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# Elisa Brune's *Le goût piquant de l'univers*: A translation and introduction

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Elisa Brune's *Le Goût piquant de l'Univers*: a Translation and Introduction

by

Ryan Orgera

A thesis submitted in partial fulfillment  
of the requirements for the degree of  
Master of Arts  
Department of World Languages  
College of Arts and Sciences  
University of South Florida

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“Elisa Brune’s *Le Goût piquant de l’Univers*: a Translation and Introduction”

Ryan Orgera

ABSTRACT

*Le Goût piquant de l’Univers* is written by the Francophone Belgian writer Elisa Brune. Brune holds a Ph.D. in environmental sciences, and this novel does not stray far from her training in science. The setting of this oeuvre is that of a Provençal village of Peyresq, the premiere annual rendezvous for the world’s foremost cosmologists. The vocabulary employed in this book is that of highly scientific coteries. The work’s sentence structure is a mix of dialogue, and unruly compound phrases. These two aforementioned stylistic choices made the translation of this work especially difficult.

In translating, I worked with Dr. Gaëtan Brulotte, a French-language writer and professor; Dr. Roberta Tucker, a French literature professor; and Dr. David Rabson, a theoretical physicist. All of their unique knowledge, in tandem with my familiarity with French and English, allowed for engaging exchanges on subtleties, nuances, and technicalities in the translation.

A Translator's Notes and Introduction of  
Elisa Brune's *Le Goût Piquant de l'Univers*

*Le langage est source de malentendus.*  
Antoine de Saint-Exupéry *Le Petit Prince*

Language is the source of misunderstandings.  
Antoine de Saint-Exupéry *The Little Prince*

*The Universe's Fiery Taste* is a novel from the Francophone Belgian writer and scientific journalist Elisa Brune. Brune has authored seven novels. She came to novel-writing via extensive studies in environmental sciences, a subject in which she holds a doctorate.

This particular work centers on a cosmological conference in the French Alps:

Each year, topnotch cosmologists descend on the small Alpine village of Peyresq from all corners of the earth.

As these men and women hack away at the mysteries of the cosmos and gravitation, we will make a televised piece scratching the surface of their work. The narrator, a journalist, heads out with equipment and sidekicks. We're rolling! "So, what news from the Universe?"

A tale "in weightlessness" presents scientific creativity and discussion in all of its freshness. Accelerated expansion, vacuum energy, inflation, string theory, and the anthropic principle are subjects of extensive discussion. Our physicists are far from what you might imagine, they are a fiery bunch! In their official communiqués they remain majestic and incomprehensible, but in their

efforts to translate their research, they are impassioned, captivating...and intelligible! (Translation of back cover)

Translation is an unforgiving task. Language is a very personal realm; people choose their words in relation to personalities, social situations, or art form. Being assigned the task of translator entails the responsibility of transposing an author's intent in a new language, for a new audience.

This requires a familiarity with both the source language and the target language. It also, however, requires knowledge of cultural references, and at times, when appropriate finding corresponding examples in the new language. It is important to note that this has to be done sparingly. It is decidedly not the job of the translator to take a work completely out of the cultural context, i.e. changing all of the references to France, the French language, food, to North American, British, or South African equivalents. The work was written in that context for a reason, and the author could just have easily chosen to set her/his stage elsewhere. It is not the job of the translator to make every aspect of the work categorically accessible without some work on the part of the reader. However, it is the opinion of this translator that if the cultural reference is too obscure, then the image is completely lost. In rare cases, when I felt the work would lose very little, I chose to change the image to something that most Anglophones (especially Americans) can understand. On page 72 Elisa Brune writes: "Je me sens en plein dans l'album : Les Pieds Nickelés font un reportage télé." After some research into the Les Pieds Nickelés stories (comic books) I discovered that there are three main characters, all male, and all generally silly, goofy, and often slapstick in nature. I came up with the

following: “I feel like I am smack-dab in the middle of a *Three Stooges* episode: Larry, Moe, and Curly make a documentary.” The imagery is similar; the readers lose very little in changing the original image. In this case, a change of cultural perspective is a useful tool in conveying the meaning of the author. Such changes, however, remain at the discretion of the author.

The language in Elisa Brune’s novel is extremely varied, from vulgarities to string theory. Covering cosmology and everyday life, Elisa Brune’s rash, straightforward delivery is more delicate than is usually expected from a scientific novelist. As a translator it is important to keep (at least try to) the harsh contrast between seemingly incomprehensible scientific jargon and very rough, crude retorts. There is a common tone of levity throughout the entire novel. This undoubtedly is a deliberate device employed by the author, as a reader would be overwhelmed by the intense scientific language coupled with a general heaviness. Though at times easy to forget, this work is in fact a novel, and not a scientific piece. In order to compensate for Brune’s “speaking” style, I opted to generally use contractions in English. I find contractions to be a very effective way of conveying levity in writing. It is not possible to use only contractions as it would sound contrived. Anglophones tend toward a mixture of contraction and standard structure when speaking. This effect depends on intent: for example: “it is not the case” versus “it’s not the case.” The former lends itself to more authority. For an example of alternating contraction/non-contraction usage from the text, let’s look at page 91:

“It is a very natural way of understanding why gravitation can go everywhere; it’s because it stems from closed strings, which are unattached, and thus which cannot be detained.”

I began the sentence with the standard non-contracted form: “It is.” This is more natural for me, a great way to start a long phrase. It almost acts as a precursor to the following idea. In the middle I found “it’s” to be more appropriate, as not to add to the heavy nature of the sentence. “It’s” is followed by “because”, a heavy, common word. It would be completely unnatural to pause in a sentence and articulate “It...is...because.” And the final possibility of contraction is the word “cannot.” This is a personal preference. “Cannot” is not much heavier than “can’t”, and then in turns lends itself to all levels of formalities in speech.

In general, contractions were used in situations including the word “is:” “it’s,” “that’s,” “she’s.” It is such a common word that Anglophones almost always contact it. I did, however, stray away from other kind of contractions: subject pronoun + would. Unless the dialogue was specifically in quotation marks I opted not to use contractions containing “would.” “Would” has some many important qualities in the English language. It can be used in a conditional sense and an imperfect sense. Shortening it would assuredly detract from this richness.

Negative contractions are also used in the translation: “don’t,” “doesn’t,” “can’t,” “won’t,” and “hasn’t.” These constructions are almost exclusively used in spoken word. The weight difference between “do not” and don’t” is more marked than such affirmative



counterparts. Only in cases of necessary demarcation did I choose a non-contracted structure.

The French language contains many fewer words than the English language. English is a very vocabulary intensive language, feeding from its Germanic and Latin origins. In no way does this impugn the French language. The subtlety of the French language lies in its definition-richness. One word can mean so many different things, i.e. the word *piquant*: spicy, tangy, savory, piquant, prickly, nippy, pungent, and fiery. In translating from French to English, the true difficulty is in finding which one of the English words most closely compliments the meaning in French. Furthermore, the true difficulty in translating from French is trying to understand which meaning the author intends. This generally boils down to the interpretation of the translator a propos the general context of the work.

The sentence structure of French is remarkably different than that of English. English (especially the American brand) almost always tends toward very straightforward, minimal-punctuation structures. French can very easily continue a sentence for the entirety of a paragraph. Elisa Brune, however, mixed very intensive sentences with very short, verb-free sentences. This is something that goes against most rules in both languages; therefore I tried to keep her structure throughout. Sometimes her subject matter made a very short sentence difficult to understand and a very long sentence almost undecipherable.

The matter of scientific vocabulary is paramount in this translation. Elisa Brune's narrator is working with world-renowned physicists. Elisa, herself, is not a newcomer to science, though her field of expertise is quite different from the subject matter in this book. Quantum physics, cosmology, and physics in general all possess a certain set of current language that is associated with them; much like linguistics or astrology do. Most physicists do not only study theoretical physics. This creates a very specific subset of terms that are unfamiliar in the everyday speech of anyone outside of the aforementioned fields. While almost all of the theory names I have encountered fleetingly at some point in my life, I have never had the opportunity to study what they meant, or their particulars. Translating this novel has taught me more about physics than I expected. Were it not for the help of scientific reviews, and a physicist, I would have never been able to make the translation palatable to a trained professional. Scientific language is highly specialized and my translation required the review of someone who can discern the mistakes of a layperson from something that would be said in physics' coteries. The language problems were not confined to science.

This novel is in great part dialogue. Dialogue lends itself to a very distinct set of vocabulary. Words used in political treatises do not always appear in common speech, and vice versa. While there are many fixed phrases found in both English and French, there are just as many not-so-conventional phrases employed by Brune. Puns are almost always lost in translation, alteration is rarely transferable, and nuance is systematically lost. Idiomatic phrases are rarely comparable in the "new" language.

Idioms are a very delicate practice in translating. I tend to feel that they are hackneyed in English. Well, at least belabored. Sentences like: “get your ducks in a row” are best avoided. You run the risk of detracting from the surrounding words. Almost like indelible stains on the page, a reader has trouble overlooking too many set idiomatic phrases. This is, of course, a stylistic choice. It is rather hard to try and gauge the similar effect on native French speakers and English speakers. Meaning, how does a French reader see phrases in French versus an American reader in English? So much of translation is personal, like language itself.

Translation has taught me to embrace my own brand of English. The English language is spoken on every continent of the world, which is more or less the case of the French language. The English that I speak is very different from that of an Australian, Kenyan, or even someone from New York. The French that Elisa Brune likely speaks is very different from the French spoken in Quebec, Dakar, or Perpignan. The fact that Elisa Brune writes in a certain brand of French does not authorize me to try and equate that to a common accent or colloquialism in English. For example: the conference takes place in Provence, and at times interacts with locals. Provençal people have a very diverse accent from that of Belgium. It would not be in my power as a translator to transpose the geographic position of Provence vis-à-vis Belgium, and thus impose a Southern US cadence or speech pattern on the local characters. This would be in complete violation of the cultural context.

This “weightless voyage” was in fact a tremendous learning experience. When I set out to do this translation, I never imagined that I would also be learning about physics. And as I finish this portion of the translation I feel considerably better versed in it. I also have gained knowledge of the novel as a medium. The act of sitting for countless hours with one single work in front of you allows you to see details that would have otherwise gone unperceived. This work is a real challenge for both the translator and the reader; it requires attention and reflection. Something that I feel I have put into it, and something hopefully readers will follow suit.

***Le Goût piquant de l'Univers***  
*Récit de voyage en apesanteur*

***The Universe's Fiery Taste***  
*Tale of a Weightless Voyage*

Elisa Brune

Translation by Ryan Orgera

**Friday, June 21<sup>st</sup>**

*A Conference Must Be Earned*

Nice, June 21<sup>st</sup>, first day of the heat wave. The heat weighs a ton. At the Provence station I take the train for Digne, a small railcar which bumps along at thirty miles an hour.

