MILLER INSTITUTE NEWSLETTER

Winter 2004

Miller Fellow Focus: Huan Tran

"To survive in this business, it's like Indy 500 racing, you have to drive fast and come close to crashing, but then don't". This is how the intensely competitive field of experimental cosmology has been described by host Professor Adrian Lee, from the Department of Physics. The competition is so fierce because the prize has been so tantalizing: a quantitative understanding of the universe through precision measurements of cosmological parameters.

Second year Miller Fellow Huan Tran is foremost an experimental physicist interested in developing instrumentation for cosmology. His studies have taken him to exotic locations with ambitious experiments built on shoestring budgets. The experiments often look like they were built in a garage with sticky tape. There isn't enough time to make things look nice. Hesitation can be the difference between making a major discovery and becoming a historical sidenote.

Seven years ago, when he started graduate school, the field was completely open. The object was to search for extremely faint ripples in the bright, nearly uniform Cosmic Microwave Background (CMB) radiation left over from the Big Bang. The ripples trace the distribution of normal matter when the universe was a scant 300,000 years old, just enough time for the matter to experience self-gravity and begin to form clumps, but not enough time so that more complex structures such as stars and galaxies could form to complicate the picture. The exact nature of these clumps, the size, the density, the distribution, is influenced by a few key cosmological parameters.

Measurements of the ripples allow inferences to be made about the parameters. Before 1992, nobody knew how big the ripples should be. Initial measurement attempts from the ground always turned up a uniform, isotropic sky. It took NASA's Cosmic

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Deadlines To Note

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Visiting Miller Professor nominations due

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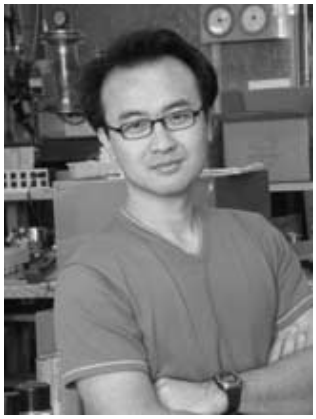
Background Explorer (COBE) to finally see departures from uniformity, or anisotropy, at the level of one part in 100,000, just below but very close to the sensitivity of most sub-orbital instruments. COBE's resolution was poor, it could only make out details larger than 7 degrees. Even so, the fact that it could see structures at such a large scale is a conundrum for naïve Big-Bang cosmology. Large structures should not have formed from an initially uniform universe because there was not enough time for one end of the structure to "know" about the other end due to the finite speed of light. For this and other reasons, the theory of Inflation was invoked to explain these large structures. Inflation describes the universe milliseconds after the Big-Bang, when space was thought to be a sea of quantum fluctuations. These tiny subatomic particle-scale fluctuations inflated into universe scale fluctuations during a period of superluminal space-time expansion, leaving the large-scale anisotropy observed by COBE.

With the initial observation of the ripples firmly in place, the race to measure them at smaller scales was on. As a young grad student, Huan 'cut his teeth' on one of these experiments. The TOCO experiment, a ground based telescope, had spent an earlier life as a balloon-based payload. After the hasty conversion, it was hauled up a mountain (for which it is named) in the desert of the Chilean Andes. Every day of operation was an adventure, involving a drive up to 17,000 ft, in the thin air, to service an experiment which needed constant attention. The reward for this type of seat-of-the-pants science was the first detection of a peak in anisotropy spectrum. The amplitude of the anisotropy spectrum at scales smaller than COBE's resolution was tenfold larger. At still smaller scales the amplitude was small again. This rise and fall had long been a predicted feature of the spectrum. It indicated a characteristic size that corresponds roughly to scales that had had just enough time since the big bang to collapse under self gravity. This was the long sought-after standard ruler in cosmology. The apparent size of the ruler today is a measure of how much the light from the early universe was bent on its way to us, and therefore is a measure of the overall curvature of the universe. For the first time, there was convincing evidence that the universe is flat.

