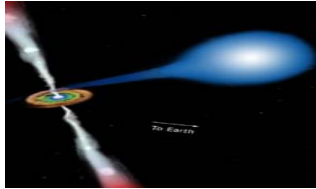
Center for Fundamental Theory: Thanks in large part to Einstein's revolutionary ideas, our view of the cosmos changed dramatically in the 20th century. The primary goal of this Center is to develop even better theories to take us beyond Einstein. The focus will be on cosmology, quantum gravity and string theory, particularly on fundamental questions and on confronting theory with the spectacular observations that are being made in the realm of cosmology. Research at Penn State has already provided one of the two leading approaches to quantum gravity, which is being pursued world-wide. With recent additions to the faculty in cosmology and string theory, the effort has achieved notable breadth. Penn State is the *only* US institution in which these three fundamental areas are being developed. Thanks to the new synergy, Penn State researchers have already begun to change the 20th century paradigm on such basic issues as the nature of the big bang and of black holes. Because of this exceptional combination of strengths and the resulting cross fertilization of ideas, one can hope for deep and lasting contributions



Center for Gravitational Wave Physics: Over the last year LIGO, the gravitational wave observatory in the U.S., has started collecting data. Other major ground based observatories will become operational soon. An observatory in space, LISA, is among the leading contenders to become a major space science project of NASA. These observations have the potential to transform astronomy and astrophysics in a way not seen since Galileo first turned a telescope to the Heavens. The Center for Gravitational Wave Physics is dedicated to realizing that potential by linking general relativity, astrophysics and experimental gravitational wave detection in the pursuit of deeper understanding of gravity and the development of gravitational wave observations as a tool of astronomy.

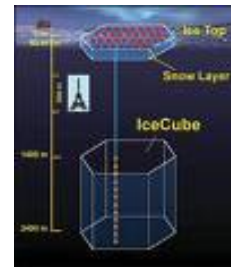


Center for Particle Astrophysics: Almost everything we know about the cosmos has come to us in the form of electromagnetic waves. Particle

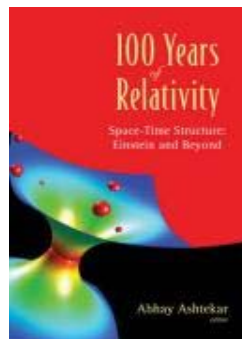
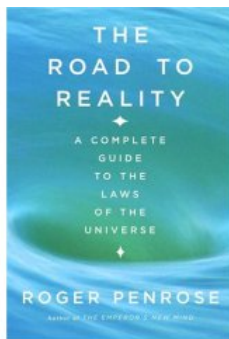


Astrophysics provides brand new windows to the cosmos. Penn State faculty are prominent participants in three novel initiatives: the Pierre Auger Cosmic Ray Observatory located in Argentina, the IceCube Neutrino Observatory at the south pole and the Swift Gamma-Ray Burst Explorer satellite. Both Auger and

IceCube are in advanced stages of construction and poised to make major discoveries in the next few years. Penn State is the *only* U.S. institution participating in both of these premier ground-based projects. Gamma ray bursts are especially violent supernova explosions which spew out, in a few blinding seconds, as much energy as a thousand suns do in their entire life times. Swift, with its mission control center at Penn State, has been providing the best observations of these explosions for two years, making Penn State a dominant player in this exciting area. These bursts and other energetic cosmic events can also be studied using cosmic rays, neutrinos and gravitational waves. Thus, there is now exceptional synergy that places Penn State in a unique position to introduce a bold, multi-pronged approach to high energy astrophysics. The potential for major discoveries is enormous.



Faculty in the current Institute for Gravitational Physics and Geometry have trained and mentored a large number of undergraduate and graduate students



and post-docs in emerging disciplines, with special attention to women and under-represented minorities. They have also been involved in significant outreach efforts, communicating the excitement of their frontier research to other scientists and to the general public. For example, two of the

recent semi-popular books of the Institute faculty were featured in major book clubs. (For other activities, see the outreach page at

<http://www.gravity.psu.edu/>). Members of all three proposed Centers will continue their vigorous participation in all these activities.

Opportunities

In recent years, the public has shown ever growing interest in cosmology, astrophysics and quantum gravity. There is an increasing number of semi-popular articles, popular books and even documentaries on these subjects. Therefore, even in an era of tight budgets, funding agencies have proudly supported large projects such as LIGO, Pierre Auger, IceCube and Swift. The Institute for Gravitation and the Cosmos is poised to make significant contributions to these areas of forefront research.



Institute activities will also add considerable synergy within Penn State. We close with a few examples. First, its inter-disciplinary research will significantly foster scientific interactions between several departments and Centers in the *Eberly College of Science*. Second, the Center for Gravitational Wave Physics and the Center for Particle Astrophysics routinely deal with phenomenally large data which can provide challenging problems at the forefront of computer science. These offer opportunities for collaboration with experts on data mining and/or image analysis at the *College of Information Science and Technology*, particularly on the problem of giant pattern recognition. We also expect close interaction with the *World University Network*, especially for joint conferences, summer institutes and exchange programs with Leeds, Nanjing, Southampton, Utrecht and York. Finally, in recent years a large number of honors students in the *Schreyer College* have carried out research under the guidance of our faculty. In addition, several distinguished visiting scientists, including Roger Penrose, have given talks and held discussion sessions at this College. These activities will be further strengthened at the Institute for Gravitation and the Cosmos.

