Conference Report

FFP11: Frontiers of Fundamental Physics Are Explored in Paris

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Abstract

A gathering of scientists from around the world took place in Paris, on the 6th through 9th day of July – the 11th international symposium on the Frontiers of Fundamental Physics. There are admittedly quite a few scientific conferences every year, but most are limited in scope to a fairly narrow range of topics, where the organizers of the FFP conference series have quite deliberately tried to be broader – without sacrificing depth. I made a special effort to be at this one, after attending FFP10 in Perth last November, and it was indeed worth the effort for me. The roster of invited speakers was impressive indeed, with several of the top names in each field. But the depth and breadth of the contributed talks and posters was rather impressive, as well, making for a lively and well-rounded conference.

Key Words: fundamental physics, symposium, frontier, Paris.

Introduction:

FFP11 was a four day affair, and I arrived in Paris the morning of the first day, so I had to hustle a bit to make the opening talk, which was also in the morning. The entrance to the Buffon Amphitheatre is recessed into the building, and it was not prominently marked as the FFP11 location, so I almost walked by without seeing it. But once I found my way into the building, I found the rest of the preparations by the conference organizers to be excellent and exemplary. The first day began strongly, despite the disappointment that Roger Penrose was not able to attend. There was plenty of intellectual firepower (or should I say brainpower?) regardless of the absence of a few speakers. And some of the contributed talks were every bit as strong as those of the main speakers. This is not so surprising, when you note that many of the people who gave those talks are featured speakers at other conferences. So it was an honor to be chosen to give an oral presentation myself. In any case, I got into the auditorium in time to hear the introductory speech on behalf of the scientific committee by E. Brézin, and the brief international organizers' welcome by B.G. Sidharth.

The event was hosted by the APC (Astro-Particle and Cosmology) Institute of the Paris Diderot University, and it was a lovely place to hold a conference. The local organizing committee did a good job providing for conference participants, with Wi-Fi and designated workrooms available, so folks who wanted to fine-tune their presentations or continue their research during the event had every opportunity, as well as other thoughtful accommodations. Of course; Paris is a lovely city, in its own

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right. It was as welcoming as ever, and the public transportation made it easy to get within a few blocks of the Amphi Buffon, where most of the conference was held. Parallel sessions took place in

FFP11 Location: Buffon Amphitheatre

the adjoining building, which houses the APC labs and classrooms. The coffee breaks were quite well-supplied, giving folks ample incentive to go out and mingle with the other attendees, between sessions. And the value of getting people together, just to talk about topics of interest over breaks, is certainly not lost on me. In fact; I think it is a major feature of such gatherings.

I am certain the organizers would not thank me if I said the coffee breaks were the highlight of the event. But I can assure you that this was not the case. The lectures were both engaging and informative. There were, in fact, quite a few high points of FFP11 for me – so picking just one may be difficult – because several of the presentations were quite excellent. In the remainder of this paper, I'll focus on some of what was said by various speakers, and try to give a sense of how things flowed. I found that things flowed quite well, on the whole, with attention given to each of the five conference themes, as well as to creating variety within a day's schedule, and to having continuity within each 'track' during parallel sessions. The themes of FFP11 were Big Bang Cosmology/Dark Energy, Dark Matter/Astroparticles, Particle physics and Fundamental Interactions, From Entanglement to Quantum Information and Quantum Gas, and Epistemology and the History of Physics. This mix of topics invited quite a range of interesting conversations, and a fair amount of cross-fertilization. I imagine that many attendees learned unexpected things about one of the other areas of specialization, or were inspired to collaborate by finding common ground with others. Thus; in my view, FFP11 was a success – because it fostered learning and cooperation.

Talks and presenters:

The first day of the conference had only plenary talks. That is, we were all seated in the amphitheater, where we heard and saw one speaker at a time. This was good for me, as I needed a

while to adjust to being on Paris time, and that schedule made my transition easy. With parallel sessions on the ensuing days, there was much more planning and choice involved – since sometimes there were two or three interesting talks at the same time – so it was nice not to have that the first day. With Penrose absent, the first talk was given by Quantum philosopher Jeremy Butterfield from Cambridge, on "Emergent Phenomena in Physics" and the "Uses of Infinity." The first half of his talk focused on the idea that the concept of emergence reverses the mode of thinking found in most of Physics (top-down vs. bottom-up), and was more philosophical, where in the second half he talked about a specific application of this idea to Physics. As luck would have it; in the final talk of the conference, 't Hooft revisits the subject of emergence, but more on this later.

