APS Forum on Graduate Student Affairs

FGSA Newsletter

International Meeting on Graduate Student Affairs in Mexico, October 2003

From Tom Tierney, FGSA Treasurer

Planning for a joint meeting of the Canadian, American and Mexican graduate students in each of the physical societies (called CAM2003) is under way. At the invitation of Dr. Carmen Cisneros Gudino, President of the Division of Atomic and Molecular Physics for the Sociedad Mexicana de Fisica (SMF), FGSA Treasurer, Tom Tierney, attended the annual SMF meeting in Leon, Guanajuato Mexico during the week of October 27, 2002.

During this meeting, Tierney not only had the opportunity to meet Mexican undergraduate and graduate students, but also to attend the conference sessions. The discussions with the students constitute the first stage in drafting a program for the inaugural meeting that will incorporate the interests of American and Mexican students.

One of the results of these discussions is the decision that the conference will be held in Merida, Yucatan Mexico during the month of October. The CAM2003 meeting will be held in parallel with the annual SMF meeting such that students may see the broad scope of physics research currently conducted in Mexico. In addition to the oral and poster presentations of work performed by students, several topical sessions will be held. These sessions include: graduate education in the three countries, how to develop international collaborations, career development, reviews of major discoveries in the 20th century and major physics problems for the 21st century. The FGSA is very excited about the potential this conference has to offer. We welcome your input! If you would like to share ideas or participate in the planning, please email cam2003@aps.org. Please see Karsten Heeger's article in this newsletter for further details.

Plans for the Future, Notes From the Past

From Karsten Heeger, FGSA Chair

2002 was an exciting year for the FGSA. - For the first time FGSA participated as an independent forum at the annual APS meetings and division conferences. In 2002 the Forum on Graduate Student Affairs hosted several APS sessions in addition to special student receptions at the March and April meetings. A student lunch was organized for participants at the Four Corners' meeting.

A broad program of meeting activities was initiated last year by FGSA's chair Chad Topaz and organized with the support and help of the APS staff. The sessions at the APS meetings included: "Astrophysics in the 21st Century," "Improving Physics Graduate Education," "Lunch with Experts," "How to find and Hold a Faculty Job," and "Rethinking Graduate Education." These sessions were attended by both students and senior APS members. The attendance numbers of these sessions varied between 25 and 150 students and up to 200 scientists.

The traditional student receptions at the March and April meetings, organized with support of the FGSA, were a big success. A quiz with great prizes tested the students' knowledge of physics trivia and everyone enjoyed the free food and drinks that were kindly sponsored by the APS.

For 2003 FGSA is planning an even more ambitious and exciting program. In addition to activities at the annual APS meeting, FGSA is heading the organization of a graduate student conference for students from Canada, Mexico, and the US.

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The American Physical Society has agreed to jointly organize a conference for graduate students together with the Canadian Association of Physicists (CAP) and the Mexican Society of Physics (Sociedad Mexicana de Fisica or SMF). This joint Canadian, American and Mexican conference (CAM2003) will be held in Mexico in October 2003 and will be the fourth such meeting over the past 15 years. For the first time it will be organized as a graduate student conference by student representatives from the three countries. The SMF has offered to host the meeting as a satellite to their annual meeting and will act as the local organizing committee.

The goal of CAM2003 is to bring about 200-300 students and scientist together in Merida, Mexico, for a unique gathering under the theme "Student Visions for the 21st century". Last October Tom Tierney (FGSA Treasurer) traveled to the annual meeting of the Mexican Society of Physics to start the planning process for the CAM2003 student conference. He hosted a session with student participants of the SMF meeting to discuss ideas for next year's meeting and to make contact with our fellow students from SMF. A NSF proposal for support of the organization and American student participation in this Canadian, American, and Mexican conference was submitted in late October. We are hopeful for a favorable review which would allow us to move ahead and pursue the planning and organization of CAM2003.

Stay tuned for more information on CAM2003 and other exciting FGSA activities next year, and be sure to check our website (http://www.aps.org/units/fgsa/) regularly for news and updates.

Hope to see many of you at the APS meetings and at CAM2003 in Merida, Mexico this year!

