



O R I O N

Newsletter of the Friends of Astronomy Cornell University

Greetings

As we approach the end of another year, I would like to extend my warmest wishes to all our Friends of Astronomy for the very best of holidays and for many good things in 2003.

I also want to thank you for your continued enthusiastic support of the Department's many activities, large and small—symposia, undergraduate teaching, graduate fellowships, colloquia endowments and support of the Atacama Project. 2003 promises to be an especially exciting one for us with the launch of SIRTf in April and of the two Mars Exploration Rovers in May and June.

The New Year will also bring us a new Director for NAIC, a new Dean for the College of Arts and Sciences and a new President for Cornell. I hope it brings each one of you much happiness, good health and a deeper appreciation of our amazing Universe.

-Joe Veverka



Cone Nebula
ACS Science and Engineering Team, NASA

Happy Holidays!

Very Dear Friends of Astronomy,

The last six months have been very active indeed with events that involved many of our Friends of Astronomy. I was happy to see such a large group at the Contour launch in Florida, and equally happy to see that many of you participated in the Don Campbell Symposium in Ithaca. To honor Don on his birthday, his friends and colleagues came from all over the world to discuss radar studies of objects in the Solar System.

During the Labor Day weekend we were delighted to receive the visit of Friends of Astronomy Lee Corbin and Adadot Hayes, who came to Ithaca to celebrate their 'big' birthday with their friends. Lee and his wife Nancy established the Josephine Hopkins Foundation Astronomy and Space Sciences Annual Colloquium. The first speaker was Professor Peter Goldreich from the California Institute of Technology. During his visit on



Winter 2002



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Happy Holidays

(cont.)

October 3 he discussed "The Formation of Kuiper Belt Binaries" in the outer Solar System.

I was thrilled that during a visit to campus Astronomy Friend Fred Young attended my class in Critical Thinking and left puzzled with new knowledge!

Our new web gallery of pictures has been updated thanks to Phil and Maddy Handler and the good work of undergraduate Silin Yang. Take a look at <<http://www.astro.cornell.edu/people/friends/photos.html>> !

We hope 2003 will be a great year for all of us.

Happy holidays to all!

-Yervant Terzian



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Night Launch

Ann Harch, Science Operations Coordinator for the Contour mission, wrote her impressions shortly after the launch on July 3rd.

When arriving at the launch viewing site, it is about a mile or more away from the rocket. It seems very far away, and the rocket seems very small in the distance, but it is beautiful. The night sky is black and I can barely make out two slender white cylinders sitting down at the end of a long dark corridor cut through the trees. The cylinders are brilliantly lit with spotlights that project into the sky. One is the rocket; another is the tower that carries clean air and nitrogen to be fed into the rocket and spacecraft. The clouds that had been threatening all day are starting to clear off and stars are visible in a huge part of the sky. While everyone is sitting in the bleachers watching the rocket, chatter from the flight control rooms is broadcasting over the loud speaker. Systems are being checked, the spacecraft is powering, there are weather reports, systems reports and the countdown process with its built-in 'holds'. Weather was a concern at some point, but the time seems to fly and soon I hear Mary Chiu say that the spacecraft is ready for launch. My stomach tightens. Suddenly I hear someone say, "30 seconds to launch," then "25 seconds." I'm vaguely aware that the time is imminent but my brain can't process all the dialog that has preceded so I'm not completely sure.

More quickly than I would like to hear comes, "10, ...9, ...8, ...7" ... many people in the crowd are counting along with the broadcasted countdown ... "6, ...5, ...4" It is clear now this is going to happen ... "3, ...2, ...1" And then in the night silence I see a flash that grows into a brilliant white ball of light beneath the rocket. Still no sound as the rocket seems to hover above the pad for a moment. It starts to rise and now there is orange fire in addition to the white ball. I'm totally focused on and consumed with this brilliant spectacle and the implication that this rocket, with a precious package inside the tip of its nose that will be our lives for four or more years, is now rising off the earth into a very huge black space above us.

