



## Mathematician's quantum gravity research may have interstellar applications

To Louis Crane, who remembers a science fiction story from his childhood which contained the motto *Ad Astra Per Aspera*, it seems strange that his current work connects with it.

The Kansas State University mathematician has just received a \$135,247 grant from The Foundational Questions Institute to tackle one of the big unsolved problems in theoretical physics—a theory of quantum gravity. This research will be used to study gravity, black holes, black hole power sources and their applications to propulsion for interstellar space travel, as well as to study the origins of our universe.

Three of the four forces of nature—electromagnetic, strong nuclear and weak nuclear forces—which operate inside the atom, are covered in quantum mechanics. Currently, the fourth, gravity, has Einstein's theory of relativity with its time and space continuum. The theory of relativity predicts black holes and even the Big Bang. Relativity says that as a star collapses into itself creating a black hole, time and space curve into themselves to a point called a singularity. And that our universe sprung from one of these singularities. Here relativity breaks down as it does not work on the microscale of the atom. In fact, physics as we know it ends. Enter quantum mechanics.

"The current understanding of the physics of gravity is that it is geometry. General relativity is a theory of curved spacetimes that explains gravity. So, in order to work out a quantum theory of relativity, I'm trying to invent a quantum geometry," says Crane.

"[I am] trying to build a geometry which is a structure based on many wave functions, instead of many distances, represented as numbers. Think of a triangulated map with distances on the edges. That's a kind of geometry. Now, replace the numbers with probability waves, and go to 4D. It needs a lot of abstract math to work. People thought it wouldn't work, but it did. It looked infinite, but turned out finite. So, I'm sort of optimistic," says Crane.

Crane will try to complete an interpretation of a well-known model for quantum gravity that he helped develop about ten years ago, the Barrett-Crane model. This is a mathematical description of spin, specifically the angular momentum of a black hole. This rotation speed, along with mass and electric charge, is one of the three characteristics of black holes.

The BC model has been ruled finite, meaning there are limited parameters which can, in principle, be set in experiment. "It is a mathematically rigorous proof. What is missing is a description of the classical states, which would allow us to describe an experiment," says Crane.

He would use these results to look for quantum corrections to gravitational processes; for cor-

rections or changes to the Hawking radiation and black hole evaporation and the Planck (energy) scale; and to discern any significance for black hole power sources and propulsion systems.

Black holes, which Crane calls "the ultimate energy source," relate to interstellar space travel in that "a black hole is believed to radiate energy (termed Hawking radiation) due to the effect of its trapped surface on the quantum fields of matter. If the hole is small, it radiates fast. It is also possible to stimulate the radiation, an effect called superradiance.

"Black holes also move in response to light pressure similarly to normal matter. This is well accepted among relativists. So we can contain the [small, artificial] black hole in a cavity (like a rocket engine), and arrange for part of the radiation of the black hole to reflect back on it to accelerate it together with the ship," says Crane.

"Black holes are the most intense energy phenomenon existing in the universe unless there's something else we know nothing about," says Crane.

According to Crane, to make an artificial black hole with the energy to fuel a starship would take a black hole in the range of one million tons mass. Its size would be measured in nuclear dimensions—femtometers. The reason this can't be done now is there is no way to concentrate the energy.

In Crane's opinion, though this is far out and way into the future, it is at least imaginable—any other way to make a starship is "flatout impossible." For example, take two other ideas for propulsion: anti-matter and warp drive. Antimatter is inefficient to make, hard to produce and store and too dangerous. Using warp drive requires a negative energy density. There's nothing known in nature which has a negative energy density, no reason to believe it exists anywhere, according to Crane.

"I am not trying to answer questions like this on the level of practical engineering. A simple physical plausibility argument is all we should attempt at this moment," says Crane.

"It is just conceivable to develop a theory that will allow our descendants in 200 years to make it to the stars. Science often knows how to do something long before it is possible to be done," says Crane.

