Institute for the Physics and Mathematics of the Universe

May 15, 2007

The Science

- How did the Universe start?
- What is it made of?
- What is its fate?
- What are its fundamental laws?
- Why do we exist?
- We need new data to address them
- We need both new mathematics and physics to describe them

Mathematics and Physics

quantitative foundation

Mathematics

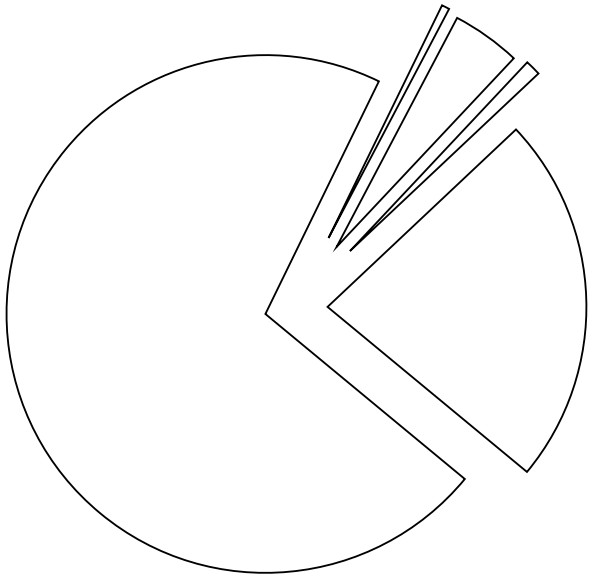
Physics

inspiration

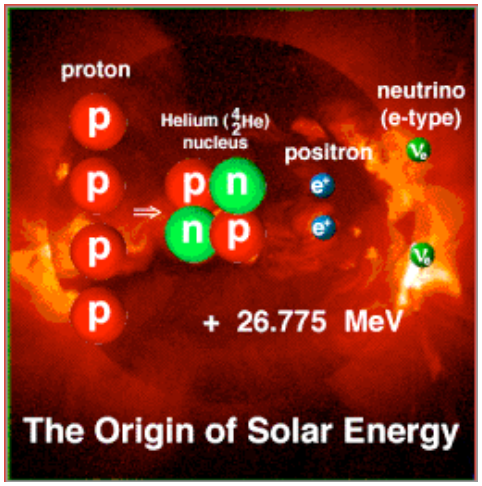
There are many
things we don't see

Energy Budget of the Universe

- Stars and galaxies are only ~0.5%
- Neutrinos are ~0.1–1.5%
- Atoms (baryons) are 4.4%
- Dark Matter 23%
- Dark Energy 73%
- Anti-Matter 0%
- Dark Field ~10^{62}%??