Gerard 't Hooft at FFP11

Joseph Silk gave the second talk; showing how progress in Cosmology – especially in modeling and a greater wealth of astronomical and astrophysical data – has been reproduced in our understanding of galaxies. He suggests that the interplay between dark matter and dark energy plays an important role in how galaxies come to form, and explains the range of forms we observe. The next speaker, Pierre Salati then explained that 77 years after Zwicky first inferred the existence of unseen matter, now called Dark Matter; we still don't know exactly what it is. But he went on to describe the many candidate ideas that have been investigated, and explored what we have learned. Then Daniel Fournier gave us an introduction to what has been happening at CERN with the LHC. He discussed both the trials of the failed initial attempt, and how preliminary results offer us reasons to be optimistic for a great Physics run, as the machine is finally ramped up to its full power. For the last lecture of that day, Pierre Fayet talked about how there is a frontier to be explored, involving both astrophysics and particle physics. He explained how observations of emanations from the cosmos supplement what we learn in particle accelerators in important ways, while the latter serve to help us narrow down the candidates for dark matter (for example).

The second morning, I arrived a little late – due to some confusion about which corner the bus departed from. But when I showed up; Jean-Loup Puget was in the middle of his talk, discussing how we can learn a lot about the early universe by studying the polarization modes of the Cosmic Microwave Background, or CMB. He explained that our knowledge is largely accumulative, and that the insights gained from the Planck probe help us to better understand what earlier CMB surveys

have showed us. Chris Salomon's talk on clocks was very interesting. He spoke about the progression of clock design and about how the accuracy of clocks is a big determiner of how precise other measurements can be. His description of the newest ultra-precise clock designs culminated in discussion on how progress Earth-side is augmented by space-based clocks like PHARAO and the ACES program which will allow us to test various fundamental constants of Physics for variation, and to determine them with new accuracy. With a space-based platform in place, this allows comparison of clocks from around the world, which opens up exciting possibilities.

After the coffee break, Costas Bachas treated us to some insights into how we are narrowing our search for answers to the 'landscape problem,' in a talk entitled "Signatures of String Unification." After that Frédéric Hélein spoke on "Finite and Infinite dimensional representations of Hamiltonian Structures." The fact that Hamiltonians are ubiquitous in Physics speaks to their utility, but Professor Hélein gave us quite a bit more depth and breadth than most of us learn there is to the subject. I must admit that parts of this lecture were not comprehended by me, but I think that speaks to my own limitations, as the speaker did a fine job of presenting the subject matter. After the Lunch break things got complicated, as there were three tracks of parallel sessions at once; Big Bang Cosmology and Dark Energy, Particle Physics and Fundamental Interactions, and Epistemology and the History of Physics. I chose to stay in the main auditorium for the first of the three tracks, which started with a lecture by Barrau Aurélien, who spoke about Loop Quantum Cosmology and the Big Bounce. After that was B.G. Sidharth, in the same track, speaking about Planck scale oscillations as a source of Dark Energy. Interestingly; I see from the program that those following the second track got another angle on fluctuations at the Planck scale from Fabio Scardigli.

I got the urge to check out some of the posters, at that point, after realizing that I'd missed the time allotted for that when I was exploring the other building after lunch. Having been given only an opportunity for poster presentation in some past conferences, I know that many poster presenters put in an incredible amount of time and effort to create something worthy of a major conference. Well; there was some very interesting stuff on the walls, including a paper on light gravitons by Andrew Beckwith – who asked a lot of intriguing questions of the speakers at this conference. I wish I'd taken photos of what was posted there, as I'd done at FFP10, before it came down. But when folks came out for the coffee break, I had some pastries and java, and sat for another lecture. This one was by Alexander Mayer, whom I met at the 2nd Crisis in Cosmology Conference, a few years ago. His talk proposed that SDSS and Hubble UDF data suggest we need a new cosmological model to replace the concordance view, or Lambda CDM. His work is in some measure an outgrowth of unfinished work by Hermann Minkowski, which suggests we take a rather broader view of space-time than that adopted by Einstein. But Mayer's talk drew some vocal criticism from Paul Steinhardt during the question and answer period.