Later measurements showed other peaks in the anisotropy spectrum, and the increasingly precise measurements allowed other parameters to come into sharp focus. The definitive measurement of the peaks was released recently after NASA's WMAP satellite finished its first year survey. The WMAP team claims measurement of certain parameters to remarkable accuracy, such as the age of the universe: 13.7 +/- .2 Gyr.

With such a comprehensive measurement of



the anisotropy completed by the WMAP team, most physicists working in the field have been busy chasing after the next frontier. Coincident with the prediction of the series of peaks is strong prediction that the ripples are about 10% polarized. The polarization is a consequence of velocities in the primordial fluid, and its measurement would not only sharpen the measurement of cosmological parameters, but also would give cosmologists more confidence in their picture of the early universe.

When Huan first arrived in Berkeley, he agreed to work on MAXIPOL, another experiment reincarnated from a very successful ripple mapper. MAXIPOL had incorporated the most sensitive detectors of CMB, and a simple retrofit allowed it to measure polarization. MAXIPOL was already in full swing, with a small team preparing feverishly for a balloon flight over the New Mexico. The conditions in the desert were a different type of exotic from the Chilean Andes,

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Visiting Miller Professorship Program Fall Awards

The Miller Institute is pleased to announce the Visiting Miller Professorships granted during the Fall competition cycle. The purpose of the Visiting Professorship program is to bring promising or eminent scientists to the Berkeley campus for collaborative research interactions. The recipients will be on campus for terms during academic year 2004-05

ASTRONOMY	**GREG HAMMETT** **PRINCETON UNIVERSITY**
CHEMISTRY	**RICHARD EISENBERG** **UNIVERSITY OF ROCHESTER, NY**
	RUTGER VAN SANTEN **TECHNISCHE UNIVERSITEIT EINDHOVEN** **THE NETHERLANDS**
EECS	**ZHI-LI ZHANG** **UNIVERSITY OF MINNESOTA**
EARTH & PLANETARY SCIENCE	**LARS STIXRUDE** **UNIVERSITY OF MICHIGAN**
ESPM	**YUTAKA KAWARABAYASHI** **NATIONAL INSTITUTE OF ADVANCED INDUSTRIAL SCIENCE & TECHNOLOGY, JAPAN**
MATHEMATICS	**SERGE LANG** **YALE UNIVERSITY**
MCB	**JAMES HABER** **BRANDEIS UNIVERSITY**
PHYSICS	**MARCIS AUZINSH** **LATVIA UNIVERSITY, LATVIA**
	JAN PETER TOENNIES, **MAX-PLANCK-INSTITUT FUR STROMUNGSFORSCHUNG, GERMANY**

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but the distance from home combined with the microcosmic pressure cooker still made for an intense experience. Ballooning can seem like the poorest cousin in the NASA family of experiments. There are no ultra clean rooms or lab coats, no hierarchy of management, just some large men capable of handling the Volkswagen-sized balloon payloads and flight bosses whose job it is to handle all of the flight details, operating as much on trained instinct as meteorological data. NASA uses ballooning to test out new and somewhat risky technologies for future space measurements. As such, success often comes down to a few key people. This approach meshes very well with the fast paced CMB field, but of course will sometimes lead to failure.

After half a year preparing for flight, the MAXIPOL team finally got its chance for a flight last fall. A balloon flight is almost a magical event, requiring the simultaneous preparation of many complex systems. The days leading up to flight are a hectic mess of insomnia and nail biting. The preparation and launch went off without a hitch, but as the balloon ascended to the stratosphere, it became increasingly clear that something was tragically wrong as the data ceased to transmit. After recovery of the payload, it was discovered that a single faulty wire was responsible for a transmitter failure. Not willing to give up so easily, the team quickly rehabilitated the experiment and within three weeks was ready to fly again. Unfortunately, by then the winds had changed and it had become impossible to fly until the next spring. To add to the frustration, a University of Chicago run experiment in the Antarctic had just announced that they had detected polarization at the 5-sigma level. Instead of discovering polarization, the MAXIPOL team would have to be content with verifying this result.