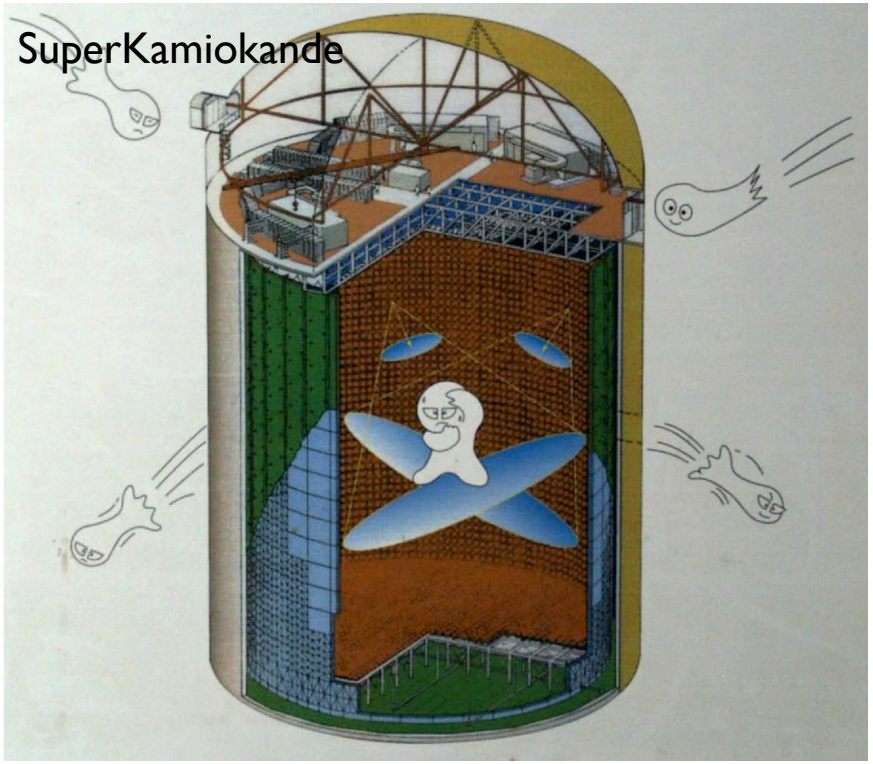


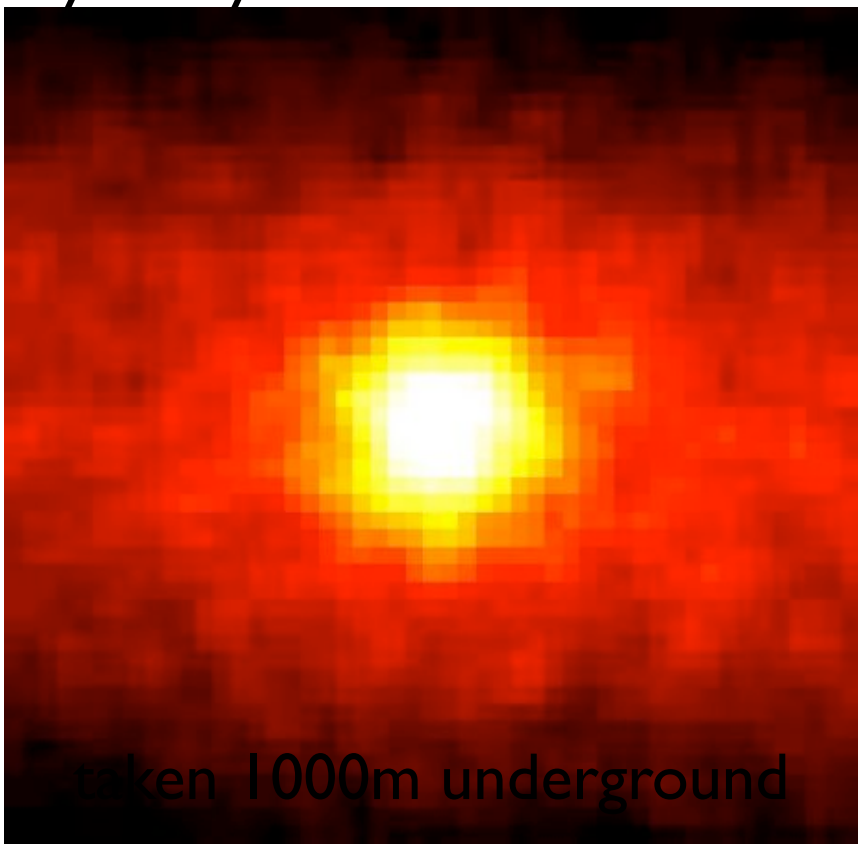
Don’t be afraid of invisibles



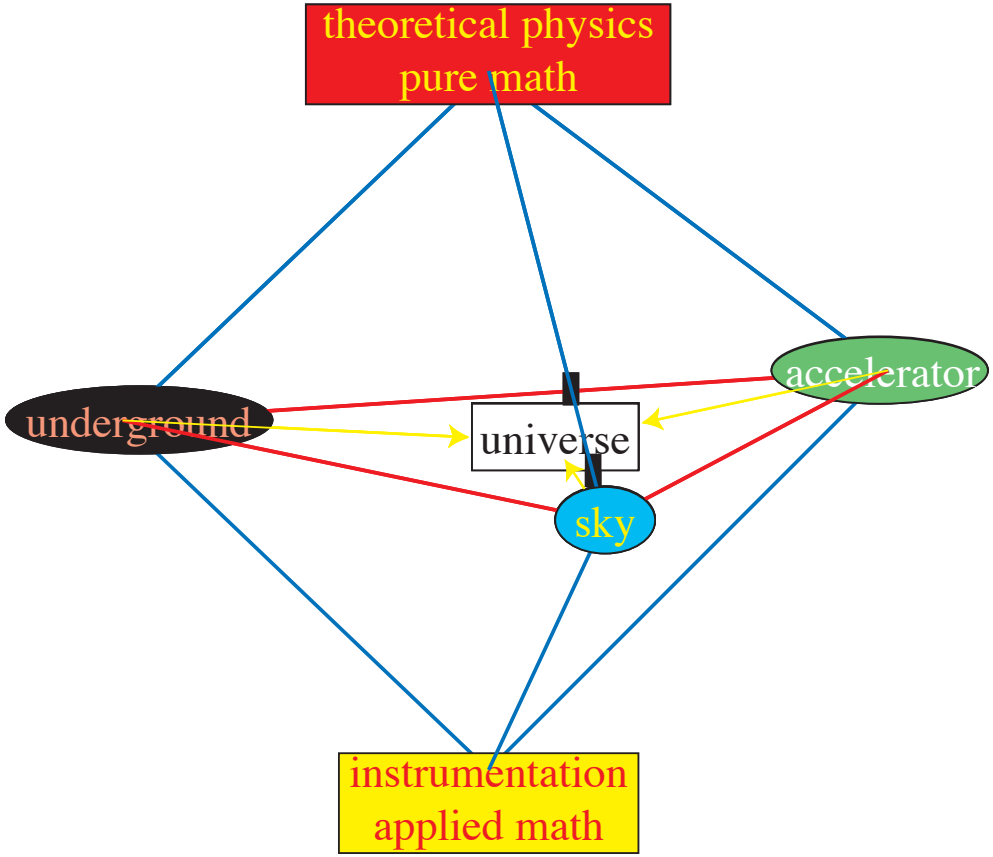
Pauli regretted to have predicted neutrinos nobody can detect

