ORION

Newsletter of the Friends of Astronomy Cornell University

Summer 2009

Dear Friends,

Another year is drawing to a close. As you know, the University is facing financial problems. As a result of these, all departments in the Arts College, including ours, have had to cut their budgets by 5%, with similar cuts expected next year. These cuts are unwelcome but unavoidable. We continue to work hard in both research and teaching, and to do our best to maintain our excellence in both.

One noteworthy event this spring was the commemoration of the life of Ed Salpeter held here on March 14. Many of Ed's friends, students and colleagues from all over the world came to Ithaca to be part of this remembrance. Key speakers included Freeman Dyson, Ed's long-time friend and colleague, Kip Thorne, who reminisced about his 1977 sabbatical from Caltech spent as Ed's "postdoc," and Lars Bildsten, one of Ed's last Ph. D. students, who shared his memories about Ed's often inscrutable but ultimately enriching teaching style. After dinner speakers included an array of Ed's former students, now influential and renowned scientists in their own right, plus his grandson, Nick Buckley, who is just starting his career in science as a Caltech freshman. Ed, who was one of the most optimistic, forward-looking people I have ever met, would have liked the event.

We hope to see you at the Friends' Special Symposium and celebration of Yervant's birthday October 9-11, 2009!

–Ira Wasserman

NGC 604, a giant stellar nursery some 3 million light-years away, is about 1,300 light-years across (nearly 100 times the size of the Orion Nebula). Blue hues show X-ray data from the Chandra Observatory on optical data from the Hubble. (X-ray: NASA / CXC / R. Tuellmann (Harvard-Smithsonian CfA) et al.; Optical: NASA/AURA/ STScI).

Greetings

I am writing this letter from my hotel room in Cape Kennedy, Florida. A couple of hours ago I witnessed the spectacular launch of the Shuttle Atlantis on its way to repair the Hubble Space Telescope (HST). This was a unique experience. The astronauts will replace old and broken instruments with new improved ones to make the Hubble better than new. The HST has already provided enormous amounts of the best astronomical data and has taught us what the universe looked like billions of years ago. Surely, new discoveries are waiting to be made and we look forward to being surprised by the secrets of the cosmos.

We invite all of you to our next Friends of Astronomy Symposium in October, and do not hesitate to bring your family and friends.

Best wishes,

–Yervant Terzian

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P. Fernández de Castro, Editor

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Outreach in the International Year of Astronomy

Ann Martin is a fourth year graduate student who uses the Arecibo Radio Telescope to study hydrogen in nearby galaxies.

Among scientists, astronomers are lucky: from kindergartners to octogenarians, people *love* what we do, and invariably want to know more about it. In 2009, the International Year of Astronomy, the astronomy community as a whole is renewing its dedication to outreach and to sharing the night sky with everyone who sleeps under it at night. Being able to share that excitement—the thrill of looking through a telescope for the first time, of contemplating the scale of the Universe and our place in it, or of some complicated concept "clicking" for the very first time—is a large part of what drew me to astronomy. It's also the reason I've made education and public outreach a major focus of my experience as a graduate student here at Cornell.

This is true of many of my peers and of the Department as a whole. We have a strong history of public outreach, as can be seen from the large corps of volunteers that shows up whenever an opportunity arises. Moreover, in recent times we've benefited from the arrival of our Outreach Coordinator, Nancy Schaff. Perhaps our most visible outreach effort is our website *Curious? Ask an Astronomer* <http://curious.astro.cornell.edu/>. This web service, started by graduate student Dave Kornreich 12 years ago and still run by graduate students, answers questions submitted by members of the general public. We have over 700 questions posted online, but if someone has a question and can't find the answer there, they can use a simple web form to submit the question which graduate student volunteers answer via email. At the moment, we have around 20 volunteers answering between 50 and 70 questions each week!

Since my second year here, I've been responsible for sorting through the *Curious* questions as they come in and assigning each one to the grad students who are likely to shed some light on it. I've enjoyed answering the questions that end up in my inbox, but it's been even more interesting to see every single question that comes through and the background information included by the submitter. We reach a wide range of people this way. As you might expect, we receive many questions from students in elementary school, but we also get questions from physics and astronomy high school teachers, amateur astronomers, science fiction writers, and from people who have taken up astronomy and cosmology as a hobby during retirement. The questions themselves are as varied as the people who ask them. Naturally, we see a lot of questions about school projects and about objects visible in the night sky, but I've also resolved bets between friends. Once we even got a question about the best time and place to propose marriage under a full moon. (We helped the prospective groom figure out when the Moon is closest to the Earth in its eliptical orbit—the lunar perigee—including daylight time corrections, pointed out that no place would be substantially "closer" than any other and that the moon would look just like it had the night before, and wished him luck!)

