O R I O N

Newsletter of the Friends of Astronomy Cornell University

Greetings

Dear Friends of Astronomy:

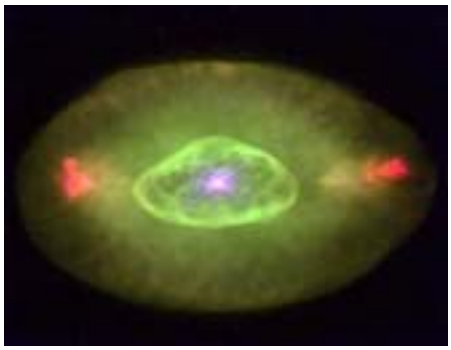
Time flies.[1] It's hard for me to believe that the Friends of Astronomy is now in its tenth year.

We have enjoyed many good times together: symposia in honor of Yervant's birthday, Joe's birthday, Ed's retirement, and several others for no reason beyond our interest in astronomy and the department's willingness to host us. All of these have been stimulating events, and good fun, besides. And good things have come from your support of the department: the Terzian Scholarships, several fellowships, a professorship, the Hewitt classroom lab, student awards for research achievement, and several sponsored colloquia, to name a few.

There's more to come. Over 75 Friends are signed up to attend the launch of the Contour mission from Cape Kennedy on July 1, 2002. We're looking forward to a great behind-the-scenes tour of the Space Center and some wonderful lectures and presentations by Yervant, Joe, and some of the mission team members.

Many, many thanks to Patricia Fernández de Castro for her good work in putting this newsletter together.

-Bob Cowie



[1] Always in accordance with the principles of special and general relativity, of course.

The Best Friends of All

It was early in 1992 that I discussed with a few Cornell Alumni and Trustees the possibility of forming a group called 'The Friends of Astronomy at Cornell'. Robert A. Cowie strongly encouraged me to pursue this idea and the late Vice President for Public Affairs Dick Ramin was enthusiastic. Our first organized function took place in the Fall of 1992 where we hosted about 70 Friends in a Symposium on campus and discussed issues on cosmology and the exploration of the solar system. The late Carl Sagan was with us and I recall how eager and happy he was meeting all the Friends.

Today the group numbers about 100 Friends and we have managed to organize on the order of about one event per year. Typically, more than 50 Friends participate in each gathering. Last Fall a large group was present to celebrate Joe Veverka's 60th birthday, and on July 1st of this year about 75 Friends will view the launch of the spacecraft CONTOUR from Cape Canaveral in Florida.

Continued p. 2

Spring 2002

Contents

Department of Astronomy
Cornell University

Editor
Patricia Fernández de Castro
pf46@cornell.edu

Best Friends *(cont.)*

There we shall celebrate our 10th anniversary.

I am happy to inform you that I have worked with Cornell Adult University to organize a trip to Saint Thomas and Puerto Rico the first week of March 2003 so that we can visit the Arecibo Observatory. I suspect many friends will participate since we have had many requests for such a visit.

Through the last decade, our Department benefited greatly from the generosity of many of you. Thank you for thinking well of us.

Make sure to visit the Department's web site <http://www.astro.cornell.edu/> and click on the Friends' page. There we also have begun a gallery of pictures from our many events. You can also inspect our 'Ask an Astronomer' website at <http://curious.astro.cornell.edu/>.

This is the first Newsletter directed to the Friends of Astronomy, and we owe this to Patricia Fernández de Castro who volunteered to put this together for us. Thank you Patricia and we look forward for the next issue.

-Yervant Terzian

WOULD YOU LIKE TO UPDATE YOUR E-MAIL?

Send a note to
Patricia Fernández de Castro
pf46@cornell.edu

Interview with Professor Joseph Veverka

The State of the Department

Professor Joseph Veverka, Chair of the Department of Astronomy, talked to Orion about the current state and the future of the Department

What is the state of the Department at the present time?

One of the things that we do is great research and we have many, many projects. The other thing we do is we teach people, both at the graduate and undergraduate levels, and one of our goals is to improve the quality of what we can offer our graduates and undergraduates.