Tomorrow, twenty or so eminent physicists will take this same route to descend on the village of Peyresq. If I'm arriving in advance it's because I'm part of a TV crew. This conference will be unlike the others, we're going to film it.

Ever since the project took form, I've been concerned about how the scientists are going to handle the camera, boom, and all that stuff. I've always wanted to be completely invisible, to be a fly on the wall and to grasp the truth. Wouldn't that be the height of reporting? Here we are, all four of us, arriving with a cartload of equipment, hello discretion. Aren't we going to bother them? Aren't we going to alter the course of events? Worse even, aren't we going to taint these great minds, whetting their appetite for pageantry?

The idea was hatched while talking to Edgard; Edgard Gunzig, the organizer. Physicist at the *Université Libre* in Brussels. For the past seven years, he has been inviting a handful of colleagues to Peyresq. He finds the experience so decisive that he suggested that we let the world benefit from it.

He's right. We know too little about the goings-on of these insider meetings. We, the ignoramuses, are only good at swallowing known facts, severed in sterile slices from

popular journals and treatises. But science by trial and error, the everyday plodding of these researchers, their not-so-polite exchanges, who hears about that? They practically live in secret societies. So this week, journalist's honor, we're going to catch them in the act.

When I get off at the small Saint-André station, all three of them are there: Alexandre whom I know well, Olivier and Damien I have seen only once. They drove down from Brussels with all the equipment. Alexandre is a journalist and filmmaker. He proposed I do this story with him. The two of us will be in charge, even if it's my first time. Olivier is a cameraman, and has already worked with Alexandre. He has his full confidence. Damien, the youngest of the troupe, will be our soundman. Our organizational meeting was a month ago. Now we are going to work together for a week, on a tricky subject. I feel like I am at sea with them. Everyone pulling together.

There is more than one way this project can go wrong. Firstly, because you can never be sure of making a good film, regardless of the subject, moreover this subject is difficult, if not perilous. And also because we've no guaranteed backing. In fact we left without a single cent. The producers we contacted were lukewarm at best (Us: "a cosmology conference, what a treat, huh?" Them: "Yeahhhh, it could work"). Only one producer said yes to opening a small dossier and to submitting it to two financiers.

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But their boards are not meant to meet until after the conference. What to do?

All-the-same, we decided to leave, wagering that one of the two sources would finance the project. And were it not the case, we would manage somehow to convince some producer, once the documentary is filmed. Olivier and Damien agreed to come with

all of the equipment without any assurance of remuneration. So, this is starting as a hazardous undertaking. But we're already happy to have found the means to make here and film. We'll see about the rest.

As we left the valley floor to climb its opposite slope, Damien asks me abruptly:

"By the way, what is cosmology?"

"It is a science that studies the Universe in its entirety. In other words, the only object without an exterior."

"No exterior?"

"Yeah, all other entities are limited in space and can therefore be situated in respect to other things, maintaining relationships with these other things. You, you are seated to my left, you live at such and such an address, etc. A planet, a galaxy, are also objects which have an address and which maintain relationships with their neighbors, their environment. The Universe, itself, has no address, no neighbor, no environment."

Alexandre cuts in:

"So therefore certain people think that cosmology is not a science. A science always establishes relationships. The Universe cannot be described in respect to anything since it is everything. Whether it can be studied poses a huge epistemological problem. If the study of this object is legitimate, scientifically founded, see what I am saying?"

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"They are going to talk about that?"

"No, that is a philosopher's debate. The cosmologists don't care so much if what they do is founded or not, they just do it. They are going to talk about quantum gravity.

"About what?"



“About quantum gravity. It is a theory of gravity that is not yet finalized, but which should soon replace Einstein’s, which in turn replaced Newton’s. You know who Newton is right?

“Some guy who had an apple land on his head?

“Yes, do you know what gravity is?”

“It’s what made the apple fall?”

“Very good. Only it can be explained in different ways. You could say that the apple falls because it is pulled by the Earth – that was Newton’s idea – or that it falls because the Earth deforms time-space and bores a well which becomes the apple’s natural path – that was Einstein’s idea.”

“The apple’s natural path? Are you messing around?”

“Not in the least. There is no gravitational pull in Einstein’s theories, just gravitational wells. Let’s simplify it, imagine the Universe as flat as a pancake. Space would be a taut sheet, and each mass, for instance the Earth, would be a bocce ball placed on the sheet. It forms a depression. Consequently, if a little marble is let go nearby, it will fall in the hole because it is its natural path. Without the bocce ball, the sheet would be flat and the marble would go in a straight line. But with the ball, the straight line dips into the well. Now imagine the same idea in 3D and you’ve got gravity according to Einstein. No one attracts anyone, but everyone makes his/her well in the sheet.

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When a small mass passes near a large mass, its path curves and it falls in the well, that’s it.

“And why is another theory necessary to replace that one?”

“I hope that will be explained to us.”

After half an hour of climbing, we see Peyresq, it is superbly situated overlooking the valley. In terms of landscape, it is sublime. Edgard and his wife Diane wait for us at the village’s entrance, seated on a low wall which edges the road. You’d say that they’re going to watch us go by, muttering commentaries like the centenarians in *Asterix in Corsica*. But no, they hop up nimbly and come over to us, visibly happy with our arrival. For them, too, there is excitement in the air. In the seven years they have been organizing this conference, this is the first time that there will be outside witnesses, and thus a chance for posterity. That changes everything.

Before all the hello’s, they suggest that we park the car in the village square. As they walk over, I asked the boys where they had put the bottle. Today is Edgard’s birthday, and they procured a magnum of *Clairette de Die* en route. Here, all four of us are feverishly rummaging through the car, while Edgard and Diane approach. Finally Alexandre put his hand on the object and we turn, triumphant, when Edgard was about to tap us on the shoulder. His expression lights up when he realizes what was going on. “No, you didn’t?” He said with a big smile.

The *Clairette* isn’t for tonight. It’s warm. But the meal awaits us in the village’s largest house, which serves as a banquet hall. Around a big table, the participants of a conference ending today are assembled.

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They’ll leave tomorrow morning, while our physicists arrive in the afternoon. It’s amazing, such an intellectual payoff at this altitude. While we are finishing a vegetable soup heavy enough to have been the entire meal, a bizarre man joins us. Red-skinned,

white-haired, blue-eyed, a real French flag, he look likes an ad, the kind where the person points out tourist attractions. A kind of intendant-guardian-mountain guide. He sits authoritatively at our table and shoots off stories, adventures each more unbelievable as he went on: espionage in Africa, Rwandan genocide by Elf Aquitaine. If he knows so much about it, it's because he was buddy-buddy with all sorts of folks, indeed the only body found from the Dieuleveult team was wearing windsurf booties, the very same booties he is wearing. The man is named Jean Van Compernelle, he's more Belgian than waffles! He personally knows Jacques Brel, who, while out drinking, declared: "you, each time there'll be a windmill, it will be for you."

A little taken aback by his logorrhea, we look at Edgard questioningly. He shrugs his shoulders as to show his powerlessness. He does not even know who he is. Later come the stories about hiking in the mountains and forty sheep belly-up because of a lightning bolt. Right at the moment when the tourists are lost in the storm, about to die of hypothermia, a most opportune cell-phone ring beckons our storyteller to the adjoining room, liberating us from his stranglehold! We shake ourselves out of it. A blow like that, you have to see it to believe it.

Shouts break out from the neighboring table. Dessert has arrived. At the end of each conference, the chef prepares a

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chocolate cake, decorated according to the meeting's subject matter. There are mathematicians here who thrashed out integrable systems in quantum field theories. That is worth going to have a look. The chocolate frosting is entirely covered in equations made of sugar. And of course, not just any. That said, I am most interested in the cake

itself, its succulent prospects, notwithstanding the equations. After negotiations with the kitchen, I get a piece. My instincts did not let me down; this cake is to die for.

We are going to go sit on the terrace to sip a *Génépi* or two. The local liquor, it can't be refused. Since we are all together for the first time, all the upcoming film's "artisans", Edgard takes pleasure in answering our questions about "his" conference. Because, really it's his baby, almost unintentionally though. The first round was not qualified as a conference, but rather a simple working meeting among colleagues who happened to be in France at the same time, and who managed an invitation from Edgard. The exchanges were so productive that they decided to see each other the following year, and to invite a couple more colleagues. And thus was born the "Peyresq Physics" conference. True to the initial principle, Edgard refuses to have any fixed format beforehand, everyone comes with his/her ideas and the rest is improvised.

While listening to him, I tell myself that he is perfectly natural, and that this is the moment that should be captured. A spontaneous moment. I am sure that a simple appearance of the camera equipment is going completely mess it up. We will be ill-at-ease, perturbed, inhibited. I'm getting angry.

Edgard's description gives us an idea for title for the report: "Jam Sessions with the Cosmologists."

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Since nothing is set beforehand, since the program is made on the corner of a table each night before the following day, the idea of musical improvisation would gel perfectly. Why not with a jazz soundtrack? In lieu of the endless classical concertos that we gild over stars. I personally picture the stars swing dancing. Edgard's last words, in his

slightly confused tone, before going to bed were exactly what I wanted to hear before the start of a film project: “I don’t know how things are going to happen. I am not sure at all.” Apropos, Alexandre laid this on me:

“Me either, I don’t know at all how this is going to happen.”

But he is talking about the filming. It’s true that we did not even remotely prepare for it (all of our energy was spent trying to woo producers with our dossier). So will it also be “Jam Session with Filmmakers”? It scares me a bit that nothing feels concrete. He is the professional, right? He recruited me for ideas, a viewpoint, but certainly not to know what has to be done. I hear him groan: “What did we undertake here?”

Damn...we really need TWO filmmakers to end up as up as clueless as we are: without funding and without a clear vision.

*But how did we end up here?*

Alexandre and I never doubted the interest of this endeavor: Big Bang, expansion, emptiness, the how’s and why’s of the Universe, it all makes our neurons spin. Edgard Gunzig’s proposal literally launched us into orbit. Imagine, entering the holy of holies, where only the most select physicists can enter?

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On the other hand, we knew from the beginning that it would not be a cake walk, finding a way to translate the jargon into reasonably compressible language. But, after all it’s our job, and we have a couple of tricks up our sleeves: a little experience, lots of passion, a fair level of scientific initiative to bring these professor Nimbuses to the laymen’s level.

Worst off all, finally, before charming future audiences, we have to start by charming a producer. And producers have seen their fair share. In particular, they've seen quite a few failures (statistically it is inevitable).

So we've taken the greatest care in explaining this project in clear and concise terms. I'll skip the successive drafts giving you the final version of what is called the "Statement of Intent" from our dossier.

Each year, in the little village of Peyresq, in the French Alps, the world's top cosmological physicists assemble. They come from the four corners of the Earth, in order to evaluate each other's research. They are going to attempt to dig deeper into the mysteries of gravity and the cosmos.