Crane also will use his findings to study the theory of evolutionary universes. Because the universe is so precise, with minute changes in the elements making the difference between the existence or non-existence of stars or other fields in the universe, using randomness as an explanation for all this complexity is unscientific. Scientists working on a quantum theory of gravity suggest that time and space do not collapse to a point in a

black hole, but instead into a four-dimensional tube which opens into a new region of space and time which is the source of new universes.

In the evolutionary theory, those universes with the ingredients for producing stars and black holes would be more prolific in producing baby universes than those that lack those ingredients—sort of a survival-of-the-fittest theory.

A quantum theory of gravity would be a "capstone" which would unify the laws or forces of nature. And should explain mysteries like dark matter or dark energy that are known to exist because of empirical evidence in the cluster galaxies. And we may learn of new laws or forces we don't know about yet, according to Crane.

Crane's grant was part of The Foundational Questions Institute's first-round grant awards of \$2 million to 30 grant recipients.

The institute is a new, philanthropically funded, scientific grant-awarding agency. This private, independent foundation is run by scientists for the express purpose of furthering research on questions at the foundations of physics and cosmology, particularly new frontiers and innovative ideas unlikely to be supported by conventional funding sources. More information can be found at <http://www.fqxi.org>



**Black Hole**

NASA illustration

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## Pluto, we hardly knew ye...

The ex-planet Pluto.

It is smaller by mass than any of the other planets and smaller than seven of the other planets' moons—only one-sixth the mass of the moon. It has only 6 percent of the gravity of earth.

Pluto's thin atmosphere is probably nitrogen, methane and carbon dioxide which varies between being gaseous or frozen depending on where it is on its 248 year orbit around the Sun.

Yet, this icy orb is special to us here in Kansas, having been discovered in 1930 by native Kansan Clyde Tombaugh.

In August, at a meeting in the Czech Republic, the International Astronomical Union (IAU) approved a new definition of a planet which demotes Pluto to a dwarf or second-class planet.

Science must move on, according to Dr. DeWayne Backhus, chair of the Department of Physical Sciences at Emporia State University.

"Pluto has remained a planet as long as it has as a matter of sentimentality, not rationality. When technology detected the swarm of debris in the Kuiper Belt Region something had to clear the way. With so much debris in the Kuiper Belt that could at some time vie for the status of a planet, coming up with a definition of a planet was the practical thing to do."

According to the IAU definition, to be a planet a body must:

- 1) orbit the Sun.
- 2) be massive enough to be a sphere by its own gravitational pull.
- 3) clear the neighborhood around its orbit.

The third point is where Pluto flunks the test. Barbara Anthony-Twarog, of the KU Dept. of Physics and Astronomy, has problems with that third point. "[I'm] not sure what it means. It's open to different interpretations—possibly that it is the main body in its orbit. But we don't know how to determine that."

Anthony-Twarog believes the decision was "pretty slapdash and kind of silly." "The IAU didn't follow the recommendation of its own commission which it had asked to come up with a definition of a planet. What they adopted looks like it was written specifically to exclude Pluto," she says.

The subject may not be closed. According to Anthony-Twarog, a large number of astrophysicists and scientists have signed a petition asking the IAU to look at this again.

Pluto is now officially a dwarf planet. The New Horizons mission, launched last January, will explore Pluto and the Kuiper Belt Region in 2015. As of mid-September the spacecraft was on the outskirts of the asteroid belt (181 million miles away from Jupiter) according to NASA information.

## Liberty Bell 7 returns to Kansas for good

HUTCHINSON--After a national six-year tour, the fully restored Mercury spacecraft Liberty Bell 7 has landed at its new home at the Kansas Cosmosphere and Space Center.

On Sept. 18, it was lowered into the lower level Hall of Space Museum to become a permanent exhibit in the Cosmosphere's Early Spaceflight Gallery.