Letter From The Editor

From Jennifer West

In this second issue of the FGSA newsletter we have updates from the forum officers, interviews with 2 famous and wise professors, articles on human integrity and more. We have been working very hard in our forum and hope you like the directions our group is taking. We welcome communication from our members. If you would like to contribute an article or have any interests you would like to see mentioned in our newsletter, please send us an email.

Join Us!

Join the FGSA! Current APS members may join the Forum on Graduate Student Affairs (FREE) by amending their membership online at http://www.aps.org/memb/unitapp.html or by checking the box on their renewal form.

Nonmembers of the APS may join both FGSA and the APS (and another Forum free!) online at http://www.aps.org/membstudents.html or http://www.aps.org/membhalfprice.html. The membership fee is WAIVED for first-time student members. New regular members (and all junior members) may join at a special rate of $50.

This newsletter comes out after the 2002 midterm elections and what I find most interesting is the number of people who did not vote. Approximately 55% of the population stayed home. During the same year, our membership has almost doubled. It makes me curious - what causes us to get involved? What causes some to remain uninvolved? What can we do to encourage people to speak their minds and become involved, both on a small scale (the FGSA) and on a larger scale (national voting)?

Certainly the amount of time devoted to social and economic issues in any debate is alarmingly low. Watching the television debates and ads does not inspire or compell a person to cast a vote. Apparently in the race for governor of Massachusetts, one candidate aired television ads that showed early photos of his wife and himself at a highschool dance, and early family photos from raising their children. And that was it. The opposing candidate bought air time for ads equally devoid of political content.

I would like to echo Professor Jaffe from MIT (interviewed in this newsletter) and say that it is a good idea for us to get involved with any issue that we feel strongly about, whether it be federal funding for the hard sciences, education, campaign finance reform, war and peace, postdoctoral salaries, anything at all. It is harder to do this when we have families and houses (for those of us who don't already!).

Becoming involved may mean a greater involvement for those of us doing research in collaboration (probably all of us!). This touches on Brian's article about scientific integrity. If our names are on a scientific paper, to what extent are we responsible for the reported results? According to the independent reviewers of the Schon case, the collaborators were not guilty of intentional deception. The question of how responsible co-authors are for results is an active area of study right now, and one we might want to think about. I know that I have my name on a paper with at least 7 co-authors. I would not have felt comfortable unless I was able to reproduce the results of the data analysis myself, which I was able to do. In my case it was not difficult, since the raw data was x-ray satellite data easily accessed by all members of the group, and more or less easily reduced. I may have differed with the first author in his interpretation of some of the features in the data, but at least I was confident that the features were indeed there.

In large collaborations it is not realistic for each co-author to do all the analysis him or herself. However, leaving a large part of the data analysis to only one person strikes me as unwise. Unwise not only because of the possibility for some kind of data faking, that is actually the least worry statistically speaking, but because of some data mistaking. It is easy to make mistakes in data analysis. And unless you write scripts for every step in

Letter From The Editor

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the analysis (a smart thing to do by the way) then redoing and checking all steps in data reduction can be prohibitively time consuming. It is important to check your data analysis, and unless you are writing a paper by yourself on a new result, it is a good idea to have your collaborators check key results with their own analysis. More than one person should have a copy of the raw data!! That is an absolute must. It is very good for us, the younger generation of scientists, to learn from the mistakes of our elders.

As well as learn from their glories!! Which is why we include 2 new interviews in this issue of the newsletter. The first interviewee is Joseph Polchinski from the University of California, Santa Barbara, a renowned high energy theorist who is also a wonderful and inspiring person to talk with. The second interview is with Robert Jaffe, a professor and director of the Center for Theoretical Physics at MIT, also a famous and passionate physicist who was kind enough to talk seriously with our forum. I hope you enjoy reading their thoughts as I enjoyed talking with both of them.

Integrity in Research

From Brian Utter, Member-at-Large

Science is the process of discovering truths about the world. Ok, perhaps it's not that simple - biases, pride, and honest mistakes certainly add elements of subjectivity to the pursuit of truth, but we hope that objectivity and integrity are the dominant motives in physics research. When we collaborate with other scientists or read the papers of our colleagues, we expect them to not only adhere to these values, but to fully endorse and encourage them. However, the discovery of two high-profile examples of blatant data falsification in the past years has made it evident that truth is not always sacred. As the surprise over these falsifications fades, questions about the roles and responsibilities of scientists have been raised.