I participate in several other outreach efforts, including activities for visiting school groups and giving public talks at nearby science centers. Personally, however, my favorite type of outreach is a workshop. Unlike other forms of outreach, this format allows you to get to know the participants and help them evolve and learn over the course of several days. For example, for the last two years I have organized, with the help of other graduate students, a three-day workshop for high school members of 4-H. Each year, Cornell invites these students to visit and spend three days with the department of their choice in a program called "Career Explorations: Focus for Teens." We of course try to have a lot of fun with the students, whether we're making ice cream with liquid nitrogen or launching rockets on the Library Slope, but we also focus on giving them an idea of what it's like to have a career in science. We incorporate elements of problem solving, engineering, and team work into each session that we offer. This year, we're planning a poster session where groups will present information on an important chemical element, as well as a longer session where teams will plan a mission to Mars from beginning to end, starting with the selection of mission goals and ending with a "proposal" to NASA that incorporates engineering and other constraints. Workshops like this allow astronomers to show what, exactly, it is that we do all day, and participants have an opportunity to walk in the shoes of a scientist. This being the International Year of Astronomy (IYA), we're making a special effort to involve as much of our community as possible in outreach events. I've had the honor of being chosen as one of 52 NASA Student Ambassadors for IYA, through the New York Space Grant program, and I have a lot of ideas up my sleeve. My projects include developing a set of talks for a Cornell Astronomy Department speaker's bureau, to make it easier and simpler for Cornell astronomers to visit schools and science centers with current content. I'm also building a set of kits that can be used in various outreach programs through the Cornell Public Service Center. Each kit

A visit to Fuertes Observatory to view stars and other astronomical objects awes and inspires children and adults alike.

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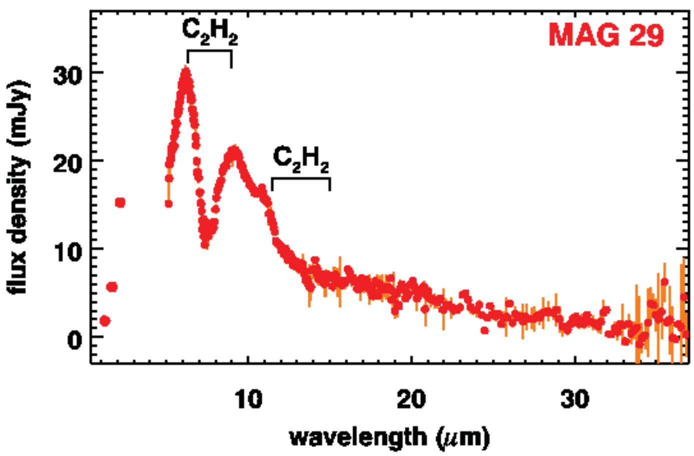
Fun with the *Spitzer Space Telescope*

Greg Sloan recently led a paper describing the detection of dust around a carbon star in the primitive Sculptor Dwarf Spheroidal Galaxy over a quarter million light years away.[1]

We are in the midst of a revolution in astronomy. Advances in technology are driving the progress as much as the cleverness of astronomers. Infrared astronomy provides a great example. The military has had a strong interest in infrared detector technology, which makes it possible for ground forces using night-vision equipment and spy satellites in Earth orbit to detect radiation from room-temperature objects, such as people and vehicles. For astronomers, the development of infrared detector arrays and the launch of a series of infrared space telescopes, in combination, have meant we can observe classes of objects we could only dream about a decade ago.

Jim Houck, the Kenneth A. Wallace Professor of Astronomy, has participated in the revolution of infrared astronomy from its beginnings, going back to the launching of sounding rockets with infrared detectors in the 1960s. In the 1980s, he was heavily involved in the *Infrared Astronomical Satellite (IRAS)*, which surveyed the entire infrared sky, recording the positions and brightnesses of nearly a quarter million point sources. As impressive as this feat was, there was more to come. Even while *IRAS* was operating, in 1983, Prof. Houck was preparing a proposal to build the Infrared Spectrograph (IRS) for a future infrared space telescope.



This spectrum indicatesS the presence of carbon rich dust and acetylene gas (C_2H_2) in the Sculptor Dwarf Spheroidal Galaxy. Located within the constellation Sculptor, this galaxy is a satellite of our Milky Way.

It would be 20 years before the telescope, now named the *Spitzer Space Telescope*, was finally launched. Today, *Spitzer's* sensitivity allows us to routinely study the infrared spectra of objects 500 times fainter than what IRAS could observe. Such jumps in technology open up whole new classes of objects for observation and often revolutionize what we know. It's almost inevitable. It shouldn't be surprising, then, to learn that Prof. Houck assembled a large team of infrared astronomers, in advance of the launch of *Spitzer*, not just to take the IRS through its paces but also to capitalize on what it could show us.

Our projects have covered a wide range of astronomical topics, from the study of the moons in the outer Solar System to high-redshift galaxies close to the edge of the observable Universe. My research on the IRS Team focuses on nearby galaxies in the Local Group (the group of galaxies that includes our Milky Way, the Andromeda galaxy and their satellite galaxies). *Spitzer* has enabled us to study individual objects in them, such as interstellar dust clouds, nebulae around hot young stars, protoplanetary disks, dying stars, and the nebulae they produce. Many of these galaxies have primitive abundances of elements heavier than hydrogen and helium, much like the early Universe.

Spitzer's sensitivity effectively makes these galaxies time machines, allowing us to probe conditions that existed when our own Galaxy was young and the Big Bang was a recent event.

Infrared astronomy is all about dust, since it is the dominant emitter and absorber of radiation at those wavelengths. Dust is also a key coolant in galaxies. Without it, collapsing clouds would remain hot and unfragmented, allowing only very massive stars to form. It takes dust to allow normal stars, like the Sun, to form. Thus, our primary interest is in how the properties of this dust have changed from the beginning of the Universe until now.