Everyone knows gravity, Newton and his apple, movement of planets, the buttered toast that falls the wrong way... Yet it continues to pose unsolvable problems to twenty-first century physicists.

This force is one of the most fundamental elements of the Universe. The space-time curve that it determines is in effect the frame, the container, of all phenomena involving the matter and energy that constitute the Universe.

All of these phenomena are governed by quantum physics. But gravity, itself, is described by general relativity.

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And between the two theories, there is complete incompatibility. To make the link between the two, between these two knowledge sets, that is the conquest that physicists peruse. It is the dream of the "Grand Unification."

Edgard Gunzig, theoretical physicist at the *Université Libre* in Brussels, and founder of the Peyresq Conference, invites us to observe the goings-on of this event. He brought together an exceptional smattering of theoreticians who agree to share with us moments in their unparalleled and precious scientific lives.

Our original documentary is at the same time a portrait of this special event and an initiation to heated questions in the physics of the Universe. It offers a two-fold interest:

1) Whereas science is mostly presented through its tried and trusted aspects, here we see scientists hashing a scientific field in real-time. The discussions are speculative, hazardous, and contradictory, like probes launched into space. The discussions show still very divergent perspectives, and deal with such recently proposed concepts as multiple dimensions, strings, vacuum energy, etc.

Not being open to the public, the seminar is at the center of the specialists' research – still works in progress – and the spectator is invited. As a guest you will enter a holy of holies of contemporary physics. For Peyresq is the place to come if you want to know what science DARES to propose today.

2) Whereas most international conferences are huge and impersonal, this one assembles only about twenty specialists; who during the week establish

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close and lasting relationships. Whether at a meal, or during walks and other outdoor activities or during the wine-filled evenings, there are numerous occasions to discuss the meaning of life and the mysteries of the Universe; as well

as enjoying simple pleasures or sophomoric jokes. In addition to experiencing daily science, we enter into the daily life of the scientists.

Obviously followed by a solid dossier echoing our references, those of the participants, photos of the previous meetings, and reflections on the scientific content of the conference. In all, fifty pages of rock-solid sales pitch.

Our confidence started to wane when the when the profoundest, deepest silence answered this irresistible call. Only a friend of Alexandre declared herself “possibly interested.” She invited us to lunch so we could discuss it and see if she could defend the project. Defend? In front of whom? Naively I thought the producer was the person who gave out the money. Not at all, Alexandre explained to me, the producer generally doesn’t have the cash. But he/she knows exactly where to go to get it. Television stations, cultural institutions, etc...there are always several financial partners in a production. Often, there are even several producers, each looking for money in his/her network. Thus Alexandre’s friend invited one of her French colleagues, a producer specializing in the distribution of television popularizations of science; someone who she would like to incorporate into the project.

The man immediately put us off. He knew everything, and we nothing. In order to demonstrate to what a degree

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we knew nothing, he said: “I’m going to read you a text.”

And then he started to spew some mumbo-jumbo peppered with “pink puree,” “procrastination,” and other weird terms.

At the end he shrugged his eyebrows:



“Don’t you recognize it? It is a paragraph from your dossier. I replaced “dark matter” with “pink puree” and so on. Impressive huh?

What did he demonstrate? That jargon is a privilege of specialists who exclude the no-so-enlightened. What a breakthrough! Did he really think we’d address the TV audience in the same manner that we addressed him? Apparently so.

Here we are assuring him that we are quite aware of the dangers of jargon, and that we are not going to talk about pink puree without explaining what it is. Our goal is not to ask go into the technical subtleties, but rather to ask questions about current science in accessible terms. And most of all, we want to show the people behind such questions.

Right away the jerk goes in the opposite direction. “Very bad idea. Scientists are people like you and me. If you don’t go into technical detail, you’ll film a report about a group of guys, it’ll look like a Club Med montage, and no one wants to see that.”

Whatever we say, we are wrong. The entire meal unfolded through a series of 180 degree turns, and Alexandre left raging mad. That very evening he called his friend to tell her that he didn’t want to work with that man. She understood, and did not try to twist any arms. In order to work together, things have to go smoothly, right? She promised

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us that she’d present the dossier before such and such commissions. Nevertheless, she would have liked that we add a text explaining the content of the conference, without being technical at all, well you know, something with pictures that people understand, I don’t know, metaphors...

Onward to a new writing exercise... Alexandre, a little annoyed, got caught up in the flashiest of current events (the World Cup). He wrote a text comparing the Universe to a soccer stadium. He forgot that he was writing this for a woman. She thought the idea strange. "Could you not do something a little less absurd?"

Hmmm, now she wants something serious! We delved a little deeper and added this supplementary document to our "Statement of Intent."

"Where are we going? Where are we from? These questions have always been obsessions. Today they've become ardent as scientists come closer to answering them. Questions about the Universe seen globally: its size, its duration, its shape, were philosophical or religious speculation only ten years ago. No mathematical tool, no measuring device permitted us to grasp the world in its entirety. Today, it seems science is nearing its goal. Observational techniques, as well as computational techniques, have reached a level of refinement that allows us to be on familiar terms with the ultimate secrets of that which is real: be they infinitely small, with elementary particles, or infinitely big, with large-scale structures of the Universe. Contemporary

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cosmology attempts to combine these two approaches in order to formulate a complete scenario of the world's history. In their crosshairs are definitive responses to questions like: Is the Universe infinite or finite? transitory or eternal? What is its shape? What is to come?

This intellectual adventure starts with Einstein, in 1917. Assisted by general relativity, he, for the first time in history, formulated scientific questions

concerning the Universe in its global nature. His theory furnished different mathematical solutions. He chose the one where the Universe was finite, curved, static, and eternal. It was a hypersphere – a four-dimensional sphere, in other words, a space where if you take off in a rocket, you end up at your point of departure always moving in a straight line (exactly as a pedestrian would end up at his/her point of departure if traveling a straight line on a sphere, only that the space (surface area) of the sphere is curved in three dimensions, while the space of a hypersphere is bent four dimensionally).

A couple of years later, in 1929, Hubble discovers the outflow of galaxies and plays havoc with Einstein's model. The Universe is not static. It grows each day. Like a raisin cake cooking in the oven. The raisins represent galaxies, big cosmic loops comprised of millions of stars, and the cake represents space, which swells and carries away galaxies further and further from one another. If all existing matter is dispersed in such a manner, then necessarily there is a moment when the expansion started. It is the start of the Big Bang concept, initial moment – a veritable revolution in our vision of the world. The Universe is growing and has

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a birth date: roughly fifteen billion years ago. Certain mathematical solutions to Einstein's equations allow us to describe this type of Universe. There are even several possibilities. In some of them, the Universe expands endlessly to end cold and completely diluted, in others it expands and contracts periodically in an eternal resumption. The models gain momentum, but this time all make the hypothesis of a "flat" or a "Euclidian" space, meaning not curved, that which

supposes an infinite Universe. No longer a question of ending up at your starting point, when you travel a straight line. The trip will have no end (exactly like a pedestrian who walks on an infinite plane).

With the turn of the century, the possibilities of observing some of the Universe's fundamental characteristics multiplied: the density of matter, black holes, fossil radiation (vestiges of the Universe's first light, emitted three hundred thousand years after the Big Bang). Then in 1998, a dramatic turn of events! A group of astrophysicists observe that the expansion of the Universe has not decelerated, as scientists expected, but rather it has accelerated. Not only does the Universe grow daily, but it grows faster and faster – unlike the raisin cake which slows its expansion. The big, huge problem is that universal gravity cannot explain this new fact. It was believed that gravity governed the cosmos, pulling masses toward each other. Therefore it should act as an rubber band, bringing back, or at least, slowing the masses dispelled by the Big Bang. Scientists set out to find the mysterious factor that obliges galaxies to flee from one another faster and faster.

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Is there still an unknown repelling force? Is it an unperceivable vacuum energy? Behold the questions which define the activities of today's cosmologist. They have made tremendous progress in the describing "Everything," and they feel close to a denouement, a theory which justly describes "everything" and not just certain aspects of reality. This theory must combine general relativity and quantum physics. One of the best candidates is called string theory. It has a high profile right now.

In going to observe twenty cosmologists at a closed-door conference, we are going to delve into the secrets of their research. We will be let in on the Universe's latest news. Some work on strings, some on vacuum energy, others on the supposed inflation after the Big, others on quantum gravity, but all are evolved in the same grandiose project, that of dissecting the Universe as a whole, much like they would disassemble a bicycle (within a couple thousand calculations).

We are going to watch them (these men and women who flirt with the foundations of the cosmic edifice) work, we are going to watch them live together, and most of all we are going to listen to them, obliging them to translate their webs of equations into clear language. In their official "communications" they will be majestic and incompressible, in efforts to explain their research, they will be passionate, fascinating, unfailing, and comedic. In their anecdotes about daily life they will be accessible, human, touching – capable of

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making dumb jokes or of shouting during a televised soccer match (let's not forget that the World Cup final will take place during the conference, where ten or so nationalities will be represented).

In all, it is the portrait of a conference that is painted stroke by stroke: with a didactic component (we want to understand the world in which we live), a competent of curiosity (we want to discover what cosmologists do day-to-day), a convivial component (we want to meet and make friends with the endearing people).

In practice, this is like doing the splits. On one hand there is the spectator. He/she is not a scientist or amateur astronomer, or even a reader of *Scientific American*. They simply wonder what people who work on the Universe do. On the other hand, there are cosmology's best and brightest, scientists at the cutting edge of their field; people who cultivate virgin fields. We are going to link them here. With small animated modules that present fundamental notions like gravity or the standard model, and colorful explanations from those participants with a knack for teaching: invaluable milestones will be set. Enough to gage the stakes and difficulties of this adventure that are playing out in front of our eyes. Straying as much as possible from the most banal observations, we will lead them through the laws which govern galaxies and black holes. We will see how the rigor of the scientific method, far from disenchanting the world, gives off a magical quality."

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This text seemed to have the good fortune of pleasing our producer. "Ah yes, I love the image of the cake in the oven."

See how I was saying it was written for a woman!

The dossier was sent off to two financiers who sort through projects, funding only the finest. We will be up against social, political, economic, and geographic documentaries. How much weight does cosmology pull among these worldly prospects? We were a bit scared to find out.

In any event, we had to leave before hearing; otherwise we would have missed the conference.

## Saturday, June 22<sup>nd</sup>

### *Casting Ants*

Up at seven (nervousness chips away at sleepiness), I go admire the sunrise outside of the village. I crossed a fox in the road, where a minute earlier he had his nose buried in garbage cans. I disturbed him. And therefore I altered his behavior. We are going to disturb the cosmologists as well, and we'll never see them as they would be without us. But, I suppose they do not rummage through garbage cans.