When it is 60 degrees up, a crack and a roar and thunder washes over everyone and the rocket just keeps charging straight up. Red fire underneath. After all this worrying and waiting, it is happening so fast. Too fast. Part of me wants it to come back. Away and up it is rising and moving to the northeast over the ocean now. I am crying. The rocket still thundering. The path takes the rocket through a tiny wispy cloud that is momentarily lit up as it slips through and beyond. When the solid rocket boosters burn out we see them jettisoned. Four tiny orange glowing lights falling from the now tiny orange fire of the main engine. It keeps going, the orange light becoming smaller and smaller. Off into what we now realize is a very large amount of space above the earth. CONTOUR is gone from us. Gone from the clean rooms and the caring hands that built each strut and circuit. Within minutes it will clear the atmosphere and we know that the protective nosepiece will be jettisoned and the tiny little spaceship will be hurtling through space above a darkened earth at incredible speeds. All this I imagine because it is now the tiniest little orange



July 3rd, 2:47 a.m.

Robert Barker, Cornell University Photography

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Mars Rovers Preparing for Launch



Mars Rover (Simulation)
JPL/NASA

The *Mars Exploration Rover* mission is just eight months from launch. MER is NASA's next major mission to Mars, sending two large rovers to the surface of the red planet. Each rover will carry an identical copy of the Athena Science Payload, which is a set of scientific instruments and tools for study of the Martian surface. Professor Steve Squyres is the Principal Investigator for this payload, and will lead an international team of scientists as they operate both rovers on the Martian surface in early 2004. Professor Jim Bell and Senior Research Associate Rob Sullivan are also members of the Athena team.

All of the instruments on the Cornell-led payload have now been delivered to the Jet Propulsion Laboratory, where the two rovers are being assembled. Over the past four months, the science team has been focused on calibrating the "Pancam" panoramic cameras that will be mounted atop masts on each rover. This calibration work involved many from the department, including faculty, staff, graduate students, and undergraduates, working around the clock at JPL. The first spacecraft is almost fully assembled, and is undergoing testing while assembly of the second spacecraft takes place.

Both spacecraft will be shipped to Cape Canaveral next March. There they will be readied for launch and mated to their two Delta II boosters. The launch of the first MER spacecraft is scheduled for the afternoon of May 30th, and the second for shortly after midnight on the morning of June 25th. After a seven-month cruise to Mars, they will land on January 4th and 25th, 2004. Operations are expected to last for at least three months for each rover, and perhaps longer if conditions permit. Over this period, the rovers will each traverse for hundreds of meters across the Martian surface, sending back several gigabits of images and other scientific data.

For weekly news updates on the mission's progress toward launch, see <<http://athena.cornell.edu>>

Curious About Astronomy?

-Steve Squyres

Ask an Astronomer

Astronomy is a science that is particularly good at inspiring curiosity. News on television, documentaries, movies, science fiction books, and just viewing the world around them lead people to think of good questions about stars, black holes, space exploration, and many other Astronomy topics. Since the advent of the World Wide Web, it has become easier to find astronomy facts, but a lot of the information available on it is poorly organized. Finding a readable response to a specific inquiry can be hard.

Curious About Astronomy? Ask an Astronomer is a website <<http://curious.astro.cornell.edu>> run by graduate and undergraduate student volunteers answers to Astronomy questions. Anyone site and ask a question, either by sending e-mail directly. The Curious who now run the site, provides aspect of astronomy to those maintains an up-to-date previously answered questions.

Meet the Stars of the Curious Team at:

<http://curious.astro.cornell.edu/aboutus.php>

at Cornell that aims to provide specific with an e-mail address can visit the filling out a web form or by Team, a group of twelve students individual responses about any who e-mail us and searchable archive of



Dave Kornreich, who is now a Professor of Physics at Humboldt State University, started *Ask an Astronomer* in 1997, when he was still a graduate student at Cornell. In September 2001, several current students decided to update the site. They added topic pages about various areas of astronomy, each of which has a list of questions that are cross-listed and searchable. There are currently hundreds of answered questions posted on the site for browsing, and the Curious Team receives and answers a few hundred questions each month! All this is done with no formal budget or faculty involvement.