First of all, let's talk a little bit about graduate and undergraduate research. One of the things which, as a Department, we are very good at is getting undergraduate students involved in some of the forefront research projects that we do. That is, surprisingly, somewhat unusual. A lot of Departments don't do that. In that context one of the areas that we need to focus on is the future of optical and infrared astronomy. Right now we use the 200-inch telescope at Mount Palomar. This used to be the largest telescope in the world, but now it's something like sixteenth on the list. To continue to offer our students the best research facilities in those areas we really need to go beyond Palomar, and that's why we're devoting so much energy as a Department to the Atacama Project, the goal of which is to build a large modern telescope that will be important for research and provide our students with the opportunity to get involved in forefront scientific research.

What else is important for the Department at present?

On a smaller scale than Atacama, we must consider that most of our students will not be professional scientists—will not be professional astronomers. But they are interested in astronomy. And one of the things they are extremely interested in is actually observing the sky, in using a small telescope. And in that area we have a challenge, because for years we have been using a telescope which is located near some residences near Bebee Lake. A number of things have happened. One of them is that telescope is literally 60 or 70 years old, at least. So it's certainly no longer representative of a modern telescope. But worse than that, in the last year the University has built large dormitories and dining halls right next to Fuertes Observatory. So that at night, instead of being able to see the sky, you see sky light from dormitory windows and dining hall windows. To continue offering the best instruction for undergraduates, we have to embark on a replacement for the facilities at Fuertes, which means a modern telescope in a site that is dark. That is a bit of a challenge because we also want it to be accessible to students, so obviously, we don't have the option of locating it far away. We're actively working right now, trying to find a site

on campus which is dark enough, and we have developed some plans for a replacement telescope.

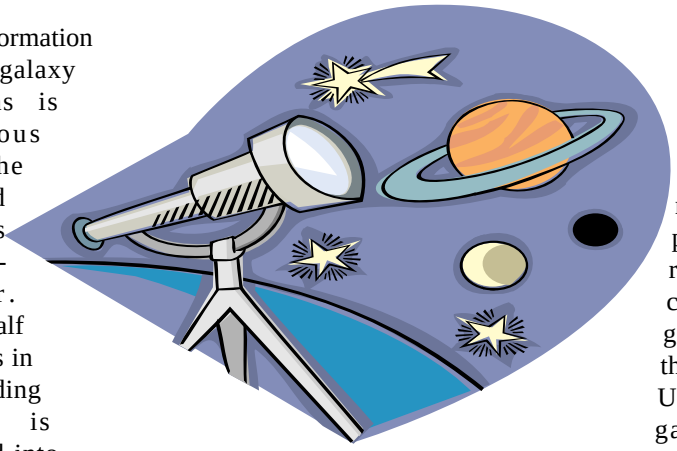
Another area that's related to undergraduate education is that, in addition to traditional astronomy, the Department also has a number of people who use spacecraft, to observe the universe. One of the exciting things about being an undergraduate at Cornell is that students have the opportunity to participate in research projects that involve space missions. Unfortunately, in the past we've only been able to get students involved using whatever facilities we happen to have available for a particular mission. In fact there is no central facility where students can participate in such projects on a larger scale. And there, something like the Hewitt Laboratory comes in mind—the Hewitt Lab is a facility that Ed Hewitt helped us set up to teach students how to analyze astronomical data. It would certainly be very valuable if we had a similar facility for students to participate in some of the space missions that are actively being pursued from this building, like the Mars missions and the CONTOUR project.

The last thing that I would like to add is that we are trying to involve not only students from the Physical Sciences, but

Continued p. 3

OH Megamasers: Natural Microwave Laser Beacons from Colliding Galaxies

For my Ph. D. thesis, with advisor Riccardo Giovanelli, I used the upgraded Arecibo radio telescope to hunt for rare microwave lasers produced in distant colliding galaxies. These microwave lasers, called OH megamasers, are produced by the OH (hydroxyl) molecule. Masers (microwave lasers) are known to occur naturally in star-forming regions of our own galaxy, and megamasers, which are at least a million times stronger than these local masers, only seem to occur in the wreckage of colliding galaxies.



The star formation in these galaxy collisions is prodigious and the associated fireworks are spectacular. Nearly half of the gas in the colliding galaxies is converted into millions of stars in a few dramatic bursts. Some of the gas is also fed into supermassive black holes lurking in these galaxies' hearts. At some time during these chaotic festivities, the reservoir of OH gas achieves just the right density, excitation, and geometry to send a maser beam towards the Earth. These strong beams of radio waves can be detected at the giant Arecibo telescope with great sensitivity from distances of a billion light years or more.