At breakfast, for the first time, all four of us meet up to talk somewhat seriously about the film, in light of what Edgard said yesterday, and about our first impressions of the place. Alexandre insists on the improvisational theme, which evidently was to his liking. If the scientists don't have a set program, why should we? I propose underlining the poetic dimension. We don't want to make a course on the Cosmos, but rather we want to send the audience on a sort of spellbinding acid trip. Olivier likes to film Zenic shots. He suggests focusing on the connection between the Universe as a whole and the smallest aspects of nature. I shift into gear: "Yeah, show that a galaxy and a spider are basically the same thing." Alexandre is astonished: "you mean that incites the same fascination?"

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"Not only, I mean fundamentally it is the same thing."

"How can you thereby identify the living and the inanimate?"

"Well, it's six of one half dozen of the other really. Once the process is underway, one produces the other."

“Be careful, you are saying that the spider was programmed from the start, are we too then? That is anthropomorphism.”

“Not at all! But I don’t see the spider as a spider, but as a bud in the process, there, now. It could have been something else had the Earth’s history been different.”

“So you group the galaxy with other things?”

“Yes, all that exists: from the smallest to the largest, it’s all part of the same cake.”

“Damn *piece of cake*<sup>1</sup>!”

“Completely. The Universe is a cake.” Your producer understood that image right away.

So, what’s in a cake? At first there are ingredients. And that is the cosmologists’ job to identify them. But we can’t see the ingredients any longer; we only see “pieces of cake.”

Each element of the Universe is a piece of cake. A galaxy should be looked at in the same way we look at an ant. Or a pebble, if you will.” Alexandre concedes: “In any case, it is interesting for us to go from one scale to another. Olivier, feel free to film spiders.”

Olivier is thrilled. Now he wants to know how we are going to get organized for the start of the conference:

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“When are we going to film their arrival? Here, in the village? How are they arriving?”

“A bus is picking them up from the train station and bringing them here.”

“Wouldn’t it be better to film them at the train station? If it is a deserted little station like the one we passed yesterday it could be cool. The rickety railcar and all...”

Alexandre reflected: “I didn’t think about that. That would be pretty good. But we’ll have to ask Edgard what kind of welcome he set up down there, and if he plans on going. We

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<sup>1</sup> Note: the original text was in English.



can't show up in front of everyone with cameras if there is no one to welcome them. That would be rough, right?"

The idea of going to the station is tempting, so I push it.

"Suggest to Edgard that we go down with him."

"And if he isn't going down?"

"Oh he'll go!"

"We said that we wouldn't interfere."

"Oh come on, just a little!"

"Oh no! Either we make things happen, or we film what happens, whatever that may be."

"Hey, here's Edgard, you can ask him."

"Good morning Edgard, we've got a question for you."

Edgard, his feet heavy and sleep still on his face, sits at our table.

"Hang on kids, without coffee I don't function. You have to give me a minute."

We let him be. It is like certain artists who have trouble settling into the day. Creators, in a general sense, often say that they work all night, subliminally, and that a stroke of

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genius can crop up upon wakening. We would be sorry to hurry them. (Or maybe it is an excuse to snore longer). After a couple of mouthfuls of coffee, Edgard seems again operational.

"Go for it. I am all ears."

"So. We would like to go down to the station to film their arrival, if you'd come along."

"Would you now? I hadn't planned that. I was going to welcome them here, show them their rooms, etc. If I am down there, Diane will have to do all the work."

Seeing that he is he was resisting, we are about to forget it, but Olivier and I are sad. Then he thinks a bit, maybe visualizing the set-up at the station, what a set-up it would be!... I help him along: "It is certainly possible to make it back up here before the bus even starts up. If need be, we can ask him to wait little. You can be back to welcome them again well before they even arrive."

"Alright, sure, we could do it, but only if Diane doesn't need my help beforehand."

"We'll help her earlier if she needs us to."

It is a done deal. There's a start. And we decide to forget that we just interfered with the program.

After breakfast, Olivier and Damien go off to get some shots of the village, while Alexandre and I establish the list of participants with Edgard. There are twenty two. Edgard gives us a rundown of each of them. They each have their own character, and it is better to know what we are dealing with: what their story is, their specialty, their reputation. And what the potential points contention are, again Edgard is careful to invite only minds able to get along in everyday life (equations, that is something else, to each

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his/her own). Because in this two-street village, it is impossible to avoid conversation with an undesirable colleague.

We especially have to know who to interview and about what. It is impossible to have them all. We have to concentrate on ten or so big names, and possibly two or three younger people who are capable of explaining some basic concepts in French (because, many of the older participants are not French-speaking, and we would prefer not to have to subtitle the entire thing from start to finish). We decide on ten people. Two interviews

per day will not be easy to squeeze in. We will have to fit them in during the after-lunch break, between two and four PM.

Olivier and Damien are enthralled when they return from their walk. They shot some beautiful images of the village, but also all sorts of nice, quaint scenes: like two kids playing with ants. They made an artificial island in a well-water basin, and then they airdropped the little bugs right in the middle. Olivier only talks about this metaphor he sees between what they shot and the creation of the world, so much so that we wondered how long he could possibly stay on that kick. We cannot forget the material constraints. Thirty forty-minute cassettes, and not one to spare.

*Atmosphere!*

We are lucky, there is a party in the village today, and it will make waiting for the evening easier. It is for the reopening of the small Peyresq station, five hundred yards straight up hill. The municipal bigwigs from Annot gather around Mady Smets, who you could consider Peyresq's "godmother,"

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its benefactor. She and her husband, along some friends, invested heavily in order to reconstruct the village – which was nearly abandoned in the fifties. She is the one who got the ball rolling on all of these scientific conferences, in tandem with other tourist activities. She is also the one who threw the party, a feast with plenty of orange wine, a local specialty. But before the ratatouilles and quiches we have to listen to speeches by local personalities. They make reference to the stages of the village's reconstruction, all the way up to its current international splendor. And about an American physicist was seen arriving in Peyresq carrying all his luggage, sweating buckets. He had climbed the

entire way up the mountain path. Because, at the station he was told, when he asked the direction of Peyresq, that “It’s that way,” pointing up.

After the speeches, a musical number is announced. Everything is set, and who do we see walking to the microphone? Jean Van Compernelle. The man plays guitar! And guess what he is singing: *Little Train in the Mountain*. You have to hear it to believe it. We are surely either too urban and/or too young to appreciate this local color for what it is worth. We can’t shake the kitschy notion of wanting to film; Olivier grabs the camera. To the delight of the assembly, Jean Van Belgian even sings a refrain or two in Provençal. You would think you were in an Italian realist film, in such a deliciously rural setting. What a strange start to a cosmology conference. Luckily, the internationally reputed scientists are not yet here. Save one, to whom Edgard just introduced us. He works in Tours and drove down with

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his lady friend, a gorgeous English woman who manages to speak French in an almost-comprehensible fashion...love works wonders.

The man is part of the “younger people” whom we intend to interview. Consequently, I suggest to Alexandre: “What if we were to start an interview this afternoon?”

Alexandre appreciates initiative. Why should we wait to jump in the water tomorrow, when we can start drowning right away? Alright, chop, chop, let’s get in the thick of things. Proposition made. Appointment set. Our interlocutor suddenly got nervous when he learned that we mean to film him. Edgard warned everyone of the film

crew during the conference, but not of individual interviews. Deep down, our victim is lucky. He was warned and filmed that very day. His suffering will be short.

But we have to film Mady, the benefactor that Edgard wants to introduce us to. And then to Louissette, the guardian of the village's history. Not only does she live here, but she is also an historian; therefore a well of knowledge for us. Edgard explained that she knows how to forecast the weather according to the phases of the moon. Lately it seems that the moon "is properly aligned" and we will have good weather for a spell. It amazes me that a physicist in good standing can tell me that, without so much as raising his eyebrows. But he seems to think that if Louissette said it, then it must be for real.

While we are running after our three, singled-out victims, Olivier is calmly filming ants, still concentrating on the two little girls. I ask Damien to ready everyone to go interview the physicist. Five minutes later,

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Alexandre announced that we are going to start by filming Louissette. Five minutes later, I return to explain that Louissette says she tired, but that we are going to film the physicist all-the-same. Then Alexandre let me know that Mady is the priority, as she might leave, possibly not to return before the end of the week. I convey this to Damien, who suddenly seems to be in a bad mood. I hear him grumble behind my back: "We have to make some sort of plan as to what we are doing. This is not filmmaking, shit!"

Consequently, I understand that this is a job for him, and for me, well, I am his boss. He waits for directives. And he prefers clear orders rather than all this confusion. Holy cow, here I am anguishing over not being up to the film, I did not think I would

have to be up to the team! I imagined us as four friends in the same boat. So, warning: if all four of us are rowing, then Alexandre and I are the coxswains.

But I must say that my co-director does not set an iron-fist example. He saunters around, making spectacles of niceness to each Tom, Dick, and Harry. He seems to be everything to everybody, except a guy who takes matters in his own hands. As for me, I am discovering how to step up to the plate... Anyway, it is not my thing either.

Nonetheless, I'm going to relay our team's gripes. "Alexandre, it seems that Damien doesn't like our way of working."

"How so? Is he crabbing already?"

"Yes, because we change our minds every five minutes."

"And that is a problem for him?"

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"Technically you could say that it changes the game for him. He slams on the buttons each time a change in the program is announced."

"Listen, he has his limitations, and I have mine."

"? ? ?"

"Well yeah, my priority is the people. I can't hurry them along. They'll get uneasy. You have to approach them when it is polite, we can't jump on them when they are talking. Look, I am waiting for an opening with Mady, and if that doesn't happen, we'll go see the physicist. That's it. Cool. Technicians have to adapt to how I work, not visa versa."

"Okay, okay."

We hesitate in roping Mady, she is deep in conversation with Louise. But really, why not have them together? There, an idea to solve everything; we leave them

together, but we film them. They pout a bit, one because she has to get to the neighboring village to inaugurate something and the other because she is still tired. Let's just say that these two are certainly not fighting over who gets to be on TV. But we are unsure if another such opportunity will present itself, so we insist. They give in, agreeing, go ahead, we will meet you. The team is going to set up, but I sense that these two victims should not be alone. Louissette stays the course, but Mady, strikes up a new conversation en route, sitting down again.

I take the reins. "You promised us."

"Oh, but I don't think I'll have enough time dear, I have to leave in five minutes."

"Five minutes, that's enough; it'll be done in five minutes."

"Okay, okay let's go."

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I am a little ashamed of this deception, because I know very well that this will take twenty minutes, if not half an hour, but it was the only way. For all of her eighty-nine years, Mady is a woman who emits an unbelievable vitality. Impeccable hairdo, neat makeup, bright outfit, assured speech, she flutters around like an exotic butterfly. I think of Elizabeth Taylor. Still her age imposes certain limitations; she is worried about having to climb a staircase without a banister to get to the terrace. "Who is going to help me back down?" Alexandre comes to the rescue, what a gentleman: "I am going to help you." Mady flashes a charmed smile. "Ah, great."