Hendrik Schˆn, a physicist at Bell Labs, was heralded as a rising star in the physics community based on his research in molecular semiconductors that would revolutionize electronics. His results were good. I mean, too good. Experimental curves looked nearly like theory and repeated attempts to reproduce these results failed. These first signs of trouble culminated in the September release of an independent review confirming the falsification. The review summarized the allegations and categorized them into three classes: (1) substitution of data, (2) unrealistic precision of data, and (3) results that contradict known physics. In 16 cases, they found compelling evidence of scientific misconduct. Schˆn has since been fired and the original papers retracted by Bell Labs.

Meanwhile, at the Lawrence Berkeley National Laboratory (LBNL), the topic of conversation is element 118 - or rather, the nonexistence of element 118. In 1999, a team of researchers at LBNL announced the discovery of the heaviest artificially-created isotope observed to date, a discovery with important implications to the so-called "island of stability" of long-lived nuclei at atomic numbers around Z = 120. Three years later, it has become clear that the decay chains observed were in fact falsified by Victor Ninov, a member of the research team. Again, the lack of reproducibility led to concern and the eventual retraction of the findings in 2001.

One obvious question is, "How did a couple of intelligent physicists think they would get away with this?" There are actually allegations that Ninov has been involved with falsifying data since work done in 1994. This might be a deeper question of psychology, as denials of wrongdoing from both Schˆn and Ninov provide no obvious illumination.

Perhaps a better question is how it happened that the coauthors of the papers didn't catch on. Admittedly, most of us give our collaborators the benefit of the doubt. Ninov's coworkers trusted him as an expert and, for good reason, didn't see the need to double-check his work. Yet for such a major discovery, it's perhaps a little surprising that nobody else analyzed the raw data files. In Schˆn's case, it's far more baffling, as he managed to publish a paper on average every 10 days for about 3 years; many of these papers appeared in premier science journals. Some of these contained identical plots, even when different materials were being studied. In both cases, the collaborators have been cleared of intentional falsification of data.

Some people fear that these cases cast science and scientists in a bad light. But to the contrary, science worked perfectly in these instances as shocking results and a lack of reproducibility led to inevitable retractions by LBNL and Bell Labs. The misinformation has been identified and corrected, even though many students and scientists now realize that they have devoted limited time and resources to pursuing research goals based on false data. The obvious failures were isolated to two individuals; for that, there is no remedy.

But while the immediate situations have some closure, a new set of questions have been opened. They are far more complex than how to respond to a particular set of results that cannot be reproduced or an individual person that has falsified data. They are ethical questions about how we communicate our truths and how we maintain and insure our integrity. How much responsibility does a scientist have for the results of the entire collaboration? To what extent can referees be expected to catch inaccuracies, particularly as they volunteer their time? What standards should exist for archiving data and laboratory notebooks? What sanctions exist for scientific misconduct?

Science must remain focused on discovering truths about the world, with the intent of finding objective and universal laws. We are reminded by these failures that scientists are human and that as a group we must hold ourselves and our collaborators to the highest standards of integrity.

Author's notes:

1. The results of the independent review can be found at http://www.lucent.com/news_events/researchreview.html.
2. For a fascinating account of the element 118 saga, see the September issue of Physics Today, or http://www.aip.org/pt/vol-55/iss-9/p15.html.

A Letter From The Past Chair

From Chad Topaz, Past Chair

With 2002 behind us, I want to take this opportunity to give you a brief report on some of the goings-on of the APS Forum on Graduate Student Affairs.

Membership. I'm pleased to announce that since the formation of the FGSA in mid-2001, our membership has grown to include over 700 members. One of our primary goals is to keep this number growing so that even more physical scientists in academia and industry can experience the benefits of membership. I encourage you to let your colleagues know about our group. Membership information is conveniently available at http://www.aps.org/memb.