Spitzer allows us to observe different galaxies in the Local Group to study different stages of galactic evolution. Our work is ongoing, but we have already reported one critical finding: you don't have to wait long for dying stars to make carbon-rich dust,—not if you consider half a billion years long. The Universe is 13.7 billion years old, and in the greater scheme of things, half a billion years is pretty quick.

This carbon-rich dust produced by dying stars is a key ingredient of the material between stars. In spectra from almost every type of object imaginable, we see the telltale signs of organic material, complex hydrocarbon molecules that seem to be able to survive in surprising places. We know that these hydrocarbons form as a component of the dust produced by dying stars. We also know that they are the building blocks of more complex structures, among

[1] *Science* (Vol. 323, p. 353).

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The Atlantis Launch

At 2:01 pm EDT on May 11, 2009, the space shuttle Atlantis and crew took off on a mission to repair, for the last time, the Hubble Space Telescope. Yervant Terzian was among the guests invited to see the launch.

The day before, I had the opportunity to meet with Mission Specialist astronaut Dorothy Metcalf-Lindenburger, who has been assigned to the crew of STS-131, targeted to launch in February 2010 to the International Space Station.

Workers close space shuttle Atlantis' payload bay doors around the hardware for the STS-125 mission to service the Hubble.

Photo: NASA/Kim Shiflett.

Six minutes and 33 seconds to go. We were all counting!

The launch, finally. Everything went as scheduled.

As I write, on May 20th, the crew is preparing to return after working on the Advanced Camera for Surveys, the Cosmic Origins Spectrograph, the Imaging Spectrograph, the Data Handling Unit, and the batteries (which were part of the original equipment!).

-Yervant Terzian

Photo: NASA/Scott Andrews.

The Big Bang Chronology: Evidence and Gaps

Terry Herter studies galaxies and star formation. He leads the Near Infrared Telescope on the Joint Astrophysical Nascent Universe Satellite (JANUS), which has been proposed to observe gamma ray bursts and quasars in the epoch of re-ionization.

The Big Bang theory postulates that the Universe started in a very hot, very dense state and expanded into what we see today. The figure and timeline on pages 6 and 7, from the NASA mission WMAP (Wilkinson Microwave Anisotropy Probe), show this remarkable evolution.[1] There is compelling observational evidence that the basics of the Big Bang theory are correct. The three fundamental "pillars" of evidence are 1) galaxies are moving away from each other with a velocity proportional to their separation, 2) the presence of the CMB (Cosmic Microwave Background) radiation, a remnant of when the universe was dense and hot, and 3) the observed abundances of the lightest elements (helium, lithium, and deuterium), which could only have been produced in a hot dense early Universe, not in stars. However, there are definite gaps in understanding the details, particularly at very early times. Let us trace the growth of the Universe and look at how well we understand the steps.

The Universe began with a bang but we really do not (and may never know) how or why it started. The first (Planck) epoch requires new physics, such as string theory to unify gravity and quantum mechanics, but even then we will need testable hypotheses to validate any models that are put forward. After (or maybe during or at the end of) the GUT (Grand Unified Theory) epoch there was an inflationary period in which the Universe expands rapidly. Inflation, which is an expansion of *space itself* and is not limited by the speed of light, is used to explain why the universe is (geometrically) "flat" and causally connected (looks the same in all directions) but it requires a very large extrapolation of the known laws of physics.

As the Universe began to expand, it also began to cool down, allowing particles of ever lower mass to exist for more than just an instant. In much less than the blink of an eye (1/1000 of a second) the Universe cooled to the point where protons and neutrons could remain stable (known as the Hadron epoch). After a few minutes, the light elements, helium, lithium, and deuterium formed (Nuclear epoch). After about 400,000 years, the Universe cooled enough for atoms to form, the epoch of "recombination." At this point the Universe became transparent, allowing the radiation left over from the earlier periods to travel freely. This is the CMB radiation we see today. These epochs are reasonably well understood.