Adding Liberty Bell 7 to the Cosmosphere collection makes the museum one of only three places in the world where visitors can see a complete set of flown manned Mercury, Gemini and Apollo spacecraft. The KCSC also houses the Gemini X and Apollo 13 capsule Odyssey.

Liberty Bell 7, piloted by astronaut Gus Grissom, sank shortly after splashdown in 1961. In 1999, a special team from the Discovery Channel retrieved it from the bottom of the Atlantic Ocean. The Cosmosphere painstakingly restored every detail.

Besides having been displayed in major museums across the country during its national tour, the Liberty Bell 7's most recent stop was the Kennedy Space Center in Florida.

## Kiowa County---meteorite capital?

Finding meteorites has been an avocation around Haviland since the 1880s--one not likely to cease anytime soon.

In October of 2005, native Kansan and professional meteorite hunter Steve Arnold unearthed what is the largest oriented pallasite meteorite in the United States in a farm field in Kiowa County. Sizewise, this 1430 lb. boulder edged out another local specimen, the 1,000 lb. Space Wanderer, that has been on display at Greensburg's Big Well museum since the 1940s. This past April, Don Stimpson of Haviland located another 1500 lbs. worth of meteorites in another Kiowa County field thought to be empty of the rocks.

These Brenham meteorites, named for Brenham Township in Kiowa County, are extremely rare pallasite meteorites. This means they are made up of iron and a form of the gemstone peridot. Only about one percent of meteorites are pallasite.

They are believed to have fallen to Earth from the asteroid belt between Mars and Jupiter about 20,000 years ago. According to W. Randall Van Schmus, professor of geology at KU, the impact area of this meteorite field is roughly three miles by one mile.

The record-holding 1430 lb. meteorite, which was unearthed about seven feet underground, is also an oriented meteorite, meaning that unlike about 99 percent of other meteorites, it did not tumble to earth, but shot straight to earth more like a bullet, morphing into a conical shape as it reached the heat of the atmosphere.

In July, the town of Haviland held a first annual Haviland Meteorite Festival with the theme "The Rock Stops Here." Also being considered is a meteorite museum and the promotion of Haviland as the "Meteorite Capital of America."

Another area in Kansas noted for meteorites is Ness County.

For more information, go to [www.meteoritestudies.com/protected\\_BRENHAM.HTM](http://www.meteoritestudies.com/protected_BRENHAM.HTM)

According to Prof. Van Schmus, a good (though obscure) reference is "Space Rocks and Buffalo Grass" by Ellis Peck (one-time owner of Brenham land) published in 1979.

## KSGC has new director, associate director

Effective this past summer, the new director of the Kansas Space Grant Consortium (KSGC) and the Kansas NASA Epscor Program (KNEP) is Dr. L. Scott Miller, Dept. of Aerospace Engineering, at Wichita State University--now the KSGC lead institution. Serving as associate director for both organizations at WSU is Linda Cory, BA Women's Studies / Ethnic Studies.

Stepping down as director and associate director are Dr. David Downing and Prof. Richard Hale of KU, respectively.

The new address of the KSGC/KNEP office is

Wichita State University  
200 Wallace Hall  
1845 Fairmount  
Wichita, KS 67260-0044  
316-978-3890  
[nasainkansas@wichita.edu](mailto:nasainkansas@wichita.edu)

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For those interested in a summer internship at a NASA academy or a NASA Higher Education Scholarship / Internship opportunity, there's just one application: NASA's Office of Higher Education Combined Intern Application. One should find that form at <http://university.gsfc.nasa.gov/application> after the middle of October. November 15 is the usual opening date to submit for the

following summer.

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Financial assistance is available for Project Discovery through the KSGC. Project Discovery is a weeklong engineering camp for high school girls to be held in June and July, 2007, at the University of Kansas. For information, contact [fboldridge@ku.edu](mailto:fboldridge@ku.edu) or call 785-864-3620 or go to the website [www.engr.ju.edu/prospective/undergraduate/women](http://www.engr.ju.edu/prospective/undergraduate/women)

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Two Kansas universities participated in NASA weightlessness experiment programs earlier this year. Pittsburg State sent a team last spring. KU's microgravity team participated in the NASA Reduced Gravity Program at Houston for four days in June, 2006.