"Here we are, everything in place to start filming. We put our two divas on a bench, with their backs to the scenery, wide-open valley. A bed of irises frame the terrace, their blue brings out the blue in Mady's makeup. How splendid.

Alexandre takes charge of the interview, I watch. Olivier suggests that I make myself useful and hold the reflector. It is a piece of white cloth that reflects light on their faces. During the last-minute adjustments before the fatal “we’re rolling,” the two friends completely ignore the tension. If they are paying attention to us, we can’t tell. Alexandre has to clear his throat to ask for permission to butt in. As soon as he asks his first question, their dialogue starts up as heartily as before. They just simply changed subjects.

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*Alexandre:* Mady, are you responsible for the renaissance of this village?

*Mady:* I wouldn’t say that I was responsible. The man named George Lambeau discovered the village. And my husband came a few days later. He climbed the small path, and arrived at the mayor’s house, Mr. Imbert. Mr. Imbert remained the mayor, with his wife and daughter. They offered my husband a glass of milk. What a great start huh?

*Louissette:* They found the village nearly in ruins. At first it was because of the war, then snowfall, which further crumbled the houses that were left standing.

*Mady:* So, the village’s true discoverer was Georges Lambeau. He was looking for a farmhouse for his students. And he ended up in Peyresq. He didn’t imagine that he would reconstruct a village; all he wanted was a farmhouse. So, he went to see my husband, Toine Smets, an old friend from the war. He asked him: “How would you like to rebuild a village?” And without a moment’s hesitation he said: “Of course!” It was impossible to imagine the work ahead. Then finally, brick by brick they managed to piece it together again.

*Louissette:* And when we saw these young Belgians we said: “What courage they have to start working on those old houses!” It was full of sheep manure, without a floor, it was



really in ruins. And what did they work with? Wicker baskets, rubber gloves, and cement that they pulled up with a pulley attached to the window.

*Mady:* We rebuilt almost three fourths of the village without a cement truck, we did it all by

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hand. There still are photos of us hand-mixing the cement with a shovel. When we started there was no road, no water, no electricity.

*Alexandre:* How long did it take to rebuild the village?

*Mady:* We only worked two months a year, the rest was spent back in Brussels. We started in '54, and you could say that we finished around 65-66. Well, by then we could already host conferences. We are still working; it is never finished

*Louissette:* It never ends. The climate is rough. The joints beaks, everything deteriorates very quickly. The townspeople always complain about something.

*Mady:* In 1980, we won second prize for a masterpiece in peril. It was quite an extraordinary day at *La Maison de la Radio* in Paris. I accepted the prize from President Giscard d'Estaing himself. At the time, I had just published a book on Fabri de Peiresc, and I brought it along to give to the President. I handed it to him, and he said: "Ah, what a lovely photo, who is it?" And I said without pause: "Your greatest humanist."

*Alexandre:* So, who was Fabri de Peiresc?

*Mady:* He was born in Belgentier in 1580. He died in 1637. He wrote a number of incredible letters. He had seven copyists. He was world-renowned. He was gifted in astronomy, in zoology, and in humanities...he was absolutely learned in all subjects. We admire him very much.

*Alexandre:* How is it he is not more well known?

*Louissette:* Most likely because he never published. He was

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a friend of Galileo. He even knew the Pope, consequently writing him to set Galileo free. When he saw to what an extent Galileo was troubled, he dared not publish. But he played a remarkable role in astronomy. Especially astronomy. In fact, I recently saw a report on *France Culture* where an astrophysicist was asked: "Space telescopes must revolutionize astronomy, right?" The man responded: "The most important discoveries were made during Galileo's time." Then in turn, Peiresc as well. In his time, people believed that the Milky Way was clouds, widespread vapor stuck in the sky. With their first telescope, Galileo and Peiresc realized that it was indeed stars. Peiresc also discovered the first nebula, and named it as such. Orion's nebula. It is outside of the Milky Way. We live in the Milky Way galaxy.

*Mady:* He even had maps of the moon engraved, and his name was given to one of the moon's craters: Peiresc's Crater.

*Louissette:* And as France was meddling in Provence, Peiresc gathered medieval troubadour manuscripts for the Provençal people. He was so important, that on Louis XIV's first visit to Provence, he wanted to visit Peiresc's chateau in Belgentier. Louis was on his way to Spain, to marry his future wife.

*Mady:* He had a magnificent garden, and was a topnotch botanist.

*Louissette:* It is said that he was even known in America, world-wide really. Thanks to better measurements, he shrank the Mediterranean by six hundred miles. He introduced jasmine and angora cats in Europe (he used to give

small cats to all of his friends). He also studied lymph circulation, and was one of the greatest numismatics of all time...really we could go on like this for hours. He even studied hieroglyphs. He thought he could achieve it by learning Coptic. He had mummies sent by boat. The boat's crew despised this, fearing curses.

*Mady:* Despite it all, Fabri de Peiresc fell into obscurity in the centuries after his death, and I have to admit that we really brought him back. In 1604, he was named Lord of Peiresc and of the consequent lands, and in 2004 we are organizing an assembly.

*Alexandre:* Through the village's renaissance, are you heeding the example of his work?

*Mady:* Hmmm, it has always been our goal. We stay loyal to Fabri de Peiresc; yes it is our lofty ideal.

*Louissette:* Nothing was known of the village, so we sought to rediscover its history. We witnessed the disappearance of a thousand-year-old civilization. And no one had the slightest idea of his/her own history. We unearthed it, little by little.

*Mady:* A couple of years ago, we stumbled on the village's archives; they had been forgotten in an attic. When we started the renovations, the workers threw trunks out the window, ignorant of their contents.

*Louissette:* First they ended up in the junk piles, and then in a ravine, where they had been thoroughly rained on. That is where we went to recuperate them. For eight years we worked, and now we managed to piece together how this seventeenth and eighteenth century community functioned.

*Alexandre:* And how about these conferences that you organize?

*Louissette:* Mady wants to do what Fabri de Peiresc did; he put people in contact with each other, dispersed books, knowledge, he wrote...And Mady's role is to bring people and knowledge together in an agreeable setting.

*Alexandre:* What will be discussed this week?

*Mady:* It's the seventh time this conference has come here. And each year they publish in America. Did you know that Louissette, that they publish each year in America? It is a very prestigious conference. Indeed.

*Alexandre:* ...that deals with the history of the Universe, the stars, and galaxies?

*Mady:* Exactly, an evolving Universe. Some mysterious energy has just been discovered. I think they are going to talk about that this time. You are lucky; you are the first ever to attend.

*Alexandre:* And Louissette, you are an historian?

*Louissette:* My training is in Geography, but I do history as well. I wrote a thesis on Provencal, which helps me understand the local texts.

*Mady:* Thanks to Louissette we can understand things that would have otherwise been impossible.

*Louissette:* For example, we knew there was a chateau in Peyresq, but not where. We looked for years for the place. The elderly Peyresq townsfolk told us that it was further away. Pierre Lambique and the architect in charge of Peyresq's reconstruction looked everywhere. Until one day when I stumbled on a notarized document, in which the lord of the lands gave all of his possessions to the community in 1713. The document stipulates that he give the feudal chateau which sits between the square and Rancurel

house. And there was only one Rancurel house, that one right there, the neighboring house to mine. Therefore I was living in it without knowing. You can imagine the surprise! It was fun. People asked: “Did you write it into your book?” I said: “Oh no! I didn’t dare. When I think that I looked everywhere for the chateau!”

Alexandre decided to stop there. None-the-sooner did Mady get kidnapped by Jean Van Compernelle, who had been chomping at the bit. He promised to take Mady to the inauguration ceremony. While the team was putting away the equipment, Louise confided in me that things had not always been rosy between the villagers and Mady. Sure, the tensions have eased, but at first it was truly an invasion. The inhabitants felt colonized by the endless flow of summer students. There was only the mayor, his wife, and his daughter that lived permanently in the village. Some others would venture up during the more agreeable months. They all felt slighted. Louise speaks in very harsh terms, even though she was all smiles in front of the camera. You can feel a deep contention; something that has not yet faded. “It has to be made clear that we’ve existed here for a thousand years, well before they came. They think they invented Peyresq.”

A truth that the film will not include. Maybe if we interviewed her alone? Either way, we would have had to cut to the montage.

We are entirely happy with the first interview. What a great dynamic the women had together!” Alexandre almost did not have to intervene at all. What gabbers! How artless! You would think that they were old pros.

Really grand actresses. The image is beautiful thanks to the harmony of colors: the flowers, Mady's eyes, Louissette's dress... As Mady was saying about the glass of milk, what a great start!

### **Renaud Parentani**

We pick up right away with Renaud Parentani's interview. He must have been waiting quite some time. Alexandre entrusts me with the scientific interviews: "You know the subject matter better," he said.

Yeah right! More like he's not prepared. We catch up to him on the terrace. He looks nervous. Yeah I know, it is not always fun. His wife asks if she can hang around during the filming. How can you refuse really? (Even if I do not understand why she wants to be witness to her husband's suffering – no more than a husband's desire to watch his wife give birth. I guess). That means that there are five people perched in front of the poor interviewee. It is reminiscent of a police interrogation. His intimidation is understandable.

When I ask if he had already been to Peyresq several times, he answers: "That's right."

He speaks without breathing, and almost without articulation. Despite my efforts, he is still tense. It would take a bottle of vodka really.

*Elisa:* What distinguishes the Peyresq Conference from other, more conventional ones?

*Renaud Parentani:* First off, its size. There are only twenty or so people, not the usual hundred. This is also a tight-knit group of people. That allows us to refine our projects,

develop new collaborations, and to pick up where we left off last time. The timing is great too, teaching and exams have just ended, and the summer lies ahead, generally a great time to do research. Over the course of the years, people become friends.

*Elisa:* What can all of these cosmologists talk about?

*Renaud Parentani:* Cosmology is fueled by two things: one, new experimental facts, and two, conceptual advances. I am not a proper cosmologist, but cosmology plays a significant role in my research. I specialize in quantum gravity. There are equally two fields of application concerning quantum gravity: one, black holes, two, cosmology.

*Elisa:* You'll have to explain quantum gravity...It's a scary term for novices.