After that I did some jumping around, as I wanted to see a number of lectures and I had an appointment to meet with my partner Caroline between sessions, since she wanted to see my lecture – when I gave it. Of course; I also wanted to be there at the appointed time myself. So I got to see parts of a lecture on "Presentism vs. Relativity," and one on the "Evolving Concept of Dimension," but they did not get my full attention. On the other hand; I did meet my traveling companion where and when expected, and I was there for my own lecture on time. I should mention that the title and source material for my lecture appeared in Vol. 1 no. 3 of this journal as "Learning to Cooperate for Progress in Physics." Of course; what can be said in 15 minutes is less

than what will fit in 10 pages of print, so it was a bit condensed, but I also had some helpful diagrams. My lecture was not well attended but it went smoothly and was well-received. So the second day ended OK for me, and I headed back with my partner for some relaxation, a meal, and some repose.

Thursday morning began with a talk by Ruth Durrer on Inflation and Dark Energy, which gave a thorough overview of how dark energy influences the character of universal evolution, in inflationary universe scenarios. Jean Dalibard then spoke on how atoms could act as qubits in quantum computation. He explained that atoms could be cooled by laser light, and then arranged into an array or lattice structure. While the photomicrographs did not show all the atoms forming a perfect lattice-like arrangement, Dalibard's team has obviously made great progress in this direction. After the coffee break, we heard from Paul Steinhardt who cataloged first the advantages, and then a long list of problems with the inflationary universe theory. One comment of his that sticks in my memory is that eternal inflation is not a choice, but rather a feature of the theory. That is; we are wrong to imagine that chaotic or eternal inflation is simply one of the many types of inflation, as it is an aspect of all the varieties of inflationary universe we have studied. The last speaker before lunch was Michel Devoret, and he talked about "Quantum Information Processing with Superconducting Circuits." This talk impressed me with possibilities for future development of technology, as well as with its relevance to our understanding of fundamental Physics. I was particularly intrigued by a superconducting quantum LC oscillator with just two components.

Again that afternoon there was a time to view posters, and then parallel sessions, which left me with choices. I attended a talk by Wlodimierz Piechocki on non-standard LQG, which I found quite interesting. As I recall; the normal approach has one reduce terms first and then solve, where the non-standard approach has one solve an equation with more terms, and then eliminate the unneeded terms through cancellation. The non-standard approach preserves some information that is lost when doing things the other way, and so yields unique insights. It suggests that spacetime would have a foamy structure which might be detectable. But as with the standard LQG that was discussed in Aurélien's talk, this variety of Loop Quantum Gravity also predicts that instead of a Big Bang, we get a Big Bounce. There was some discussion in the Q&A time afterward; about what varieties of particle might survive the journey from one cycle to the next and whether they would carry information from the previous bounce into our present-day cosmos.

With the next speaker in that track absent, I did some bouncing around myself, at that point – not knowing where I wanted to be. I caught tantalizing bits from two lectures, but not enough to report. I went back to the main amphitheater after the coffee break, and attended Natalia Kaputkina's lecture on how the coherent behavior of quantum dots varies with changes in magnetic field and confining potential, which I largely enjoyed. It would seem there is a 'sweet spot,' or a region of parameter space where interesting effects are observed. Then I caught Mikhail Ataisky's intriguing talk on Quantum kinetics for hierarchal systems, such as molecules that are formed of atoms and atoms which are formed of particles. For a system with relatively few bodies to consider, he showed that solutions can be quite tractable. I had hoped to catch Molly Swanson's talk on how cosmological observations help us to determine the neutrino's mass, but I only got there in time for the tail end, as that track's timing had been jostled by the missing speaker who finally showed up. At that point I took note of the time, however, and began to walk to where I was to meet my partner for the museum trip and conference dinner.