## KCAE member to be honored

The late Maurice Witten, past chairman of the Department of Physics at Fort Hays State University and an active member of the Kansas Commission on Aerospace Education (KCAE) will be honored with the Governor's Aviation Honors Award at the 27th annual Wright Brothers Celebration in Wichita on November 18.

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The following list is part of an ongoing reference directory featuring representative research projects in Kansas. Ad Astra Kansas' goal is to serve as an information hub in Kansas focusing on different areas of high-tech and space research for networking and educational purposes.

## ASTRONOMY / PHYSICS

**"A New Approach to Quantum Gravity, with Possible Applications to the Origin and Future of Life,"** \$135,247, Louis Crane, KSU Dept. of Mathematics. Funding awarded by The Foundational Questions Institute. 785-532-0566 crane@math.ksu.edu

**"AIN Based Extreme Ultraviolet (EUV) Detectors,"** \$30,127, Hongxing Jiang, KSU Dept. of Physics. NASA funding awarded 3-06. 785-532-1627 jiang@ksu.edu

**"Aggregation in Dense Systems Crossover from Cluster-Cluster-Aggregation to Percolation,"** \$87,748, Christopher Sorenson and Amitabha Chakrabarti, KSU Dept. of Physics. NASA funding awarded 4-06. 785-532-1626 sor@ksu.edu 785-532-1625 amitc@ksu.edu

**"Dynamical Probes of Cosmology,"** Hume Feldman, KU Dept. of Physics and Astronomy. KU General Research Fund (GRF) award 7-06 785-864-4740 humef@ku.edu

**"Ferromagnetic Ordering in Diluted Magnetic Semiconductors,"** Carsten Timm, KU Dept. of Physics and Astronomy. KU General Fund (GRF) award 7-06. 785-864-3954 ctimm@ku.edu

**"The Neutrino Matrix,"** Danny Marfatia, KU Dept. of Physics and Astronomy. KU General Research Fund (GRF) award 7-06 785-864-4591 marfatia@ku.edu

## AVIATION

**"Full Scale Testing,"** \$452,000, T. Hickey, WSU NIAR. Rocketplane LTD funding 2-06.

**"Modeling and Simulation of a Generic Hypersonic Vehicle,"** Richard Colgren, KU Dept. of Aerospace Engineering. KU General Research Fund (GRF) awarded 7-06. 785-864-2904 colgren@ku.edu

**"Modular Wireless Avionics systems for Autonomous UAVs,"** \$103,443, Dale Schinstock and Garth Thompson, KSU Dept. of Mechanical and Nuclear Engineering. NASA funding awarded 6-06. 785-532-2608 dales@ksu.edu

## INFORMATION TECHNOLOGY

**"Research Supporting Advanced Informations Systems Technology,"** \$638,296, Costas Tsatsoulis, KU Dept. of Electrical Engineering and Computer Science. NASA funding begins 12-06. 785-864-4486 tsatsoul@ku.edu

**"Proximity Microtransceiver for Interoperable Mars Communications,"** \$59,556, William Kuhn, KSU Dept. of Electrical and Computer Engineering. NASA funding awarded 2-06. 785-532-4649 wkuhn@ksu.edu

**"Hardware and Software Evaluation, Development and Testing Supporting a New Generation Computer for Airborne and Space Applications,"** \$75,000, Dwight Day and John Devore, KSU Dept. of Electrical and Computer Engineering. U.S. DOE funding awarded 2-06. 785-532-4660 day@ksu.edu 785-532-4648 jdevore@ksu.edu