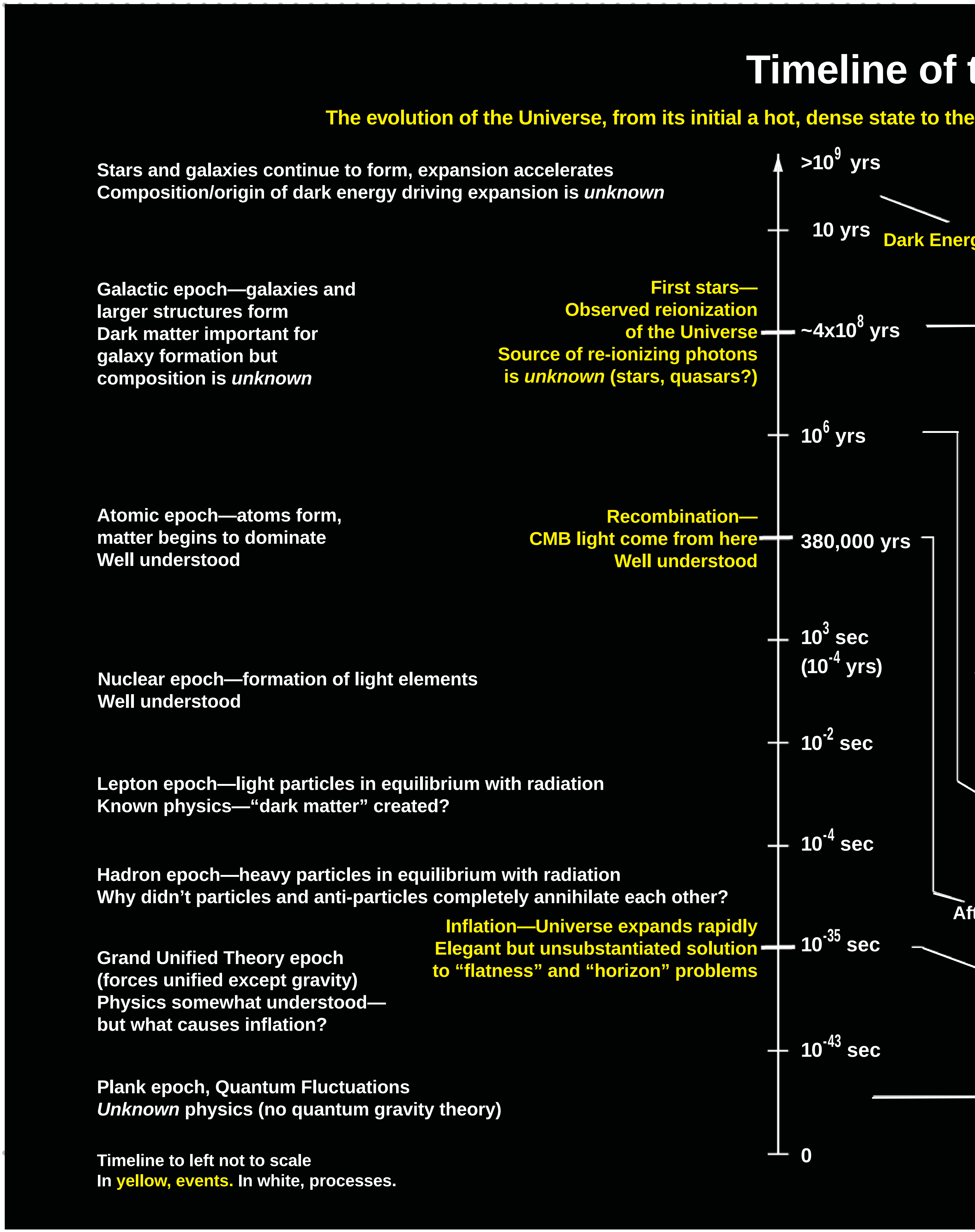
It was during the Hadron or Lepton epoch that the unknown exotic "particles" that comprise dark matter were likely created. Dark matter is the term used to describe matter which causes gravity but is not otherwise seen. Astronomers find that the mass seen in interstellar gas and stars is ten times less than that inferred by gravity. As the Universe expanded, parts began to clump together to form the structures that would be stars, galaxies, and clusters of galaxies. There is indirect evidence that within 400 million years, the first generation of stars (and maybe quasars) appeared, since *something* emits the photons which re-ionized the neutral gas that formed at recombination. In addition, observational evidence shows that by one billion years, there were greater than two billion solar mass black holes in quasars. The maximum growth rate of a black hole by accretion of normal matter was first derived by Ed Salpeter, a Cornell faculty member, but we do not understand how such large black holes appeared so rapidly. Over the next one hundred billion years or so stars continued to form.

During this whole time the Universe has continued to expand. Contrary to our original expectations that gravity would slow the expansion, the expansion rate has actually increased. An unknown energy, often called dark energy, pushes galaxies apart ever faster. The origin and composition of this dark energy is completely unknown, lending uncertainty to projections about the ultimate fate of the Universe.

In this very brief look at the history of the Universe, we can see there are many gaps in our knowledge of the formation and evolution of the Universe. In the coming decade, astronomers and physicists will explore the time before the recombination era through more refined measurements of the CMB (polarization), send probes into space to study the detailed effects of dark energy on the motion of galaxies, launch telescopes to look for the first stars, and refine theories uniting gravity and the other forces. Will the Big Bang theory survive into the future? Yes, almost certainly so. Will it undergo substantial changes and refinement? Yes, almost certainly so. Therein is the challenge and enjoyment!