As part of the conference activity; we had a trip to the wonderful Musée d'Orsay, which houses many of the paintings of Van Gogh and Gauguin, as well as a collection of other works large and small, including quite a variety of wonderful sculptures. Along the way, my companion and I made the acquaintance of Jaime Keller, a scientist from Mexico, who apparently has a fair knowledge of the Art we were viewing, as well as Science. We had far too little time to take in all of the splendor of Art offered by the museum, and got only one third of the way around the perimeter before it was time to head up the concourse, past the large sculptures, to the restaurant. But the museum's restaurant was a splendid treat, as well, with magnificent artwork overhead, and decorative trim fit for royalty. And the traditional French meal was excellent, where the dinner was served in several courses, with different varieties of wine for each course. The food was delicious and the setting was lovely. My partner Caroline and I shared a table with Jaime Keller, who was jovial and humorous, Andrew Beckwith, who had as many comments over dinner as during the conference, and Bernard Schaeffer with his lovely wife. There was some lively conversation over dinner, and I think we all enjoyed both the event and the company.

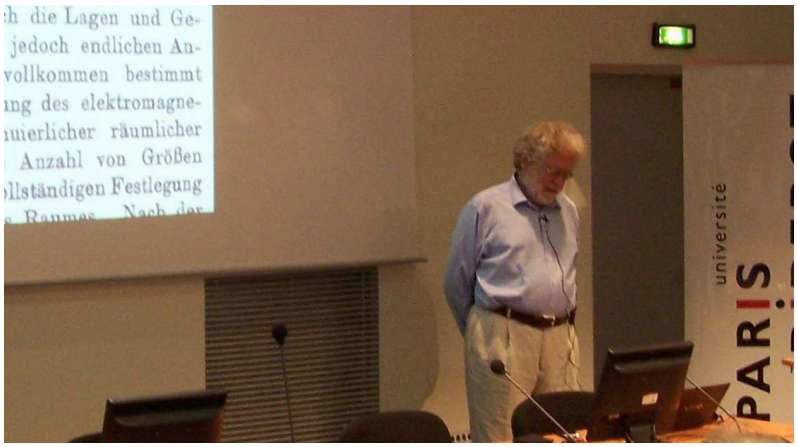
My night ended with some sightseeing near the Orsay museum, and a long walk back to our hotel near Port d'Orleans. But in the morning, I managed to catch almost the entire lecture on "The problem of time in quantum gravity" by Alexis de Saint-Ours. I found the talk rather interesting, even though I was not quite awake. I was somewhat more alert for Claude Grignon's talk "Is cosmology a historical science?" Grignon distinguishes disciplines like Geology, Archaeology, and Anthropology, which are *historical* from disciplines like Mathematics, Chemistry, and Physics, which are more rules-driven or *nomothetic*. He asks if perhaps Cosmology is different from other disciplines in Physics, in that it is by nature an exploration of the historical record of the universe, but at the same time our explanations of cosmological data must depend on what we perceive as natural law. These two talks were a good warm-up for me, in that they combined fundamental Physics questions with matters pertaining more to Philosophy, and so they gave various parts of my brain a work-out. Then; the day's first plenary speaker was Philippe Grangier, who spoke on "Quantum Information with Photons and Ions." As I remember, it was a thorough review of essential concepts in quantum information science with some cool experimental data to demonstrate.

After the (much needed) coffee break, we were treated to a surprisingly light-hearted and humorous talk about what may lie beyond the Standard Model from CERN's theorist John Ellis. He gave a through run-down of all sorts of interesting things they will be exploring at the LHC, but I most enjoyed his diagram about the real nature of SUSY and his story about the visit of Margaret Thatcher to CERN. He related that she asked him "What does he do there?" and he replied "I do a bunch of difficult calculations, then make a lot of interesting predictions, and then I hope the experiment will turn up something different." "Wouldn't it be better" she asked "if the experiments actually turned up what you were expecting to find?" And Ellis reported that he replied "No; because then we wouldn't learn anything interesting." This brings up an important philosophical issue, which was a central point in Nobel laureate Doug Osheroff's talk [1] at last year's FFP conference in Perth. He was insistent that folks not be deterred by finding something different in the experiment, from what your theories tell you it is likely you will find. Instead; he advised people to regard such occurrences as a unique opportunity to learn something new and exciting.