*Renaud Parentani:* Alright. The first gravity theory was from Newton, in the eighteenth century. This theory enjoyed great success, lasting through the nineteenth century. It was used to explain all known celestial movements. But toward the end of the nineteenth century the first holes in the theory were uncovered. Some observations were inexplicable using Newton's theory. And in the twentieth century, Einstein developed a theory that explained these observations: general relativity. Physicists have

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experimentally verified the provisions of general relativity, and until now there has been no discord between the predictions and outcomes. Therefore, general relativity holds a strong position in establishing phenomena in gravitational patterns, be it on the scale of the solar system, the galaxy, or the Universe. The situation is quite similar for the physics of the microscopic world. At the start of the twentieth century, it became clear that the way that microscopic phenomena were explained was faulty. The much more satisfactory theory of quantum mechanics was elaborated in the thirties. It saw huge experiential

successes during the entire century, leading to what can be presently considered a very correct description of microscopic phenomena. Quantum mechanics is a mainstay, on which we can count. Thus, there are two fundamental principles: quantum mechanics which describes microscopic phenomena, and general relativity which describes gravitational phenomena. Therefore, it is natural to seek a theory that combines the two, a theory that describes all of the Universe's phenomena. It so happens, however, that as they are currently formulated, quantum mechanics and general relativity are completely incompatible. And in some ways, this is one of the most important dramas facing theoretical physics. For seventy years physicists have been racking their brains in order to reconcile the two. I am working in that vein.

*Elisa:* How so?

*Renaud Parentani:* There are several possible approaches. There are very mathematical approaches or very pragmatic approaches.

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String theory is among the most successful mathematical approaches. It is the most ambitious of the approaches as well. Because, if string theory were the correct approach in the direction of quantum gravity, we would have a coherent theory, both mathematically and physically, that would therefore describe quantum phenomena and gravitational phenomena. There is a second approach, the approach to which I subscribe; it is also the approach of Stephen Hawking. Therein, one looks at situations where both quantum and gravitational phenomena occur. Black holes and cosmology are two examples of this. We find ourselves in extreme situations, where we have to take into



consideration simultaneous strong gravitational fields and phenomena of quantum origins.

*Elisa:* What is a black hole?

*Renaud Parentani:* It is such a dense object, that its surface gravity arrests even light rays. Nothing can escape a black hole.

*Elisa:* You are talking about a very pragmatic approach, but it is nonetheless theoretical. You don't happen to have a black hole on hand do you?

*Renaud Parentani:* It's true. Both of the approaches that I have mentioned are theoretical. But one is based on mathematical coherence and ambition, it is the string approach. On the contrary, in the pragmatic approach, the radiation around a black hole is studied; this particular case is used in order to appreciate its general lessons. We are not trying to create a coherent theory in one fell swoop, but we are trying to extract precise, very concrete situations little by little (still theoretical), from information

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that could be, in a future step, the same across-the-board. It's an indirect way of constructing a quantum theory of gravity.

*Elisa:* A black hole has nothing in common with a microscopic object. Why is this application of the quantum theory necessary?

*Renaud Parentani:* Indeed, black holes are, in fact, macroscopic objects. You could say that quantum mechanics is not necessary to explain the composition of black holes. The first person to see that this was not so was Stephen Hawking. He showed that there was a radical change in the behavior of black holes when quantum mechanics is taken into account. Before him, black holes were decidedly black. No light ray, no object could

make it back out. But, when we stop overlooking the quantum effects, we realize that black holes emit thermal radiation. This discovery marked the start of a work that simultaneously used quantum mechanics in order to describe a black hole's radiation and gravity in order to explain its geometry. This really became the standard par excellence for describing quantum gravity.

*Elisa:* With the other application that you call "cosmology" what do you mean?

*Renaud Parentani:* One of cosmology's characteristics is as follows: the Universe is expanding. Therefore, in the past the Universe was denser and hotter. This also means that the phenomena were more violent. If we go far enough back in time, they require the use of quantum mechanics. Quantum gravity's next, very natural application is the Universe's beginning, what is commonly referred to as the Big Bang.

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*Elisa:* What do you mean by "violent phenomena?"

*Renaud Parentani:* By this, I am referring to phenomena with high levels of energy, thus attaining what is called Planck scale. This is the boundary that separates the classical description from the quantum description. When I give my exposé at the conference, I am going to try and characterize these phenomena as they cross this boundary. We are leaving behind the domain of classical gravity in order to forge into an unknown domain, that of quantum gravity.

*Elisa:* Since nothing is known about what goes on beyond this boundary, how do you develop applicable tools?

*Renaud Parentani:* That is exactly the subject of my talk. How do we model theories that we don't know? How do we characterize the predictions of a theory that we don't know?

The approach that I have chosen is to consider the entirety of possible theories, and to seek to find out what the consequences would be. The more that these consequences are independent of the hypothesis, the more likely the theory is trustworthy.

*Elisa:* So, if I understand correctly, you theorize about theories, and not about phenomena themselves?

*Renaud Parentani:* Indeed, it is not an approach which makes predictions. It is a preliminary study which allows me to “test the waters,” to act as scout in a domain that is not yet practically accessible.

*Elisa:* Is there a connection between this kind of approach and the string theory that you mentioned before?

*Renaud Parentani:* Yes, in the sense that string theory is

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one of the prospective theories among all possible gravitational theories.

*Elisa:* Edgard Gunzig informed me that you deal with the notion of time within cosmology. It is often said that current theories in physics question the definition of time itself. Is this true?

*Renaud Parentani:* Absolutely. If we keep in mind both general relativity and quantum mechanics, we come to a definition of the Universe where time shows up nowhere. We have to get used to a description of physical phenomena where time is simply non-existent. You must wonder how we land on our feet, how we get back to the temporal description that we use every day and which works so well. Finding the notion of time from a more fundamental formulation where it is not normally found, is not such a hard operation. Time is not there at the start, but it emerges. Which means, at its base, the

entirety of physical phenomena is intrinsically described, in terms of physical, directly accessible quantities. But, it is the way in which these disparate quantities are organized and evolve; as they are in relation to others allows us to define a supplementary parameter – time. The latter permits us to describe their evolution. Therefore, phenomena have no intrinsic place in time. Time is a variable that is added to simplify the description of physical phenomena.

*Elisa:* You said: “a variable that is added,” is it not arbitrary?

*Renaud Parentani:* No, it is not added whimsically. It is

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not just a supplementary variable, it is a variable which hinges on other preexisting variables. We call that a collective variable. It’s a bit like temperature. Temperature is not a quantity that exists in and of itself. It’s something that follows from energy and the average speed of molecules, and is a very useful concept. You often hear of temperature, but temperature in itself doesn't exist. And time is a bit like temperature. Fundamentally, there are molecules, there is a Universe, the galaxies, but there is no time. Only that in order to explain these phenomena time makes it particularly simple and practical.

*Elisa:* Do you have a thought as to the philosophical repercussions of this new position on time?

*Renaud Parentani:* Right now, no.

*Elisa:* I mean, if time is a product of other preexisting physical grandeurs...is it just an illusion?

*Renaud Parentani:* I understand very well that this new concept of time lends itself to philosophical reflection. But I do not believe that philosophy has much to do with physics

and the function of nature. I think that philosophers deal with preconceived ideas, which have their own allure, their own coherence, and their own beauty, but which are not the expression of an attentive, humble examination of nature.

*Elisa:* In current cosmological theories, does the notion of space undergo a similar kind of change as time did?

*Renaud Parentani:* Not really. But, how the notion of time is implicated in the notion of space would require a very technical explanation. Let's just say that the two notions are profoundly modified when concerning quantum gravity.

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*Elisa:* Is space becoming emergent, or does it maintain a preliminary theoretical existence?

*Renaud Parentani:* The notion of space as we conceive it, meaning the geometric structure allowing us to measure distances between physical objects is, in my opinion is also an emerging property.

Edgard at the train station

Our physicist was not completely at ease with the camera. But that did not impede a fascinating start. I am sold on the subject. Yet what I did not know is that there is a world of difference between real-life moments and filmed moments. When I watch the cassettes a week later, I'll be amazed to see that tension and nervousness of voice completely disappear. The stress only appears when the torture instruments are present (the camera, boom, etc.). As soon as you zoom in on a subject, the circumstances fade away, leaving only a conversation. How lucky!

We have to scram, so many improvised interviews, and we are already late in leaving for the station. Luckily, I run into Edgard as soon as I walk out. He was wondering if we had forgotten. “Not at all, we are going to the station. Let’s go, it’s about time.”

“Were you filming?”

“Yes, we interviewed Renaud Parentani.”

“Oh, I would have liked to see...”

That is all we need. If we add spectators, especially the organizer who represents moral authority, everyone’s nervousness would be heightened. I try to explain to Edgard that it is

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better if we work alone. Afterwards, if he wants, he can see all the rushes. Besides, it is his turn to plant himself in front of the camera for the big arrival scene at the station. He’ll have ringside tickets. We descend the forty hairpin turns which connect Peyresq to the civilized world. The boys had hoped to make a stop to get some things they had forgotten: sun-block, hats, sandals, but the train will be here in less than thirty minutes, so they will have to forget it. Just enough time to setup the equipment and to film some establishing shots.

The Annot train station is small and deserted as hoped, but Alexandre finds it less photogenic than Saint André’s. Damien does not like the sounds. There is a constant hum that sounds like an electrical noise, but the station manager assures us that it is cicadas. I do say, it gives off a heavy air of waiting, of suspense. Olivier decides to film a scene straight out of an old western: Edgard on the tracks, one hand on his visor, the other on

his gun, I mean hip. The cicada's vibrato and the flies' sputtering are great effects.

Edgard hops up on the tracks, doing all he can to fit the cowboy part. A cowboy who huffs every ten seconds. Thanks to movie magic, we can edit a believable scene out of this.

To make the last couple of minutes pass, Alexandre asks Edgard some questions, though he is struggling to stay serious. It is our fault really; we are staging all of this.

*Alexandre:* Are you impatient for the train's arrival?

*Edgard Gunzig:* Of course!

*Alexandre:* Everything is ready up there?

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*Edgard Gunzig:* It's under way. There are still some sleeping arrangements to work out, but intellectually it's ready to go.

*Alexandre:* The program is set?

*Edgard Gunzig:* Uh, no. Save the first day. Exceptionally (for you), I've asked four people to present general reviews. As for the rest, it will be decided during the evening or at breakfast. Besides, it is the most stimulating part of this adventure.

*Alexandre:* Why?

*Edgard Gunzig:* Because there is an unknown, it allows for imagination. No one feels constrained by the diktats of a strict schedule. The participants decide what happens, giving them a sense of responsibility. This conference becomes theirs, and so they involve themselves more than usual. You can tell by how they speak, how they talk amongst themselves, and in the articles they write that get published in American journals. You know, the people here are so accomplished that they could improvise

exposés on eight or nine different subjects. Often they decide according to the dynamic of the moment. There are collective modifications. The result is that they partake of this conference. They are more than fans, they are Peyresq addicted.

*Alexandre:* Generally, what will it deal with?