My thesis involved a survey for OH megamasers covering a quarter of the sky out to a distance of about 3 billion light years. The survey discovered 50 new OH megamasers, which doubles the number known in the Universe. We also discovered that OH megamasers are not steadily shining objects in the sky, but can twinkle like stars as their light passes through the tenuous ionized gas in our own galaxy, the Milky Way.

OH megamasers may provide bright radio beacons of colliding galaxies early in the history of the Universe when galaxies were young. Counting OH megamasers at various epochs throughout the history of the Universe may indicate the role of merging in the formation and evolution of galaxies. Astronomers do not know if present-day galaxies, like the Milky Way, formed from the merging of many small galaxies or if they coalesced as a single unit. OH megamasers may allow astronomers to address this fundamental aspect of galaxy evolution.

-Jeremy Darling

Interview *(cont.)*

get them more involved in some of the things we do here. We're actually talking to people in the College of Engineering to try to set up some programs that would make it a lot easier for this to happen.

Sounds like it will be very exciting to be a student at Cornell in the next few years! Has the number of students increased in the last few years? Do you expect changes in the enrollments?

Our graduate population has remained more or less constant, and that's because we feel very strongly that all our graduate students deserve special attention, so we usually have a ratio of at most two to one, students to professors, and since our faculty has not grown, the number of students has remained the same. That way we can deal with them individually, providing them with a lot of attention. Certainly people very much want to come to Cornell to do graduate work, but it's very competitive. We tend to get the best students not only from this country, but from all over the world.

On the undergraduate front, most of the students that we teach—and I believe the number is something like 400 per semester—are not going to be professional scientists, so we have a whole series of courses that not only discuss general astronomy, but some deeper questions, including philosophical questions. The response has been extremely positive. We also teach courses that are more aimed at students who are specializing in sciences and astronomy, and there again, our purpose is to have a close interaction with the students, so we tend to limit the enrollments. For instance a course in learning how to analyze astronomical data, because of the facilities that are available, is limited to something like 60 students per semester and there are twice as many applicants. So certainly, the interest is out there but we have tended to emphasize quality of education over quantity of students.

What are some recent examples of successes of the Department?

There are many things that we do and many successes. One important area is that we continue to build instruments for the Palomar 200-inch telescope. Steve Eickenberry has recently developed a new camera which is able to take wonderful images of large sections of the sky at wavelengths that were not readily available.

We also have people who have been working very hard on space missions. In that area there's a mission that's called SIRTF, which is getting ready for launch next year, and Jim Houck built a spectrometer for that. Another project which is getting ready for launch is CONTOUR. The spacecraft is completely finished, and the launch is scheduled for July first.

Continued p. 4

Nicola Kountoupes/University Photography

Mars Rovers

The new game on Mars is science. Though it returned a great deal of information, the famed 1997 Mars Pathfinder mission was more about seeing if we could get back to Mars than pure scientific research. I began working with Professor Steve Squyres and the Cornell Mars team in late 1999, just after the launch of Mars Polar Lander. Its disastrous crash brought about a new sense of urgency, the next mission would have to be a success. NASA chose our 2003 Mars Exploration Rovers for the job. We would be packing them with as much science as possible and the hope of finding conclusive evidence that there was once liquid water on Mars.

With the coming of the new mission, the atmosphere changed. The two 2003 Rovers would travel up to 100 meters a day, have better cameras, more instrumentation, and greater opportunity to be involved. They called for student work on mission planning, image calibration, data compression, landing site selection. It was very exciting, and will only get more so. Over the next year, there will be periodic opportunities to fly out to NASA's Jet Propulsion Lab and work with mission hardware. One student even machined the actual calibration targets for the instrument arm. I held an object in my hand that will be on Mars in two years time!

This past Thanksgiving, I helped in constructing the first full-size model of a 2003 Rover. Working many a sleepless nights, our team made a beautiful model that will tour about museums of the East Coast. As a double major in Physics/Astronomy and Film, I have been able to work with TV scientist Bill Nye the Science Guy and even create my own documentary about the Rover mission. I am currently working with image compression, improving the Rover model, Mars outreach, a new project with Bill Nye and a personal research project on the Martian polar ice caps. Mars couldn't be a bigger part of my life.

I have watched the landing of NEAR (Near Earth Asteroid Rendezvous) mission and the launch of Mars Odyssey spacecraft along side the scientists and engineers that designed them. For me however, the most exciting event will be the launch of the first Mars Exploration Rover, shortly after my graduation in 2003. I couldn't think of a more thrilling experience to add to my undergraduate education. For me Mars is as exciting as it gets.