Programming. 2002 saw the advent of the first FGSA-sponsored events at APS meetings, including the March Meeting, the April Meeting, and the Four Corners Sectional Meeting. These events included scientific sessions, career development seminars, social mixers for young scientists, and more. The FGSA leadership is currently working to offer even more programming for the upcoming year. One option that we are pursuing is an international meeting of graduate students, planned in collaboration with the physics societies of Canada and Mexico, which would bring together scientists from the three countries. We will keep you updated on this exciting effort.

On-line resources. Our website has grown this year to include even more graduate student resources. If you haven't browsed the website recently, I encourage you to look at http://www.aps.org/units/fgsa in order to take advantage of career resources, education resources and research resources. Check back frequently, as we are continually updating the content to keep it current.

Communication. When the FGSA leadership is in close contact with the membership, everyone benefits! In order to let you know FGSA news more frequently, we are planning to send brief e-mail news updates at least twice a year beginning in 2003. We will also continue to produce our usual newsletter. Of course, we are also interested in hearing from you. The more feedback you give us, the more we will be able to provide the sorts of resources and programming that interest you most.

Leadership. FGSA Elections are currently underway for the positions of Chair-Elect, Members-at-Large, and Secretary. I'd like to thank outgoing Executive Committee members Xin Chen, Louise Parsons, and Jennifer West for their outstanding work on the FGSA. Their generous contributions of time and talent have been invaluable to the group.

The FGSA is here for you. If you have any questions, comments, or concerns for the FGSA, feel free to contact us at fgsa@aps.org.

Interviews With Famous Physicists

Interview with Professor Joseph Polchinski,

of the Institute for Theoretical Physics, University of California, Santa Barbara. Professor Polchinski is a world renowned high energy theorist, author of the most recent and widely used textbook in string theory (called String Theory by the publishers, Joe's Big Book of String by graduate students and Joe himself) and famed for his discovery of D-branes (read the book!). Here he speaks (figuratively) with editor Jennifer West on a variety of topics.

1. Why did you decide to pursue high energy theoretical physics and when did you make this decision?

JP: In high school and before, I had always been interested in fundamental questions such as the nature of gravity. But high school science can't go too deeply into these things, so my focus was more on mathematics. When I got to Caltech as a freshman I quickly learned that what I wanted to do was called high energy theoretical physics. Of course, the Feynman-worshipping culture at Caltech was a factor, but an even bigger one was my classmate Bill Zajc, who had read the Feynman lectures in high school and taught me a great deal. Bill has done well also, he's the spokesman on the PHENIX detector at RHIC.

2. Did your graduate school experience enhance/detract from/or not affect your desire to do physics?

JP: I think my desire to do physics was pretty high both at the beginning and the end. My grad student experience was a bit nonstandard: my advisor Stanley Mandelstam was very smart and creative, but a somewhat outside the mainstream; also, I didn't have a lot of `street smarts' about doing research. One consequence is that I had written zero papers when I applied for my first postdoc (and only three, two of which were not very good, by the time I applied for my second). But I learned a lot, especially about quantum field theory; one high point was a journal club with the other students and postdocs.

3. What advice did your thesis advisor give you on pursuing a career in physics academia vs. industry?

JP: Stanley was on sabbatical my final year, so Bob Cahn was a surrogate. He was the one who gave me `the talk' about how bad job prospects in academia were (to which my response was the usual `yeah, I'll worry about that when I have to'). He also coached me when I was negotiating postdoc offers.

4. Did you follow his/her advice? (Joe, this is from a conversation I remember some years ago, and you told me a story about your advisor giving you advice and I really liked that story, so I am trying to get you to tell it again.)

JP: I am not certain which story you are referring to, but in the one that I have repeated the most often the hero is David Jackson (of the textbook), and it comes a bit earlier. My first two years in grad school I was wasting a lot of time, trying to work on several things at once without much focus. I don't remember the details, I think it was a fairly short conversation, but the gist of it was that it was not enough to be smart, you had to work hard too. It made a big impression at the time.

5. What advice do you give to your own graduate students on career and physics in general?

JP: As I think back, I have given my students career advice of various sorts, but it varies greatly from student to student

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depending on their situation (e.g. some have to work out a two body problem, others need to be reminded what planet they are on ...)