*Edgard Gunzig:* Well, for example, there is a new, brilliant problem that has shaken up cosmology. It has been experimentally declared that the Universe's expansion has not slowed, as believed, but rather sped up. This creates a theoretically colossal problem. In fact, we thought

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that attractive gravitational force was the only force in play on a cosmos-sized scale, that it slowed the expansion started by the Big Bang. But if the expansion is accelerated, then there is something else that we do not yet know, a repelling effect. We could call it a repelling gravity. It is one of the subjects that will be discussed. We are surely going to speak about vacuum energy, which could account for the repelling effect; though it also poses the grandest enigma in today's physics. Because if we try to calculate it, bearing in mind the quantum theory, the result is a repulsive term of remarkable size, exactly incompatibly with the Universe as it is. In other words, the solution to the acceleration problem is still worse than the problem itself.

A train is arriving in the opposite direction, it is not ours. Olivier has to move from his carefully chosen observation post. What luck. In a station which sees six trains a day, ours has to arrive a minute later, even before the other has a chance to leave. The whole arrival plan crumbles. Olivier runs to the opposite side of the platform in order to try and capture anything at all. Damien follows, struggling through the clusters of



disembarking people, cords and equipment dragging behind. In all the confusion, Alexandre grabs me by the arm. “From now on, pay attention to everything Olivier does, making sure to stay clear of the shot. You have to watch out, he moves like the wind.”

The platform is utter commotion. People all around our technicians. Edgard looks for his physicists like a mother hen her chicks. Finally, we see him greeting them.

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The first to arrive has a shaved head and earrings. I did not imagine cosmologists as such. We have to scramble since the group is moving in our direction. We take refuge in the station. We follow what is going on through the window. The camera and the boom tag along closely. I feel a bit shameful. They were warned, but all-the-same, it is a brutal way to arrive. Were I in their shoes, I would be uncomfortable. Some of them have been traveling for fifteen or twenty hours. What is rougher than a camera in your face as soon as you unload? We do not ask them questions, no, we are just happy watching the hugs, kisses, and sighs of relief (after the ride in the railcar). They are probably saying that this will be hell, these leeches permanently latching on to them.

One by one the climb onto the bus, and we look on with a sense of propriety. There now, all our mice are rounded up, and the experiment will soon begin. Edgard asks the chauffeur to wait until we start the car, and until he joins us. We break down the equipment, leave first, and climb like nobody’s business. The bus requires some time to meet up with us at the village. This time we decide against filming the arrival, it would be too much. On the contrary, we are going to so-cia-lize, you know, we have to come off as nice. It is the least we could do before we take to filming them again, like circus freaks.

There is no shortage of boredom. As Edgard presents name after name, I get lost somewhere in the mix. It is too much. Diane asks me to guide the lone woman of the group – at least that is easy – because she

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is staying in the same house as I am. I try to muster up my finest English, but after three sentences, Glennys asks me if I would speak French, as she rarely has an occasion to do so. An American who speaks French, if that is not a first. Even though she heads the Physics Department at NYU, she talks to me with the familiarity of a cousin. I let her get settled in. No one but Olivier is filming. He is filming a commando mission; two heavily-clothed villagers are pouring a product on a bee's nest over a window frame. Olivier is amazed. He films the whole operation, along with individual bees that land on the intruders, the walls, or the steps. You would swear he's making an insect film. First ants, now bees...there he is following a bee in flight. Really, it was dumb to produce only one project, when we could do two. With a cameraman like Olivier, the rushes always reveal an animal documentary.

A little later, at dinner, I sit across from Slava Mukhanov, the Russian cosmologist that Edgard described as a phenomenon. He keeps a spittoon from sunup to sundown. Heavy drinker, heavy smoker, his voice dominates until lights out. I have to say that he rarely goes unnoticed. The restaurant has very low ceilings, which makes for dreadful acoustics. He decided that I would be his first victim. But after a while, neck-deep in the ruckus, I wonder why he insists on speaking to me in Russian. After the aperitif, I notice a

couple of English words amongst his ramblings. And after the appetizer, I realize that he had been speaking in English all along. So I try and make out any snippet of syntax, at least enough to smile when necessary. I whisper to Alexandre: “I feel like I am eating across from a jackhammer.”

I have to avoid the situation, because the Russian will not leave me be. And the longer it goes on, the harder it will be to let him know that I have no idea what he is saying to me.

Following dinner, a good fraction of the group finds the way to the terrace. The very same direction Slava is moving in. He talks, and the others listen. The chairs are arranged in a circle, with Slava in the middle. This must be an institution here, because all we hear are eruptions of laughter and commentary. There is talk of the many-worlds hypothesis, an interpretation of quantum physics that stipulates that our world is but one of infinitely many possible realizations, while others exist in parallel with it. There are as many worlds as there are offshoots of each probable event, thus creating an overpopulated Universe, which multiplies with each second. However, this model has the immense advantage of sweeping aside the immortal question of “why”. Why do we exist in this form, with our awkward history? Because all other forms, and all other histories do as well. Even if the argument is powerful, its implementation lacks simplicity. Slava suggests that if the theory is true here, it does not mean that it is true in every world. In a way, were it possible, would it not have to be as such elsewhere? Our Russian takes off into a long story on the interpretation of quantum physics through the very founders

of the discipline. Throughout, he insists on reiterating Heisenberg's trips to "Copenhagen." And finally, when Slava is tired and goes to bed, everyone follows suit.

## **Sunday, June 23<sup>rd</sup>**

*In which we escape into an extra dimension*

The conference starts today. Edgard asked four of the participants to prepare preliminary presentations. Not the usual, highly specialized sorts, but rather general talks about an entire field. The old start-out-easy story. What follows will be decided as we go along.

This particular procedure must be for the TV crew. Sensing that we would be overwhelmed starting at the first specialized seminar, he wanted to give us a hand, like a kind of stirrup to hop up on the horse. He added that this would certainly please everyone, and that our presence allowed for a dream pretext, resituating certain notions in a larger context. "Even if we don't dare say it in front of colleagues, we need this kind of reminder. Nowadays, each sub-discipline is so technical, and advances so fast. We see the day fast approaching when each person will understand only his/her own work, if that. Edgard sighs.

We're thankful for their accommodation, but already the supposed "general overview" is far above our heads. We, the ones who were so excited to listen to Gia Dvali talk about extra dimensions and gravity at very short distances, we look at each other,

stupefied, after only thirty seconds. It can't be possible that they threw us in so soon! The horse ran off before we even lifted our foot. We turn around, breaking eye contact, so as not to guffaw. We try to look the part. These five days of conferences may as well be in Swahili.

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The beginning was clear enough: we know that gravity as Newton described in equations is duly verified in a certain experimental window, which covers medium distances. Nothing proves that it is valid on a very small or very big scale. To be more precise, anything beyond  $10^{27}$  meters and within a tenth of a millimeter is unsure. Well, there is all that I got from the exposé...generally the first three sentences. But it is more than enough, at least to start reflection on what is considered a universal law. Without a doubt, there's no other example of a law in physics that has been so thoroughly proved as Newton's law of gravitation. It is used to calculate the positions of all the objects in the solar system, to control ballistic trajectories, in aviation and in astronautics, and it will be certainly used until the end of humankind. Newton never made a mistake. For very fast bodies, you have to apply some relativistic corrections (meaning Einstein's equations), which modify the calculation but do not alter the structure of the law. All of the predictions that it permits are correct. It's called universal law because, like anything that deserves this name in physics, it's supposed true in all places and at all times of the Universe. As soon as a body has a mass, or energy (Einstein showed that this was one and the same), it obeys to Newton's law. It interacts with all other mass (or energy).  
Parentheses: we have long said that bodies attract

each other, but since general relativity we say that they deform space. The idea is very different, but the results are the same. You could say: everything happens as if the bodies were attracted to each other. Close parentheses. The intensity of the exerted force between two bodies is applied by the product of their masses that divides distance squared, multiplied by a constant.  $F = GMm/d^2$ . Therefore, the greater the distance, the weaker the force. Simple, efficient, incontestable.

The only thing is that no one has ever wondered if this law remained valid vis-à-vis most improbable distances.

A priori, the question is a little weak. It is already great if a law is applied to testable scales. It's a miracle that the apple, the moon, and the Andromeda Galaxy fit the same equation – an infinitely satisfying miracle for the mind (at least a physicist's), and it would be right vicious to look any further. Why do we need to know if gravitation applies to distances in excess of one-hundred billion light years? Or between two water molecules? So far as to ask if a square millimeter of a Picasso painting is still indeed a Picasso painting!

Yet, therein, gravitation could be hiding its most important secrets. Maybe through questioning its limits, we will perceive its true nature. If gravity is predictable since Newton understood *how* it behaved, then there is not a single person on Earth who understood *what* it is. Bodies mutually influence each other, according to the equation; that is just how it is. There you have it, almost everything science can say. (Talking about space deformation, it's real nice, but it's vague. Who, what can *deform space*? Deform. Space. I guess I am kind of asking you).

Then again, gravity might act differently at very small scales, and that would reveal a heap of information. Granted, setting up experiments to see this is awful: at a small scale, gravity becomes negligible compared to the electromagnetic force. The latter doesn't assert itself except at very small distances. In some ways, we go from one reign to the other. A bit like social sciences, where the individual does not react to the same forces as the larger group; and when you concentrate on one single person, you go from sociology to psychology. In that same vein, when you reduce the scale, gravity becomes less and less marked, and the electromagnetic force becomes more and more dominant, to the point where only the electromagnetic force is measured. Yes, but that's just at the point where we want to know how gravity diminishes. Is it exactly by respecting its sacrosanct formula:  $F = GMm/d^2$ ? Really, it could just as well not be so! Some physicists believe that gravity, on very small scales, can prove to be weaker than what Newton said. The untouchable formula could thus change at the extremities. The explanation? It's great, if you are willing to expand your mind; because, at very small scales, the essential graviton escapes into invisible dimensions!

You're thinking science fiction right? Not so fast. If so many scientists put stock in it, then it must be plausible science.

To really appreciate the elegance of this argument, you have to be introduced to the graviton. What is a graviton? It is the vector of gravitational force. No one has yet observed a graviton face to face. But that is not what concerns us here, we can visualize gravitation in several ways, and therefore why not

with an with a mediating particle? Anyway, that is Gia Dvali's hypothesis. Thus, gravitation would be conveyed by small particles which are exchanged between bodies. Let's suppose.

And, what is an extra dimension? It is a spatial dimension beyond the three familiar. To try and recreate one is impossible, so don't try. All we can do is come up with a rough analogy. Think about a vertical axis in a flat world, a world reduced to a sheet of paper. This axis is complete drunken delirium; no one can envision it. As three-dimensional beings we are fully aware that height exists. So, why not a fourth dimension that we cannot perceive?

Now, get this: a fourth dimension can be very small. Meaning: not spread over infinity, like what – apparently– our three dimensions are, but rather, rolled over on themselves.