By continuing to answer questions and revise our site, the Curious Team hopes to provide a unique, growing resource for students, educators and the general public. The Team would also like to promote the site as an educational tool at conferences, such as the upcoming American Astronomical Society meeting in Seattle. *Curious about Astronomy? Ask an Astronomer* presents a great opportunity for Cornell astronomy students to participate in educational outreach while kindling an interest in astronomy in amateurs and experts alike.

-The Curious Team

Undergraduate Research

Over the years, the Department has made an effort to offer undergraduates the opportunity to work with faculty in major research projects in Astronomy, Space Sciences and related fields. Some students become involved in the work of the Department through the research grants of the faculty; others approach the faculty to work on individual projects. In addition, professor Yervant Terzian directs two programs, the NASA New York Space Grant and the National Science Foundation Undergraduate Research Program, that finance internships for students to spend eight to ten weeks working with faculty advisors on research projects.

This summer these two programs had twenty students, eight NSF interns and twelve with the Space Grant. Their research projects covered a wide range of topics.



*Our NSF summer interns
Susan Sullivan*

NSF Summer Interns

Ella Braden - Understanding the visual and infrared mapping surveyor (Phil Nicholson)

Jonathan Foster - Microquasars in the infrared (Steve Eickenberry)

Daniel Licht - Improved capacitance bridges for SPIFI (Gordon Stacey)

Thanks to the Friends

A generous contribution from Friend of Astronomy Fred Young will fund the study phase of the Atacama infrared telescope. This will be the largest instrument of its type on Earth, and its design will be optimized to exploit the favorable properties of the extremely arid high desert of Southern Chile.



Xingyang (Fred) Liu - Simulating fluid dynamics with ZEUS-2D (David Chernoff)

Amy Livernois - Designing a mounting fixture and calculating the proper motion of brown dwarfs (John Wilson and Jim Houck)

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Night Launch

speck. Suddenly, the light burns out with a puff, like a candle blown out. Only blackness remains, and a few wisps of silvery clouds and stars.

I am still crying, and we are all still there with the lights of the stands, and the happy crowd of Cornell visitors, CONTOUR and Delta rocket engineers, scientists and families all mixed together, exchanging hugs and looks of joy, thumbs up, smiles. The experience is more overwhelming than I could have imagined. I am reflecting on the incredible things that humans can make happen when they put their minds to it. This fact is blazing in my mind now. The complications of the rocket itself, attaching the spacecraft to multiple stages that are pumped full of highly explosive chemicals. The infrastructure at the Air Force base and Kennedy Space Center that has evolved over the years to support this. The incredible complexity of our spacecraft. The complexity of those things I know that are yet to come for this spacecraft. But now it's gone, it will never return.



We are left with ourselves and the crowd filing back onto the buses. The empty launch pad, still brilliantly lit by white spotlights shooting into the sky, the quiet night sky with stars. And knowing that from now on it will only be through our imaginations, and through the little signals that we see in our monitoring electronics that can think about where the spacecraft is or what it's doing. We will never see it again. The reality of this launch will slip into unreality very soon as the experience we just had is already just a memory. The reality of the mission will be a very different sort of reality. As I stand out there, I know rooms full of engineers are engaged in complicated tasks that will go on for days to get the spacecraft safely into a stable orbit. In the months and years ahead, we will talk the

spacecraft through the many complex things it will do and perform. It will wing its way through our solar system, and fly by comets and Earth. It will return pictures and data and information. In that sense the mission will be real. But in another sense, it will never again be as real as that brilliant white ball of fire beneath the rocket was just real. In the way that the orange fireball that receded into the sky, becoming smaller and smaller, was still real.