After a winter of polishing the experiment for flight, Huan returned to New Mexico with the field-hardened team. This time, the few weeks leading to flight were a relatively confident progression, and the flight was a full success, returning two gigabytes of data that are still being analyzed.

Still, it is unadvisable to rest in this field for too long. There are more secrets lurking deep in the ripples of the CMB. The most tantalizing possibility is a signature from inflation itself. The theory predicts a release of gravitational waves during the first cataclysmic milliseconds after the big bang. These waves will leave their own telltale imprint, but it will be many orders of magnitude fainter than any feature currently seen in the CMB. A large leap in sensitivity over existing instruments is required to even consider this measurement. Coupled with the large increase in sensitivity is the need to understand instrumental systematics to a level that has so far only been achieved in space. Although the task seems impossibly daunting, there are already a few groups designing and building instruments to search for the gravity waves. The reward is just too big to ignore: finding the 'smoking gun' for inflation.

Together with his sponsor Adrian Lee, Huan spends his time designing the telescope and forging the team that is building and will eventually field POLARBEAR, Berkeley's answer to the inflationary challenge. The group here has been developing new detector technologies that will allow for the required jump in sensitivity. With this next generation telescope, they will be pushing the limits of technologies and inventing new ones. But in essence, the process will not be much different from other experiments, a complicated balance between risk and reward.

OBITUARIES

Former Miller Professor James Carson , Emeritus Professor of Chemistry died November 3, 2003. He was 91.

Former Miller Professor Frank Pitelka, Emeritus Professor of Zoology died October 10, 2003. He was 87.

MILLER PROFESSORSHIP AWARDS 2004-2005

According to the Deed of Gift, the Miller Institute is "dedicated to the encouragement of creative thought and the conduct of research and investigation in the field of pure science . . . and investigation in the field of applied science in so far as such research and investigation are deemed by the Advisory Board to offer a promising approach to fundamental problems". The Miller Institute is happy to announce the awards for terms in Academic Year 2004 - 2005. Recipients are released from teaching and administrative duties, allowing them to pursue their research, following promising leads as they develop.

Recipients include:

ASTRONOMY	**ALEXEI FILIPPENKO**
CHEMISTRY	**KENNETH RAYMOND** **DON T. TILLEY**
INTEGRATIVE BIOLOGY	**TODD DAWSON** **RUSSELL LANDE**
PHYSICS	**CHRISTOPHER MCKEE**
PLANT & MICROBIAL BIOLOGY	**PATRICIA ZAMBRYSKI**
PUBLIC HEALTH	**NICHOLAS JEWELL**
STATISTICS	**TERENCE SPEED**

Birth Announcements

Congratulations **to Anat and Itay Herskovits on the birth of their baby girl, Shira, who was born on December 5, 2003.**

Congratulations **to Lee and Aaron van Hooser on the birth of their son Dylan, born on December 21, 2003.**

Miller Institute News
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Recent Publications

Please view complete lists of publications on the Miller Institute website. Publications are listed under Miller News at http://socrates.berkeley.edu/~4mibrs/Miller%20Newsletters/Table%20of%20Contents.htm

Miller Professor **Walter Alvarez** (2001-2002 term)

Miller Fellow **Yann Capdeville** (2000-2003 term)

Miller Professor **Wayne Souza** (2002-2003 term)

Awards

The Miller Institute would like to Congratulate to the following institute members:

Marvin Cohen (MP Fall 1988, 1976-77, and 1969-70) and **Steven Louie** (MP Fall 1995 and 1986-87) were awarded the 2003 Feynman Prize by The Foresight Institute.

Miller Fellow **Mark E. Hauber** was made an Elective Member of the American Ornithologists' Union at their Annual Meetting, August 14, 2003.

Jasper Rine (MP 1993-94) was named Fellow of the American Association for the Advancement of Science.

The Miller Institute is "dedicated to the encouragement of creative thought and the conduct of research and investigation in the field of pure science and investigation in the field of applied science in so far as such research and investigation are deemed by the Advisory Board to offer promising approach to fundamental problems."