Trillions of them go through our body every second





Our approach



Initial Activities

- New galaxy surveys that address nature of dark energy, which may exclude the quantum vacuum energy as its source and require a new dynamics in quantum field theory.
- Improved understanding of neutrino parameters that constrain unified theories, supernova dynamics, and the origin of matter
- Exploitation of the coming LHC data jointly by experimentalists and theorists that may reveal new forces and symmetries of nature that existed at the birth of the universe.
- Development of new underground experiments that may establish the dark matter in our galactic halo as a new kind of elementary particle and let us see inside the Earth using neutrinos.
- Full understanding of the behavior of quantum field theories as an integrable system in the strong-coupled regime, one of the "Millennium problem" of Clay Mathematics Institute, through its equivalence to the theory of gravity, i.e., the AdS/CFT correspondence.
- Developments of new tools in geometry that help us understand the full scope of solutions to the string theory.
- Discovery of new algorithms that allow us to extract science from Pentabyte-scale astrophysical data about dark energy. It further influences financial markets and biological sciences.

Management

President

Director
Hitoshi Murayama
Deputy Directors
Yoichiro Suzuki & Hiroaki Aihara
Administrative Director TBD

External Advisory Board

Scientific Advisory Committee

Kamioka satellite

- Hiroaki Aihara (Tokyo)
- Masataka Fukugita (Tokyo)
- Kunio Inoue (Tohoku)
- Michio Jimbo (Tokyo)
- Takaaki Kajita (Tokyo)
- Toshitake Kohno (Tokyo)
- Hitoshi Murayama (Berkeley)
- Masayuki Nakahata (Tokyo)
- Ken'ichi Nomoto (Tokyo)
- Hirosi Ooguri (Caltech)
- Katsuhiko Sato (Tokyo)
- Hank Sobel (Irvine)
- David Spergel (Princeton)
- Naoshi Sugiyama (Nagoya)
- Yoichiro Suzuki (Tokyo)
- Tsutomu Yanagida (Tokyo)

Collaboration

- This type of center brings in worldwide collaborators very easily
- PIs from Berkeley, Princeton, Caltech, Irvine
- Kyoto, RIMS, Yukawa Institute, NAO, Subaru, KEK, Tohoku, Nagoya, Kamioka
- IHES, BU, Oxford, CERN, Pisa, Toronto, etc etc

Organization

- Most physicists based in Kashiwa to ensure access to labs, common seminars
- Most mathematicians based in Komaba to ensure their intellectual independence
  - but 1-2 senior PIs in Kashiwa
- Semi-annual workshops to share common problems
- Weekly seminars over video

Organization

- annual External Advisory Board review
- annual Institute retreat with all PIs
- tea at 3pm to bring in *everybody* in town
- attractive and open architecture of the Institute building (à la KITP, BCTP, IAS)
- annual conference that represents IPMU
- long-duration workshops à la KITP, Aspen

Broader Impact

- Inspiration to the best and the brightest
  - questions are easy to relate
  - cross career between math and physics
- public awareness of math and science
  - public lectures, TV shows
  - publication for lay people
- spin-offs that benefit the industry
  - phototubes and multi-fiber for medicine
  - monitor nuclear plants with neutrinos

Request to the administration

- Support for fundraising
  - naming opportunity at a modest investment of about $10M
  - to continue world-leading research beyond 10-15 years
  - to make sure termed scientists will find jobs after the end of the Institute
- Encourage UT scientists to become full-time Institute members by securing their retirement and health benefits
- housing for visitors to Kashiwa
- attractively designed and furnished building