-Ann Harch

Barbara Asks!

On the Second Law of Thermodynamics

Q. *How does the time-asymmetric second law of thermodynamics arise from time-symmetric fundamental laws and why did Einstein think that it is the only law that would never be revised?*

This is a rather subtle issue, so it pays to pose the question as sharply as possible. Suppose you have a system consisting of a pair of particles interacting with one another via mutual forces only. Then the two particles orbit around one another in a completely deterministic way forever. To predict where the particles are at any given time to some accuracy, all you need to know is where they are and how they are moving at some earlier time, to similar accuracy. Moreover, one can always run the clock backwards: given where the particles are and how fast they are moving at some time, to some accuracy, you can figure out where they were at any earlier time to similar accuracy.

The situation becomes vastly worse when you add just one more particle to the picture. It turns out that even with three particles, the positions and velocities of the three particles have to be known far more accurately at some given time in order to predict where they will be in the distant future, or to run the clock backwards to figure out where they were in the past. Now given how much harder it is to predict the future or reconstruct the past

for three particles, imagine how bad it is for any macroscopic system, like the air molecules inside a room, where you have to worry about more than 1,000,000,000,000,000,000,000,000 particles at a time! If you ride on one of these particles, you will be buffeted around by the others you encounter in a way that depends on your motion relative to them. Given absolutely precise information on the motions of each and every one of these particles at some given time, you could predict where you will be sometime later with absolute certainty. But even slightly different positions and motions of the particles would propel you somewhere else! As a result, the motion of any given particle tends to become quite randomized. It is often said, correctly, that if you start out with a bag of air inside an evacuated room, and punch a hole in the bag, the air will fill the room, but still there is a nonzero chance that the air will all rush back into the bag after some time. However, that probability is infinitesimally small because of the large amount of buffeting of the molecules. It is far likelier for the molecules to spread out into a very disordered state in which they fill the room than it is for them to find their way back into the bag, with no stragglers left behind. This statistical statement, based on the randomizing character of dynamics of systems with a huge number of particles, is the mechanical basis of the second law.

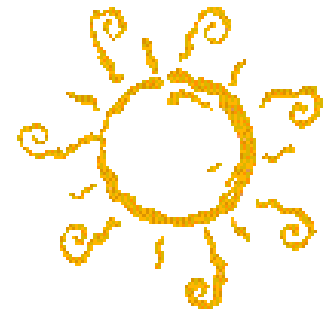
I don't know why Einstein thought it would never be revised, but the propensity for particle trajectories to spread out, both

in space and velocity, on which it is based is inevitable. Although one could, in principle, follow these trajectories exactly given absolutely precise positions at some time for all 1,000,000,000,000,000,000,000,000 (or more!) particles, attaining such precision is almost unimaginable, and clearly is impractical. Since the trajectories spread out rapidly with time, even a small level of imprecision for a small subset of particles is enough to stymie any attempt to predict where particles will go with any reasonable accuracy.

The same phenomenon has been treated quantum mechanically, but is not so well understood, by the way.

-Barbara Burger (for the question)

-Ira Wasserman (for the answer)



Postscript to Night Launch

As we wait to learn the status of Contour, I have had time to quietly reflect on the nature of the work we do. We are unbelievably lucky in this country to have the luxury of a space program. Despite the ups and downs, NASA pushes ahead year after year with the relatively modest budget it has considering the wealth of our country.