-Matt Siegler '03

Interview *(cont.)*

What is the status of the Department's Mars projects?

On the Mars front, there's a spacecraft that went into orbit last fall, Odyssey. One of the nagging questions about Mars is how much water is there and where is it and until now it's been very difficult to test the possibility that below the ground of Mars there's ice. Steve Squyres played a major role in helping design instruments on Odyssey that may be able to detect the presence of ice on the surface of Mars. He'll also be analyzing the data when they come in. We are also working hard on two Mars Rovers that will be launched in 2003.

I should also mention that Don Campbell continues to use the Arecibo radar telescope to observe asteroids. It turns out that a lot of the asteroids that come close to earth are actually double objects, they're binaries, one big rock revolving around another rock. That's something that wasn't really suspected.

What is your vision for the Department for the next ten years?

There are always two parts to any vision of that sort. One part is that we want to do things better than we have been doing, and there the major project for us would be to develop a large infrared optical telescope. That's certainly a major part of our vision for the next ten years.

We also want improve some of the other things that we are doing, and one of them is that Cornell has always been at the forefront of radioastronomy. One of the questions is what happens in radioastronomy beyond Arecibo? There is a very exciting project called the Square Kilometer Array, which is basically an attempt to build a huge radio telescope by using new technology, putting together a lot of small antennas, and we as a Department think that a lot of the future exciting discoveries in radioastronomy will be made with such an instrument so we have people—Yervant Terzian and Jim Cordes—working very hard at making that kind of instrument a reality, having Cornell play a major role.

Continued p. 6

Barbara Asks!

On the 'Unreasonable' Effectiveness of Mathematics in Comprehending the Universe

Q. *Does mathematics succeed unreasonably well in explaining the Universe?*

I can see two ways of looking at the question. To some extent, mathematics was developed originally to explain quantitative properties of the observed world. In this sense, that it does a good job seems tautological—mathematics is the language of quantitative observation, so of course it also succeeds in describing what it was developed to describe. But, over the years, mathematics has grown far beyond being the language for describing observations quantitatively. Indeed, one could say that of all the technical sciences, mathematics is the hardest, as it is based on free intellectual invention, largely independent of any experimental input. Thus, it should not surprise you that the realm of modern mathematics far exceeds what is needed by current theories of the Universe. Since only a subset of the whole body of mathematical knowledge can explain what we see in both the micro- and macrophysical realms, it is rather unsurprising that clever scientists can always find some bit of mathematics germaine to a given scientific issue. Beautiful examples include developments in geometry that preceded the discovery of the general theory of relativity, but are central to it, and developments in the related area of group theory and symmetries, which eventually became indispensible to understanding elementary particles. In fact, it was working in this area at MIT that E. Wigner remarked he was astonished at the effectiveness of mathematics in explaining Nature. Whether all of the rest of mathematics, whose applications are not clear, actually will turn out to correspond to some aspect of the properties of our real Universe is unknown to us, as is whether new mathematics will be needed in future for quantitative understanding of the world.

Q. *Why can telescopes peer only into the past, not the future?*

Relativity does not say that there is an unavoidable symmetry between past and future. The statement that time is relative means that different observers moving relative to one another (or in different places in a gravitational field) can disagree on the times, as measured on their own clocks, at which a given event occurs. However, if two observers see that one event causes another, then all observers will agree that they cause one another. The condition that two events can cause one another in special relativity is that it is always possible to find a particular frame of reference in which those events occur at the same place, but at different times. Moreover, if, in one particular frame of reference, two events are recorded as happening at the same time, but at different places, then they can never be the cause of one another. This is a consequence of one of the laws of nature on which relativity is based, namely, that the speed of light is a speed limit for all signals to be sent between observers.

If it were possible to peer into the future, rather than the past, then to do so would violate these notions of causality, and would require some version of travel faster than light, which appears to be impossible. A more complicated issue is whether highly warped spacetimes can exist that allow the 'practical' equivalent of acausal communication, but all research of which I am aware points to the conclusion that this is impossible without the presence of large amounts of exotic—and probably unstable—matter.