**"Mission Complexity Analysis/Cost Benefit Analysis (MCA/CBA) Study,"** \$70,001, David Ben-Arieh Blunt, KSU Dept. of Industrial and Manufacturing Systems Engineering. NASA funding awarded 6-06. 785-532-3724 davidbe@ksu.edu

## MANUFACTURING and ADVANCED MATERIALS

**"Preliminary Characterization of Piezoelectric Nanoparticle Reinforced Polymer Composite,"** Elizabeth Friis, KU Dept. of Mechanical Engineering. KU General Fund research award 7-06. 785-864-2104 ifriis@kuk.edu

**"Repair of Composite Structures,"** \$450,000, J. Tomblin, WSU NIAR. Ntl. Institute of Safety funding awarded Fall '06. 316-978-5234 john.tomblin@wichita.edu

Source: KU Center for Research Sponsored Project Awards / KU General Research Fund--Fiscal Year 2007; KSU Research and Sponsored Program Awards; WSU Office of Research Administration

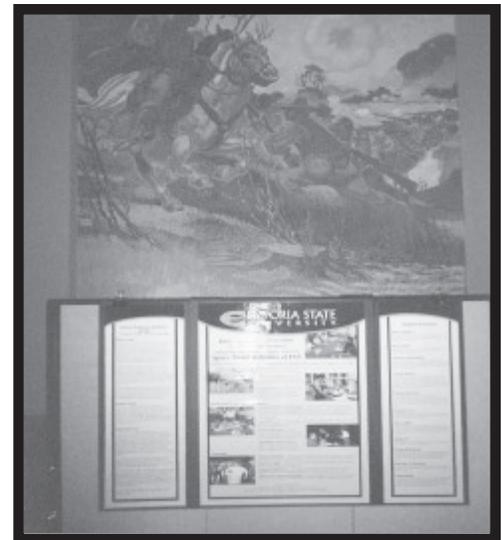
## Topeka display marks Ad Astra Kansas Day

From April 23-29, 2006, a static display in the first floor rotunda at the state capitol building illustrated Kansas' scientific prowess with the theme "Kansans reaching for the stars through space-tech education, research and commerce."

Included in the over twenty entities supplying display material were WSU's National Institute for Aviation Research, Emporia State University, the KU ULTRA Telescope project, Kansas Applied Remote Sensing Center, the Kansas BEST Robotics Competition, the Wellington Challenger Center, the Kansas Science Olympiad, Kansas Space Grant Consortium, and Wichita Jardine Middle School--an official Kansas NASA Explorer School.

Ad Astra Day is a recognition of the importance of science and technology to Kansas' future. The next participation by the Ad Astra Kan-

sas News in its ongoing attempt to publicize science in Kansas will be participation in Kansas Day activities in January, 2007, in Topeka.



# Interstellar R&D

## Ad Astra Kansas News

This "Interstellar R&D" tenth-time feature in this **Ad Astra Kansas News** tenth issue continues an enterprise to research and gather information on the most important developments preparatory to humanity's greatest adventure — voyaging to the stars. Now, at millennium's turn, is an appropriate time for grand vision and forward thinking, and there are strong signs of a renaissance in interstellar travel thought and activity. This new feature and newsletter, thus, now set forth to develop a national / international / global clearing center and storehouse of knowledge and know-how for travel to the stars: *Ad Astra*. — Steve Durst, Michelle Gonella

### OBSERVATION

#### Antarctica Astrophysics

The quest to the Stars, and to the Moon, increasingly lies through Earth's South Pole ice / rock "science" continent of Antarctica. Now host to activities from some 50 nations — about 30 with permanent staffed science research stations, Antarctica will observe International Polar Year 2007, fifty years after the birth of Antarctica astrophysics (AA) during the IGY International Geophysical Year of 1957.

21st century AA projects, such as Caltech's BICEP in 2005 and the National Science Foundation's IceCube, follow 1990s advances by Center for Astrophysical Research in Antarctica (CARA, using infrared, submillimeter and radio wavelengths) and Antarctic Muon and Neutrino Detector Array (AMANDA), both operating from the "Dark Sector" near the Amundsen-Scott South Pole Station.