-Terry Herter

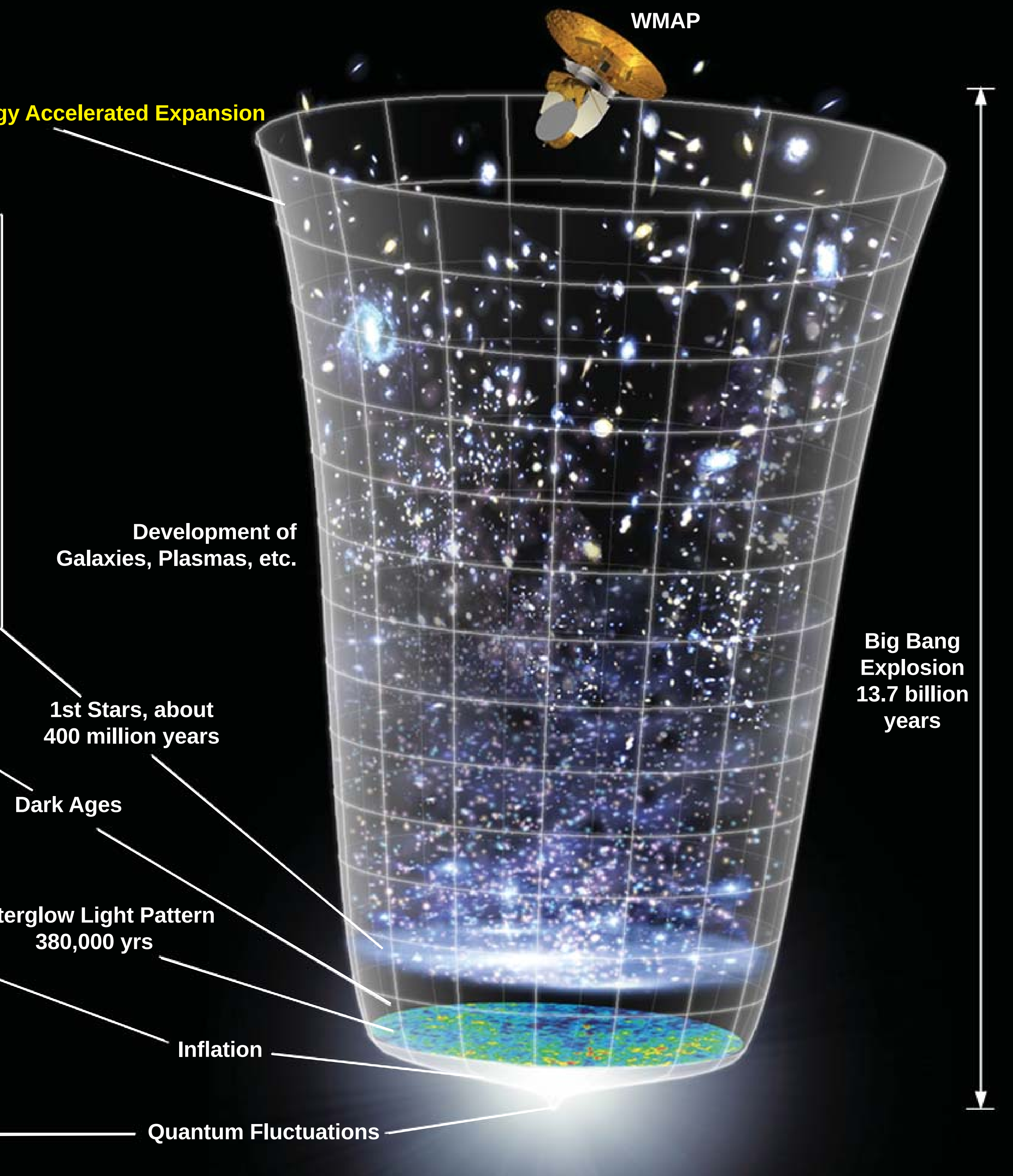
[1] The irony of comprehending the formation and evolution of the Universe is that we must deal with both the very small and the very large. To represent these magnitudes we use scientific notation (e.g. $0.00138 = 1.38\times10^{-3}$ or $299{,}800{,}000 = 2.998\times10^{8}$), otherwise we would need too many zeros!



Timeline of t
The evolution of the Universe, from its initial a hot, dense state to the
Stars and galaxies continue to form, expansion accelerates
Composition/origin of dark energy driving expansion is *unknown*
>10^9 yrs
10 yrs
Dark Energ
Galactic epoch—galaxies and larger structures form
Dark matter important for galaxy formation but composition is *unknown*
First stars—
Observed reionization of the Universe
Source of re-ionizing photons is *unknown* (stars, quasars?)
~4x10^8 yrs
10^6 yrs
Atomic epoch—atoms form, matter begins to dominate
Well understood
Recombination—
CMB light come from here
Well understood
380,000 yrs
10^3 sec
(10^-4 yrs)
Nuclear epoch—formation of light elements
Well understood
10^-2 sec
Lepton epoch—light particles in equilibrium with radiation
Known physics—“dark matter” created?
10^-4 sec
Hadron epoch—heavy particles in equilibrium with radiation
Why didn’t particles and anti-particles completely annihilate each other?
Af
Inflation—Universe expands rapidly
Elegant but unsubstantiated solution to “flatness” and “horizon” problems
10^-35 sec
Grand Unified Theory epoch
(forces unified except gravity)
Physics somewhat understood—
but what causes inflation?
10^-43 sec
Plank epoch, Quantum Fluctuations
Unknown physics (no quantum gravity theory)
0
Timeline to left not to scale
In yellow, events. In white, processes.

the Universe

formation of stars and galaxies over a timescale of 13.7 billion years.



Right side: NASA/WMAP Science Team
Left side: Terry Herter / Orion

Outreach in the International Year of Astronomy *(cont.)*

will include the materials and instructions for several activities accessible to a wide range of ages, as well as a picture book to get things started in a classroom or afterschool program. I'm also planning a large community event for Halloween in 2009. (To learn more about the IYA and events taking place across the country, or to participate, visit the website of the United States' IYA node: <http://astronomy2009.us/>).

You may wonder why I dedicate so much time and energy to these efforts. It's enjoyable, and fulfilling, but the main reason to work with the public is that informal education serves a greater purpose. The purpose of many outreach efforts is to serve as important recruitment tools for careers in the STEM disciplines (science, technology, engineering, and mathematics). Yet, when I visit a classroom of middle school students, I know that very few will ever consider a career in research science. It's not my goal to get them to love astronomy just because I want them to become astronomers. Instead, I approach outreach in a different way. First, it would be fantastic if more people had the chance to experience the awe that astronomy inspires. The people of Ithaca and the surrounding regions of upstate New York aren't less deserving of the opportunity to engage with science just because we don't live within a few miles of the Hayden Planetarium. Astronomy belongs to all of us, and should be accessible to all of us.