-Barbara Burger (for the questions)
-Ira Wasserman (for the answers)

Thanks to the Friends

In 2001 and 2002, generous contributions from Friends of Astronomy have established three annual colloquia at the Department. Ron Ekers, director of the Australia Telescope National Facility, CSIRO, discussed "The Future of Radio Astronomy" in the first Charles and Barbara Burger Special Colloquium Series on October 18, 2001. Shri Kulkarni, professor of Astronomy at Caltech, presented "Gamma Ray Bursts: The Brightest Explosions in the Universe" in the first Maryanne Shelley Jessup MacConochie Astronomy Colloquium, created by Bob and Vanne Cowie, on May 2, 2002. In addition, the first Josephine Hopkins Foundation Colloquium, arranged by Lee and Nancy Corbin, will be announced shortly.

Contributors

Barbara Burger
Founding Member, Friends of Astronomy
Robert A. Cowie
Chair, Friends of Astronomy
Jeremy Darling
Department of Astronomy Ph. D. '02
Patricia Fernández de Castro
Editor, Orion
Matt Siegler
Department of Astronomy
Undergraduate '03
Yervant Terzian
The David C. Duncan Professor in Physical Sciences
Joseph Veverka
Chair, Department of Astronomy
Ira Wasserman
Professor of Astronomy and Physics

Books in Science and the Universe

Carl Sagan, *Cosmos*. A beautifully produced account of our knowledge of the universe.
Freeman Dyson, *Disturbing the Universe*. An account of how modern science happens! An excellent personal presentation.
Richard Feynman, *Surely You're Joking Mr. Feynman*. Autobiography of a great scientist. Very enjoyable reading.
Stephen Hawking, *The Illustrated A Brief History of Time*. The bestseller on the Universe.
Roger Penrose, *The Emperor's New Mind*. A readable classic on the status of science and reality, bold and challenging.
Steven Weinberg, *Dreams of a Final Theory*. A provocative and enthusiastic account of the possibilities of finding A Theory of Everything.
Brian Greene, *The Elegant Universe*. Superstring theory without equations. A possible Theory of Everything.
Brian Silver, *The Ascent of Science*. An excellent historical account on science in our civilization, very informative.
Stephen Hawking, *The Universe in a Nutshell*. Modern theories of the universe.

-Yervant Terzian

Yervant's Critical Thinking Corner

- A student in my office, in the presence of his parents said, "Professor, I promise you that I'll graduate on time, no matter how long it takes"!
- An exam question in a science course at a prominent university read as follows: "Describe the Universe and give two examples."
- A newspaper article describing the results of a population survey had the following two statements: "The survey showed that half the people are below average", and also, "The survey showed that 3 out of 4 people make 75% of the population."
- A customer in a restaurant was asked if he wanted his pizza cut into 4 or 8 pieces. The customer replied, "Four is better, eight is too much food."
- A politician talking to a group of school children said, "I want all of you to be in the top 20 percent"!

Interview *(cont.)*

Of course we shall continue our work in infrared astronomy. Also, we're one of the leading Departments in the country that's involved in planetary sciences and again, that's something we want to continue into the next decade.

In addition, the glue that brings all of this together is that Cornell has always been very fortunate to have first rate theoretical astrophyscicists, who, while they don't generally do observations, they help us understand and interpret our observations and again that's an area that we're working hard to maintain and improve

One thing that makes us fairly unique, I think, is that as a Department we do not depend on any single person because we have so many excellent people, and so we're not in a position where one professor retires and the Department collapses. We have many, many first rate people in the faculty and that's why we have been so successful in so many projects. That's actually true, that's not just propaganda! (laughing)

It's an honor to be a chair in such a Department!

-Patricia Fernández de Castro

Recent Friends Activities and Future Events

-On September 14-16, 2001, we had a Symposium to celebrate Joe Veverka's 60th birthday. Activities included presentations and lectures by Kip Thorne (Caltech), Joe Veverka, Yervant Terzian, Riccardo Giovanelli, Steve Eikenberry, Steve Squyres, Paul Goldsmith, Eanna Flanagan, Saul Teukolsky, Terry Herter and Jim Houck, the inauguration of the Hewitt Lab, and a meeting of the Friends led by Bob Cowie. At the dinner party we had a birthday rap by Barbara Burger and friends and a hilarious skit by Jim Bell and company.

-On July 1st, we will witness the launch of the spacecraft Contour from Cape Canaveral in Florida. Activities will also include presentations by CONTOUR Science Team members and Yervant Terzian.