Supervising grad students is very rewarding. With most of my students I have been able to collaborate on interesting problems. There is a clear progression that they all go through, from working out problems that I give them to finding their own problems and collaborating with other students and postdocs; one tries to help them along this process.

For advice on nonacademic careers I am not very useful to my students and postdocs; having followed a rather straight-line academic path I don't have any useful experience. I have always worried about this, but I don't think I've ever been asked for non-academic advice —- I guess that my students have looked for it elsewhere. If there are APS or other resources that I can guide them to I would like to know, though I expect that most of them can find these without my help.

5. Why don't string theorists participate more in the APS?

JP: There are probably many factors. One is that the Division of Particles and Fields is more focussed on the experimental/phenomenological side of our field. This is logical because the experimental side is much larger and requires centralized planning (maybe there should be a Division of String and Branes!) But at the 2001 Snowmass planning meeting string theorists were very active participants.

Like most senior physicists I do a lot of `service to the field' —-advisory panels and governing boards for TASI, NSF, Aspen, and various institutions, foundations, and journals —- but aside from the journals none of these are under the APS. I am also writing an article for Physics Today (which is way past deadline - wince), I guess that counts.

6. Have you read Flatterland and if so what do you think? (I'll give you a hint, women are not lines at all, they are 2D polygons with all but one line segment living in a shadow world. Very very advanced creatures.)

JP: I hadn't heard of it until your question; now I've bought it (I looked first in sci-fi, but it was in the math section) but haven't had time to read it.

7. Does string theory have anything to say to cosmology today?

JP: The connection between string theory and cosmology has always been one of those things that seemed like it had to be important, but until recently there were only sporadic speculative ideas. In the last two or three years, though, there has been a convergence of interest on several problems in this area: the observations of dark energy and of the CMB fluctuations give us new things to try to explain; the realization that we might live on a `brane' in higher dimensions has opened up a whole lot of new possibilities for models. At the most fundamental level, we do not know what the observables in string theory are, or the central defining principle, and these questions are particularly sharp in a cosmological setting. If string theory is all that it is cracked up to be, it should be a theory of the initial conditions as well as the dynamical laws. String theory has taught us a lot about spacetime singularities, but not yet about the most interesting one, the Big Bang; there are some specific ideas that are being explored, that may or may not lead anywhere. There will be a program on all this at the ITP in fall 2003.

8. How about astrophysics, with its study of quasars, supermassive black holes, and strange quark stars?

JP: There is a very nice example. Recent ideas allow for the possibility that there are higher dimensions in which only gravitons move, not ordinary matter. How big might these be? One way that these would be detected would be in the inverse-square law turning into an inverse-cube (or higher) law at some distance. That this does not happen down to a millimeter in laboratory experiments says that the new dimensions are smaller than that. But in fact the strongest limit comes from astrophysics: if there were a new dimension larger than a micron, supernovae would radiate most of their energy into higher dimensional gravitons and would emit too few neutrinos.

9. In fact in a recent announcement at the Harvard-Smithsonian Center for Astrophysics, a star previously believed to be a neutron star seems to be made of bare quarks instead. Please see the url http://chandra.harvard.edu/press/02_releases/press_041002.html for a general public press release. Do you think that such objects if found to exist could act as laboratories for string theorists or is that too far fetched? (I am wondering if string theory could possibly say something about the spectrum of such an object - please ignore this one if it is too unrealistic - but since the densities are super high, and since this might be just plain quarks in there - well but that would be the domain of qcd which means very very complicated).

JP: I should first say that you should contact my colleague Lars Bildsten for an assessment of the evidence for quark stars, he is rather skeptical. As far as string theory, generally the energy scales of astrophysics are too low to get to string physics and I wouldn't expect that quark/neutron stars would be the right laboratories. Supernovae, which I mentioned above, are special because they are so optically dense, and so can radiate only into very weakly coupled particles. But clues might come from unexpected places. It would certainly be important to learn the nature of dark matter.