Second, science education is truly critical for my audience, whoever they might be. The students and adults I work with might not ever need to figure out the chemical abundance of a star-forming nebula, but they will need to balance a checkbook, decide which health insurance plan is right for them, and vote on critical issues related to science, engineering, and energy policy. For some people, astronomy may be the only science they ever think is "cool", That represents a major challenge and opportunity for an informal educator. Thinking like a scientist, applying critical thinking to everyday problems, and giving weight to evidence are skills that need education and practice to refine. This, and the joy of contemplating our place in the Universe, is what Cornell astronomy education and public outreach has to offer to our local community.

-Ann Martin

Thanks to the Friends!

Lamarr Parsons '09 was this year's Terzian Fellow. Lamarr, who graduated this summer, was part of the Extragalactic Group and of the Arecibo Legacy Fast Alfa Survey. He was also the treasurer of Help Us Stop Hunger, a student organization.

Phil Muirhead received the 2009 Cranson W. and Edna B. Shelley Award for Graduate Research in Astronomy in recognition of his contributions towards the extrasolar planet search program at Cornell, and his role in the development of TripleSpec and T-EDI. Kassie Wells was awarded the 2009 Cranson W. and Edna B. Shelley Outstanding Teaching Assistant Award for her initiative in the development of assignments for the writing classes for which she TA'd (Astro 233), for the assistance that she gave to the students via information on the course WEB site and her very constructive and detailed comments on their writing assignments. The Department selected Jennifer Burt '10 as the recipient of the 2009 Cranson W. and Edna B. Shelley Award for Undergraduate Research in Astronomy for her contribution to understanding the surprising structure of Saturns rings as seen in Cassini images.

The Department is very grateful to the Friends for their support. Thanks!

Fun with *Spitzer* *(cont.)*

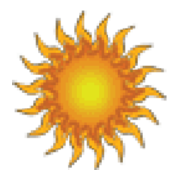
them amino acids and other precursors to life. It is exciting that we can now state that materials of this type are ejected back into space by stars soon after the Big Bang!

Many questions remain unanswered. We are looking forward to the other lessons remaining for *Spitzer* to teach us.

-Greg Sloan

Jim Houck Receives Weber Award

Prof. James Houck received the Joseph Weber Award for Astronomical Instrumentation of the American Astronomical Society, "for his extraordinary contributions over nearly four decades to major instrumentation for infrared astronomy." The citation further said, "It is no exaggeration to say that without Dr. Houck's contributions, modern IR [infrared astronomy] would never have reached its current level of maturity." Congratulations, Jim!



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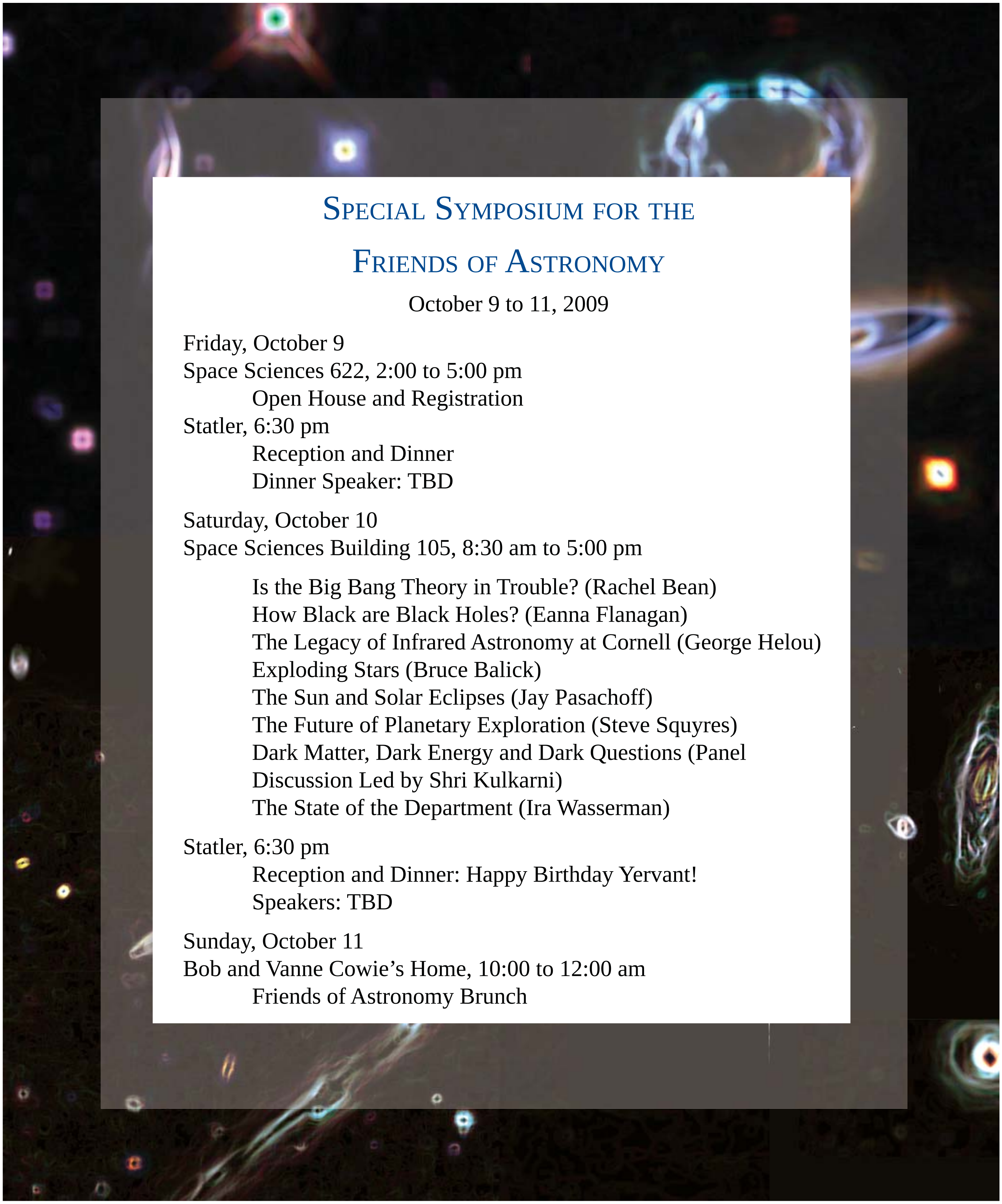