BICEP (Background Imaging of Cosmic Extragalactic Polarization) will operate at 100 - 150 GHz at angular resolution 1.0 - 0.7 degrees, and is designed to measure the polarization of the Cosmic Microwave Background, to provide answers about the beginnings of the Universe. IceCube, NSF's \$272M multi-national cosmic neutrino telescope, is partially operational in 2006, and will encompass a cubic kilometer of ice under the South Pole when complete in 2011.

Also advancing in the 21st century, VLF Antarctica research on Earth's magnetosphere continues under direction of Stanford Professor Umran Inan with the HAIL (Holographic Array for Ionospheric Lightning) study of sprites, blue jets, elves and other geomagnetic phenomena.

Internationally, increasing research activity in numerous scientific domains by many nations is highlighted by China preparations for its 3rd Antarctica permanent station (after coastal Great Wall and Zhongshan Stations) in the continent's unexplored hinterland and pristine crystal-clear air, atop highest ice cap zone Dome A.

### COMMUNICATION

#### Laser Communication Tech Advances Lead the Way for Interstellar Use

NASA's measured focus on sustainable exploration advances in support of the Vision for Space Exploration will create an infrastructure for communications within the solar system which can be extended to the stars and beyond. Increased need for reliable transmission of large amounts of data on a continuous basis from the Moon and Mars has brought a new focus on laser communications.

Laser communications can accommodate transmission rates that are 10 to 1,000 times higher than radio waves. The small size of the equipment takes up less payload space on a spacecraft and the narrow beam of the laser enhances security, also allowing for reduced antenna area and less power.

SETI involving laser communications is known as optical SETI and received the support of Arthur C. Clarke. Laser transmissions can reach across the galaxies with almost no interference and the equipment for transmission is inexpensive. Optical SETI is not hampered by terrestrial interference and it is highly distinctive from natural processes which produce noise which is picked up in the search for radio waves.

As laser communications come into common use within the solar system, the refined technology will set the groundwork for communications which will be needed for interstellar exploration and travel in the future.

### TRANSPORTATION

#### Tau Zero Foundation and EnergyUSA Seek Interstellar Propulsion Possibilities

"The Tau Zero Foundation will establish itself as

the dependable venue through which the visionary goals of interstellar flight can be advanced through imagination coupled with intellectual rigor," states Marc Millis, one of the founders of the organization.

The Foundation calls for philanthropic support, modeled on the SETI Institute and Biosphere 2. Millis, an employee at Glenn Research Center, keeps the quest for revolutionary modes of interstellar travel entirely separate from his work at NASA. His Breakthrough Propulsion Physics Project lost funding in 2002, but NASA covers his time to maintain awareness and publish assessments of ideas for interstellar travel.

Millis reviews papers focused on antigravity, which he does not believe is a viable option, "a transient inertia effect" called the Woodward effect, and a gravitomagnetic effect which exceeds the bounds of general relativity. "The bottom line," says Millis, "is that there are no breakthroughs that appear imminent, but there are definitely small steps that can be taken to continue to look into these things."

Norm Hansen, President of EnergyUSA, hopes to begin using "Mirror Energy," utilizing matter/antimatter, to bring flights to the Moon by 2016. Long considered a candidate for interstellar propulsion, five grams of the fuel would power 1,000 round trips to the Earth's nearest neighbor.

"Mirror Energy" is based on positrons, which are costly to create and difficult to store. Nonetheless, EnergyUSA anticipates technological advances bringing costs down dramatically. The same improvements in production and control of positrons open the door to use in interstellar travel.

Dr. Louis Crane, a researcher at Kansas State University, is working to compute quantum effects in experiments involving gravity. He hopes to apply this to small, artificial black holes and test the feasibility of using them as energy sources for interstellar travel.