Personally I feel grateful to have had the honor to work in what later on will be considered the very early beginnings of space exploration. We are still barely getting to know the terrain of our own solar system. It's hard to believe that only 16 years ago humans first saw clear images of the seventh planet, Uranus. And three years later we glimpsed the sleepy blue ball of Neptune for the very first time. Prior to the Voyager II flybys, these giant neighbors were only small fuzzy distant blobs of light in the largest Earth telescopes. Before 1990, we did not know the details of the topography of the planet Venus. Before 1991, asteroids were nothing

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Books in Science and the Universe

Dr. Stephen Wolfram, one of the most promising scientists of our time, visited Cornell in the Fall. He talked about his provocative new book, *A New Kind of Science*, where he describes how nature (the universe) can in principle be described with simple computer programs called “cellular automata”. In his book he clearly shows how from even very simple rules one can produce extremely complicated behavior. He implies that the entire universe could have started from very simple beginnings.

Children of the Stars is a new book by Dr. Daniel Altschuler, the Director of the Arecibo Observatory in Puerto Rico. This beautifully illustrated book has been published simultaneously in English and in Spanish by Cambridge University Press. Daniel has done a great job describing the evolution of the universe in simple, understandable language and in an easy and pleasant style. Among his chapters: “Cooking the Elements”, “The Birth of Planets”, “Other Worlds”, and “The Dark Crystal Ball.”

-Yervant Terzian



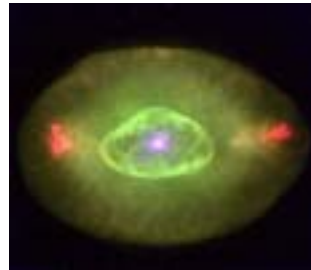
Yervant's Critical Thinking Corner

Undergraduate *(cont.)*

Laura Lopez - Infrared analysis of microquasars (Steve Eickenberry)
Catherine McGleam - Measuring galaxy rotation velocities (Martha Hayes)
Kate Rubin - Search for bow shock nebulae from high velocity neutron stars (Jim Cordes)

Space Grant Students

Mark James Adams - Evolutionary robotics (Hod Lipson)
George Thomas Adamson - Influence of ambient pressure on droplet burning and design and construction of a new drop package for the microgravity experiments (Mark Campbell)
Cathy Jordan - Jupiter clouds and winds (Peter Gierasch)
Chris Atwell and Daniel Broderick - Vortex formation from a vibrating sphere (Charles Williamson)
Wajih Effendi - Control of autonomous and semi-autonomous systems (Raff D'Andrea)
Radford Fagan - Combustion of jet fuel droplets in microgravity (Tom Avedisian)
Mike Nichols - Develop model to predict shear in meridional wind over Arecibo (Mike Kelley)
Dave Veltre - Engineering small science satellites (Mark Campbell)
Lisa Wei - Mapping aeolian features on Mars (Peter Thomas)
Marcus Woo - Radiation from neutron stars (Dong Lai)



Several readers inquired about the illustration on page 1 of our first issue. It is NGC 6826, the Blinking Eye Nebula. The image was taken by Bruce Balick, Arsen Hajian and Yervant Terzian with the Hubble Space Telescope.

UPDATE YOUR E-MAIL!



Send a note to
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pf46@cornell.edu

Dara Zeehandelaar - Transit spectroscopy and atmospheric analysis of HD 209458b (Joe Harrington)

-Patricia Fernández de Castro

- * A newspaper reported on the results of a population survey: “The results indicate that half the population is below average.”
- * A football coach, upon being appointed: “We’re going to turn this team around 360 degrees.”
- * At the airport check-in: “Has anyone put anything in your bag without your knowledge?”
- * If you don’t succeed at first, skydiving is not for you.

Postscript *(cont.)*

more than tiny flickering pinpoints of light racing around the sun. Now, after a decade of effort, we have seen the barren and beautiful landscape of four asteroids. And we have seen close up two of the millions of comets that call this solar system home.

In these exciting years, NASA still largely pushes ahead into unknown territory, with wonder and discovery at each step. The space business is not for the weak of heart. Each small success is hard won. But as long as Congress continues to provide the resources, you can be assured that there will be people compelled to fly spacecraft to the planets, the asteroids and the comets. There is so much more to see and learn in this special time. I can only wait with anticipation to see what the next decade will bring.

-Ann Harch