Special Symposium for the Friends of Astronomy

October 9 to 11, 2009

Friday, October 9
Space Sciences 622, 2:00 to 5:00 pm
    Open House and Registration
Statler, 6:30 pm
    Reception and Dinner
    Dinner Speaker: TBD

Saturday, October 10
Space Sciences Building 105, 8:30 am to 5:00 pm

- Is the Big Bang Theory in Trouble? (Rachel Bean)
- How Black are Black Holes? (Eanna Flanagan)
- The Legacy of Infrared Astronomy at Cornell (George Helou)
- Exploding Stars (Bruce Balick)
- The Sun and Solar Eclipses (Jay Pasachoff)
- The Future of Planetary Exploration (Steve Squyres)
- Dark Matter, Dark Energy and Dark Questions (Panel Discussion Led by Shri Kulkarni)
- The State of the Department (Ira Wasserman)

Statler, 6:30 pm
    Reception and Dinner: Happy Birthday Yervant!
    Speakers: TBD

Sunday, October 11
Bob and Vanne Cowie’s Home, 10:00 to 12:00 am
    Friends of Astronomy Brunch

Registration Form

Name: ______________________________

Address: ______________________________

____

Telephone number: ______________________________

E-Mail address: ______________________________

Number of persons attending: ______________________________

Names of persons attending other than yourself: ______________________________

____

Dietary restrictions: ______________________________

____

____

Amount enclosed: ______________________________
($210 per person; includes the program, meeting materials, coffee breaks, lunch, dinners and receptions. Please make checks to Cornell University)
This form and a very complete list of hotels, inns, B&Bs are available at:
<http://www.cornell.edu/events>

Please send to:

Patricia Fernández de Castro
Department of Astronomy
510 Space Sciences Building
Cornell University
Ithaca, NY 14853

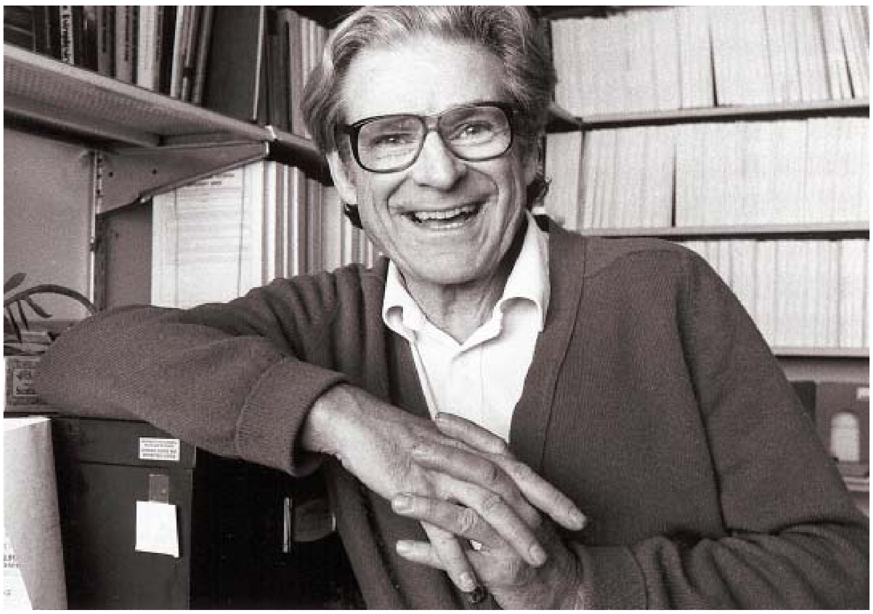
RSVP by August 15, 2009.

Barbara Asks!

Q. What was Ed Salpeter's greatest contribution to science?

A. Ed was a chameleon of science, someone who tackled virtually the entire kaleidoscope of cosmic phenomena during his career. He described himself as a generalist, but that almost understates the scope of his accomplishments.