10. String theory lives in a 10 dimensional space if I remember correctly. At one point there was interest in calculating the effects of one or more of these dimensions shrinking down to zero size and even popping out of existence. Did this connect up to the ekpyrotic model of the universe?

JP: This is one of the subjects under number 7 above. The `ekpyrotic universe' (which is an idea that has evolved a bit, and has several forms) requires that a contracting universe bounce and reexpand. This can't happen in general relativity due to various singularity theorems, but in this case the bounce looks, at least from some points of view, rather gentle and similar to other spacetime singularities that string theory does fix. So quite a few string theorists have tried to find the right tools to analyze it. I would have to say that right now things don't look so good: there is no evidence that the bounce is as gentle as required (Gary Horowitz and I are writing a paper that will be out soon)

Interview with Professor Robert Jaffe,

director of the Center for Theoretical Physics at the Massachusetts Institute of Technology (MIT). Professor Jaffe's research is mainly in elementary particle physics and most recently in the Casimir

effect (read your undergraduate physics book!) as the limit of a conventional quantum field theory coupled to a smooth background. He is a great lecturer and has even won teaching awards at MIT. Here he talks physics and civic duties with newsletter editor Jennifer West.

1. The FGSA is an apolitical group, meaning that we have no political association, NOT that we have no political interest. I think all of our leanings might cancel out leaving us in the center. However, I have noticed that in these days it is very hard to be anywhere left of center. What do you think of graduate students these days who have little political involvement, and of those who are strongly involved in the anti-war movement?

RJ: Of course it is not appropriate for an organization like the APS or one of its forums to take an overtly political position. You would compromise your effectiveness in other important arenas. Personally I never felt more passionate about politics than when I was a grad student, and recommend it to you as a natural companion to the academic life. Before children, before mortgages, before disposable income, there seems to be more time and more energy for politics.

As for your comment about the left — I agree, the US has taken a hard right turn in the past few years. The ideology of the right is ascendant and the old left has little to advocate. Perhaps the new left is Green.

2. Does the current political situation have a similar feel to it as it did when you were in graduate school? Or is there not the same consensus against the activities of the government? [note from me: sometimes Professor Jaffe I get the impression that there is a great consensus against this war and the stance of this administration, the foreign policy that has been spelled out, however to find this consensus is not as easy as turning on the television, I really have to use my computer and seek out the voices of dissent. Do you think that is true? This can be off the record.]

RJ: There was no significant antiwar movement **before** the Vietnamese War started. We were deep into it before there was any coherent opposition that you could watch on the television. Tens of thousands of American GI's were dead by the time the opposition had the attention of the mainstream newsmedia.

Today's situation seems different in many ways. In the early '60's few really knew what was going on in Southeast Asia. What is happening today in the Middle East reads like an open book. It's wonderful that there is a strong, vocal, and growing opposition to a new Gulf War. However it amazes me, as it did in the '60's, that the majority of American's seem to support US aggression.

3. Theodore Roosevelt once said (in a fit of wisdom): "To announce that there must be no criticism of the president, or that we are to stand by the president right or wrong, is not only unpatriotic and servile, but is morally treasonable to the American public." What do you think of this?

RJ: Of course I agree with Roosevelt. Early on, Bush and Ashcroft made rash statements questioning the patriotism of those who disagree with them. However they seem to have retreated on this front. And, remember, in the old days things were far worse: there was Edgar J. Hoover lurking in the shadows.

4. You were (are still?) on the advisory board of the Office of Minority Education and a member of the Campus Committee on Race Relations [the MIT Tech newspaper, V119, 1999]. How valid do you think the concerns are over unequal treatment of minority and female students in the sciences?

RJ: I left the CCRR after helping to launch it and serving on it's board for 5 years. It was time for new blood. My involvement with the OME was more peripheral and ended shortly after my term as Chair of the Faculty. Minority and women students are doing better at MIT in general, but not much better in Physics. The situation is particularly troubling for women. We have lots of excellent women undergraduate physics majors at MIT, but many leave physics in graduate school. I fear that the graduate student culture in physics is predatory and isolating, but I don't know for sure. I talk regularly with several young women physicists. Their stories are all different. A common thread is that they are turned off or disappointed by thoughtless behavior of their professors or fellow students that an ambitious young man would shrug off. So many young men think they're smarter than they are; so many young women scientists don't seem to recognize their great talent.