In one of the parallel talks I missed, Slobodan Perovic took up the related question of how much interesting Physics is missed, now that so much of the data selection and analysis is done by

machines, and we have programmed them to look for specific signature of what are presumed to be important events. What if symmetry is broken in a different way, and there is a fourth quark family instead of a Higgs, as has been suggested by Franklin Potter?[2] Would the confirmation signal of such an ordering go unnoticed for a long while, as teams geared up for higher and higher energies to detect the elusive Higgs particle? From what I heard of ICHEP (a Particle Physics conference also in Paris, later in July) announcements, there was still an ongoing search where the Higgs has remained undetected. If we follow Osheroff's advice, we will start looking in unexplored parts of the parameter space more often, and likely have quite a few more advancements. My own talk centered on the need for playful exploration, which echoes Osheroff's advice, and complements the steady progress toward higher energies, lower temperatures, and the like.

After Ellis came John Stachel with a talk entitled "Where is Knowledge?" which raised a number of important philosophical issues, and laid bare the process of how we validate what we know, and how it is that we can come to know it. Is there a truth, and where does it reside? Is it with the objects or the relations between them? Does our knowledge of truth begin with our perceptions, or with the events themselves? These are the kinds of questions Stachel asked us to grapple with in his talk, and he did a good job of making an interesting journey out of the historical progression of thinking on the subject. Of course; he also discussed where the Physics community weighs in on these issues. So we all had plenty to think about during the lunch break, and were well primed for the afternoon's talks. We were not disappointed by Anton Zeilinger's excellent lecture on "Quantum Information and the Foundations of Quantum Physics." It was an interesting and often humorous telling of the history of the introduction and acceptance of the knowledge and ideas which have become foundational to Quantum Mechanics followed by insights into what the very latest experiments are telling us.



Anton Zeilinger at FFP11

It is worthy of note that paradoxical or quizzical aspects of quantum-mechanical nature of reality have played havoc with its adoption, where even the great minds that conceived of the notions we find essential were reluctant to believe what they were proposing. Zeilinger showed us a letter from Mr. Einstein, at one point, where he lamented that his notion of photons as particles of light was probably a bad idea. And this is the idea which actually won him the Nobel Prize in Physics. But Zeilinger went on to say that Quantum-Mechanics has had even its most counter-intuitive and

paradoxical aspects confirmed, and gave us examples from experiments. What I liked best, though, was that he stressed the need for scientists to have time to play, in order to make great discoveries. He stated that he once told his employers "If you want us to be productive, don't expect us to be productive." His talk suggested that we should always be playful, both in our experiments and in how we view the nature of things. Like Osheroff; Zeilinger offered the view that we should relish the unexpected, and continue to craft experiments to look where others have not.

The final talk of the conference was given by Gerard 't Hooft, and was entitled "The emergence of Quantum Mechanics." This lecture covered some of the same ground as his talk at FFP10, but approached things from a different angle. His talk was not on the general topic of how QM might arise or emerge from first principles, but rather centered on how his Quantum Gravity theory based on a Cellular Automaton might help us chart a possible evolution for quantum-mechanical properties, arising solely for information theoretic reasons. I was flattered to see that he incorporated a discussion on possible answers to the question I had asked him at FFP10, regarding Lorentz invariance in this theory. He explained that this is actually a very difficult thing to obtain from any theory based on CA. Indeed it must be; his famous paper on "Dimensional Reduction," [3] which was one of the most downloaded papers of all time, also employed CA to investigate problems in QG – so he has been working at this problem for a while. But it is obvious that 't Hooft's thinking on this subject has evolved, even since last November. Both last year and this, I got the impression that Professor 't Hooft's mind is always at work, always attentive for new information and always exploring new ideas. So perhaps it is fitting that he fielded a list of general questions, after the conclusion of his talk – and that this is how FFP11 ended.

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