A casual glance at a list of Ed's former students shows just how wide his coverage of the world of science was. He had early students who worked in pure physics, probing the implications of quantum electrodynamics. He had students working on the properties of dense matter, critical to the understanding of white dwarfs and neutron stars, and also, at the low mass end of "cold'' bodies, the planets. He had students working on observations of the interstellar gas at the same time as he had other students working on the theory of the structure and properties of the interstellar gas. He had students working on plasma physics and astrophysics, nuclear physics and astrophysics, atomic physics and astrophysics. He even had one student who became Director of the Lawrence Livermore National Laboratory, where nuclear weapons are designed, but almost to maintain balance he had another student who is now one of the foremost scientists working on arms control.



It would be easy to say that Ed's greatest single accomplishment was to show how ordinary Helium burns to Carbon in massive stars; after all, he won a prestigious award, the Crafoord Prize, for that work. Or that his initial mass function, which describes the rates of birth of stars of different masses, was his greatest work. Or that the idea that gas falling toward black holes would make them visible indirectly was his greatest inspiration. But what about his paper with John Bahcall that predicted that primoridal Hydrogen clouds between Earth and a quasar would absorb some of the radiation, thus revealing their existence—an insight that led to what is now called "Lyman alpha cloud'' astronomy? Or his papers showing how nuclear physics affects the maximum mass of a white dwarf, the so-called Chandrasekhar mass that might just as well be called the Chandrasekhar-Salpeter mass given the importance of Ed's refinements of Chandrasekhar's earlier work. Or what about his other papers on the low mass white dwarfs, which show how solid state effects become increasingly important at smaller and smaller stellar masses, until they become dominant around the mass of Jupiter, and remain so at all lower masses?

How did he do all of this? Lest you think otherwise, he was the complete opposite of a gadfly: Ed's work in all of these different areas was profound. To add a personal note, I have known many great physicists and astrophysicists in my career—almost all of the courses I took in graduate school were taught by future Nobel laureates—but Ed was unique. He was a master of almost all of physics, and could also synthesize observations to isolate the important physics needed to explain them.

So, in the end, considering this great mass of diverse accomplishments in astrophysics, I would say that Ed had two equally great and lasting achievements in science.

First, perhaps more than any other single person, Ed brought the full menu of physics into astronomy. Others may have concentrated on one or two subfields of physics that matter, such as nuclear physics or general relativity, but Ed brought numerous aspects of physics into the field, giving meat to the often repeated maxim that anything can happen in the Universe, and often does. This represented, I feel, a transformative attitude shift. There may have been a few "astrophysicists'' before Ed, but as much as anyone else he made astrophysics a legitimate profession.

Second, and not unrelated, was his virtually unmatched success in mentoring great students who themselves became leaders in the field. In physics, one often speaks of "schools'' that grew up around some of the great physicists. Ed created a diverse and vibrant 'Salpeter school of astrophysics' that continues to energize our field today.

Oh, and by the way, I am told that he did some pretty good work in biology too.

-Barbara Burger (for the question)
-Ira Wasserman (for the answer)

Books in Science and the Universe

The Constant Fire: Beyond the Science and Religion Debate, by Adam Frank (University of California Press, 2009).

The author of the book is a Professor of Astrophysics at the University of Rochester. In some sense I am his 'grandfather' since his Ph.D. Advisor was one of my very first graduate students at Cornell, Bruce Balick, Professor of Astronomy at the University of Washington in Seattle.

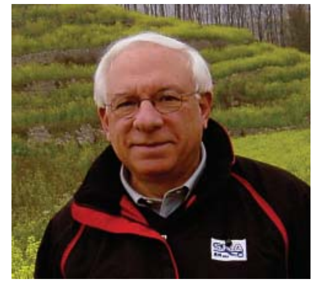
In his book, Adam has taken up a formidable topic in our society, one that has created conflict since science began to unmask the secrets of nature without the need of religion. But Adam is very much aware of this and tries to create a new path, one that ignores traditional religions and scientific dogma. He tries very hard to explain this new path, but at the end one gets only a vague idea of what his new approach is. Yet, he is an eloquent writer with many interesting discussions throughout his book. There are indeed superb and clear writings on topics like the Big Bang theory of the universe and Global Warming.
The 'constant fire' he suggests is the aspiration to know what is essential, what is real, what is true. Adam states "scientific results do not provide science's connection with the domain of human spiritual endeavor." He suggests that science is a gateway to an experience of the sacred, and that science is deeply rooted in our mythic traditions.

He states that "The longing we feel for understanding, the aspiration driving science and spiritual endeavor, will never be satisfied by an equation written on a page or a proscription encoded in scripture" and argues for a new way of looking at science and spiritual endeavor.

You have to dig deep and hard in his book to try and find this new way!

–Yervant Terzian

Yervant's Critical Thinking Corner



There was a young girl who told me she had a dog. When I asked what color was the dog, she said "He is brown or black or gray. Make some guesses and then I'll give you a hint. That should be enough for you to find the color."

So I said, "He is not black."

– "He is either brown or gray."

– "He is brown."

The young girl said, "At least one of your guesses is right and at least one is wrong."

What is the color of the dog?

Answer: If the dog were black, all three guesses would be wrong. If the dog were brown, all three guesses would be correct. Therefore, the dog must be gray.

Space Shuttle Atlantis on the launch pad before dawn last April. This image, taken by *Charles Danforth (CASA, U. Colorado)*, was chosen Astronomy Picture of the Day for May 13th, 2009.