5. Your fellow interviewee in this newsletter is Joseph Polchinski, a wonderful string theorist at the University of California, Santa Barbara. You gave a talk today on the Casimir effect and mentioned something about the possibility that putting boundary conditions of orbifolds may not be the most physically realistic thing to do – you were teasing your colleagues, but what do you really think of string theory (M-theory really) as the best candidate for unification?

RJ: String theory is a wonderful intellectual activity, which attracts many brilliant young, mathematically inclined theorists. I value having a strong, creative, and ambitious string group here at MIT — they make life in the CTP exciting. However physics is undoubtedly an experimental science. There are huge impediments in the way of bringing string theory into contact with experiment. It saddens me that so many young theorists would not know a proton if one hit them square between the eyes!

7. When is the next full scale revolution in physics going to happen? Will it involve the Casimir effect? QCD?

RJ: No one knows. However, I would bet that it will involve our conception of the vacuum. The vacuum of quantum field theory is littered with our theoretical detritus: zero point energies from every fluctuating field, condensates from the electroweak phase transition, from the chiral phase transition of QCD and possibly from others. We require they all cancel, not to zero as we thought until the mid 1990's, but to an incredibly small number that just happens at this era to be approximately the same as the energy densities of radiation and matter. Hard to believe. I can't help thinking that we simply have the wrong conception of the vacuum. The only relation to the Casimir effect is a pedagogical one: the Casimir effect is often quoted as evidence for the "reality of the vacuum energy of quantum fields". Instead it is a (fascinating and important) force between material objects, leaving me wondering: what is the empirical evidence that the way we treat the vacuum in quantum field theory is correct?

8. There have been reports of possible strange quark stars, out of the Center for Astrophysics of all places. They found 2 stars that radiate like solid bodies but are either too cold or too small to be neutron stars. The scientists

Interview with Professor Robert Jaffe

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raise the possibility of strange quark matter. Could your research in quarks and QCD say anything about these findings?

RJ: My friends in astrophysics have doubts about the quark star interpretation of these objects. The possibility exists that quark matter with the optimal "chemical" composition of up, down and strange quarks, may be stable at zero external pressure. If this is so, then huge, star-like hadrons, bound by the strong interactions rather than gravity, could exist somewhere in the Universe. The most interesting thing about such compact objects is that they would have no **minimum** mass or radius. Thus they could rotate much faster than neutron stars. A sub-millisecond pulsar would be the most exciting and compelling signature of such a beast.

Even if quark matter were not stable at zero external pressure, it might form under pressure, deep in the cores of neutron stars. The challenge, then, is to find a signature that could be detectible from our great distance.

9. Freeman Dyson gave a wonderful lecture, like yours but much lighter on the equations, and was wondering whether the laws of physics as we know them allow for the possibility of life continuing on forever. He concluded that eternal life is NOT ruled out, if life is analog rather than digital, though we may have to change our forms to something like a black cloud of dust that hibernates. The alarm clock system of 3 black clouds, 2 orbiting the other and eventually crashing or interpenetrating, sounded very interesting. What do you think of this vision of the future?

RJ: I'm afraid life is best approximated as a delta function in spacetime. More of us should be concerned with whether life can survive the next millennium and leave the subsequent 10^50 years to Freeman!

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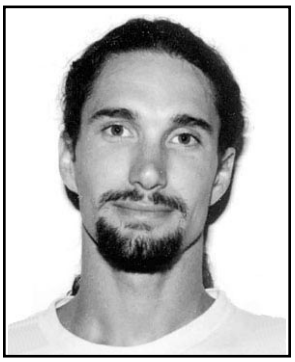

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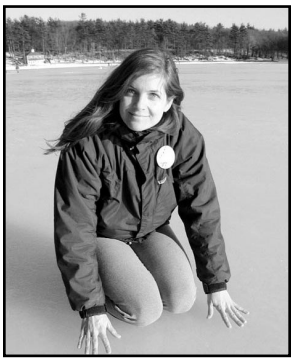

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