You must think this is April Fools or something, but really you know tons of examples of dimensions rolled over on itself. Take the Earth's surface. It is a surface, a two dimensional space, consisting of the north-south dimension and the east-west dimension. Each of these dimensions is curved to the point of latching onto itself after some 25,000 miles. The Earth's surface's two spatial dimensions are not infinite, just rolled up. See, this isn't magic.

Another example: piping. Take the surface of a pipe: one of its dimensions is very spread out (the length), the other is very short and rolled up on itself (it is the curvature which makes a pipe different from a rectangle). In a copper wire, this second dimension is even smaller, and in a hair (the roundness) is down right micro-



scopic. You could easily believe that a hair is a one-dimension object, but beneath a microscope you can clearly see a relative thickness. Maybe then, for the Universe, it's the same. Perhaps a fourth dimension is so small that it escapes us, leading us to believe that the Universe is three-dimensional. As such, a fifth, sixth, or seventh can be added.

How are we advanced by this? This allows for –I didn't lose my train of thought – an explanation of gravitation's behavioral changes on a very small scale. Because gravitons can be limited to traveling in our visible Universe for all macroscopic phenomena, but can escape into the extra dimensions as soon as a phenomenon's scale falls below their radii of curvature.

Let's recap. Take a pipe, and a unidimensional being (a dash) that lives on the surface of that pipe. It can only move in one direction, lengthwise along the pipe. But if the dash became very small, say smaller than the pipe's circumference, it could then pivot, thus being moved in a second dimension. Great, right? This being, prisoner on a pipe like a train on rails, you shrink it by a thousand and it can move in the opposite direction!

Suddenly, it seems to disappear – I mean for the pipe's other inhabitants. Take another dash, a friend of the first. In his one-dimensional world, he found his cohort, took his measurements, and checked his police record. Now that the small dash pivoted (and it was only able to pivot because he is so small), the big dash wonders where the hell he went to.

It is in this same way in which graviton escape the Universe, like rats in a ship, as so long as they are

exchanged between two extremely close bodies. Provided the distance is smaller than the curvature of the extra dimensions, then off it goes! The graviton packs its bag. Got it? Every object is stuck in a three-dimensional net, unless it becomes smaller than the net's mesh, thus sliding through.

Under such conditions, it is not astonishing that measured gravitation can seem abnormally weak. The universe is a toilet, with a very small opening, and we only perceive a tiny piece of the graviton flux emitted in very-small-scale phenomena.

At least this is one of the (numerous) possible scenarios.

That is where Gia Dvali started from, propelling us into a series of hypotheses and arguments. Really, I can only admire its general allure. He spoke of Van Dam-Veltman-Zakharov's discontinuity (I love these fairytale names). He showed that the graviton could not have mass, but that gravity could be massive. And all sorts of staggering things.

This man's composure intrigues me (as my brain rests). Before his seminar, I would have believed him shy and subdued, certainly not the type to be forward with women. But since he came to the table, there he is, brilliant, absolutely brilliant. Fast-talking, assured, structure, rigor, nuance, he's got it all. And as he was asked questions, his assurance cranked up a notch. You'd say that his responses were lined up, ready for quick deployment, as he enjoyed giving them one after another. When he is contradicted, he raises his voice to the point of scaring away any possible altercation. He is beyond animated, he is vehement, like someone who knows the question inside and out,

who doesn't understand that someone could still possibly have misgivings. I have scarcely seen a speaker more sure of his/her subject. A hunk, to boot. Eastern European charm, Russian accent. Russian, yes, but not as thick as Slava Muckhanov's.

Slava slips out to the terrace. Edgard warned us that he is physically incapable of going an hour without smoking. Through a half-opened door he follows the debates. He pokes his head in and out as he puffs his cigarette. This is a real shot for Olivier; he slips out to the terrace as well, hoping to film the assembly through the window. He can't miss this opportunity. He poises himself, like a predator chasing easy prey; he aims and shoots his camera at the chronic smoker. Slava chose the moment to stage this interference (it's coquetry, or am I reading into things?). He hasn't budged, but be assured that when he does it will be in a truly dramatic style. He's too kind, a real godsend for our report. So help me, this is the only scene that we're going to keep. An unrelenting Gia Dvali fends off his critics like Artagnan against a hoard of assailants.

The Vaïre valley burgeons below the terrace, radiant, luminous: it lies as indifferent to this cosmological agitation as reality itself.

*But what makes it possible for us to be here?*

A tenth songbird takes the floor, sharing with us the problems associated with a cosmological constant.

At first glance he looks like an alien. He's dressed completely in black. His gaze mimics his clothes as

he is wearing black sunglasses, fat as a diving mask. Very white skin. Unflinching face. Mutant? Robot? Oh no, Edgard warned us of the man with sensitive eyes who couldn't take off his protective shades. Alex Vilenkin is a Russian emigrant living in the United States for sometime. He succeeded in losing his accent. With his measured and distinguished demeanor, he surely didn't fit the image I conjured up in my head. Edgard had painted him as a real instigator. If he is shaking anything up, it lacks the zeal of his predecessor. His poised delivery makes it hard to believe that he is one of cosmology's most audacious minds. I still hear Edgard saying: "He is going to suggest scenarios of the Universe's creation from nothing – and when I say nothing, I mean nothing; his emptiness is much emptier than mine."

Edgard also gets a kick out of creating things from nothing, but his nothing represents a quantum vacuum, which implies many things. This man here has no qualms about nothingness, really nothing, meaning the complete absence of everything, including the void itself. That is quite a task. Because what does a physicist do if he/she has no "nothing" to lean on? Remove this, and (s)he loses his balance.

Alex Vilenkin starts off strong: "For some time we've had a problem with the cosmological constant. Recently, we've made progress. There are now two problems and a stack of possible solutions."

First off, what is this cosmological constant? Originally Einstein rigged it up

to stabilize the size of the Universe. At that time that the Universe wasn't thought to expand and contract at will. It didn't correspond with the observations or the concepts of

the day. But the equations of General Relativity allowed for a dynamic Universe, a Universe in movement. So, Einstein came up with an ad hoc term in order to assure its solution corresponding to a static Universe. Later, when it had been proven that the Universe was assuredly expanding, the cosmological constant headed to the chopping block. It became nothing more than a mark of mental retardation.

However, nowadays you can still find uses for it, and so cosmologists reestablished its former honor. In its new role, the cosmological constant corresponds to the density of vacuum energy. (How can a void (vacuum) have energy? Well that's a long story. So to keep it short, let's just imagine that from zero, from emptiness, or from absence, there are really only minima. For example, 0 Kelvin, what is referred to as absolute zero temperature, is really the minimal thermal agitation). A void (vacuum) is a state of the least energy possible, but that certainly doesn't mean that it has no energy at all. A little something remains. There is a hitch – and it is the first of the problems broached by Alex Vilenkin. We know how to calculate vacuum energy by employing the quantum theory. If you play around with the calculation for the entire Universe, it produces a colossal value. Such a value surpasses, by far, that which is compatible with the cosmological theory. According to the subject we are getting onto, a quantum vacuum has two faces. In cosmology, it goes almost unnoticed. In quantum theory, it moves to the forefront.

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It's like having the same person be Santa Claus by day and Jack the Ripper by night. It's unbelievable. The same object having two values, it's a catastrophe.

The second, and much more recent problem stems from the staggering discovery that the Universe's expansion is accelerated. In an expanding Universe, matter becomes less dense (since the same quantity of matter is diluted in a larger and larger space). The density of vacuum energy (which we just discussed) remains constant – vacuum is everywhere and is always the same, even as space distends. Pivotal, there is a moment when the matter density becomes smaller than the vacuum energy. The moment is now (give or take a billion years). The acceleration of the expansion is the proof. In fact, as long as matter density surpasses vacuum energy, then gravitation “restrains” its expansion. But if the opposite happens, then so goes the Universe with it, in an accelerated outflow.

Nothing to worry about. In all of the billions of years that we could have observed the Universe, we happen to live right now, just as the vacuum wins its battle against matter. This new problem is called the problem of temporal coincidence. In other words, to “why us?”, “why here?”, we now add “why now?”

Contrary to the first problem, which has no solution, temporal coincidence has generated plenty of explanations. Particle physicists have their model, but Vilenkin finds it unsatisfactory. Cosmologists invented “quintessence,” which Vilenkin believes does not resolve the problem. No, all these explanations don't

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work. He suggests coming back to a tried method which, for him, is still the best hypothesis; he means to talk about the anthropic principle.

Amazing! First he gives a speech on the cosmological constant (the most reassuring of subjects), and then somehow he just talked to us about the anthropic

principle? Something's off here, the idea of anthropogenic principle makes cosmologists, the world over, cringe (and not just amongst themselves, but with philosophers, priests, and gurus who are therein equally implicated). The guy's got balls!

The problem is that the "anthropic principle" includes a little bit of everything, baloney and all. And its founder, Brandon Carter, is here with us (we have full intentions of grilling him on the subject later). The most depraved version of the principle states that we are here because we are meant to be here. Thus all the mysteries disappear (because if everything was preconceived, there's no occasion to be astonished). But this rudimentary version is used mostly by those (often non-scientific) people who want life, man, and even their very person to be duly planned. As presented, the anthropic principle could be called Pinocchio's principle; because each time he is asked a question (Why are you made of wood? Why are you wearing blue pants?), the puppet invariably responds: "Because, that is how Gepetto wanted it."

The word "anthropic" is derived from the Greek *anthropos*, man. It thus suggests that from its origins the Universe was geared toward the creation of humans.

But Brandon Carter, Alex Vilenkin and most of their colleagues are smarter than that. For them, we can only observe a Universe where humans

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are possible. They swear that it does not exclude the possibility of the existence of other Universes. And that they exist in parallel. This is a beeline in the opposite direction of the Pinocchio principle. In lieu of claiming that the Universe is exactly what it was meant to be, dead-ending further discussion, this approach achieves quite the opposite effect. It says that our observed universe is exactly what it can be, given that we are here to

observe it. If we weren't here, it could have been markedly different. Our presence inevitably stands as proof to the welcoming nature of the Universe, since it indeed welcomed us. It defines strong constraints on what the Universe can be. In this version, the word “anthropic” does not refer to humans as the goal of creation, but rather as observers of the Universe (such a universe is subject to all sorts of conditions).

But who's to say that we represent all that there is? Really, this idea hinders any possible conception of alternate Universes, or even different part of this Universe that we do not yet know. Lifeless Universes. Universes void of planets, stars, galaxies. Universes without matter. To the question: “why do we exist, just us?”, finally you can respond: “because everything else exists as well.”

Thereby the statistical improbability (we had one chance in a trillion to see the light of day) transforms itself into statistical certainty: each of those trillion possibilities is achieved, as are we, in this ephemeral mix. That sums up our relative importance.

Such a vision is obviously an overly-simplified gloss of the illustrative portion of a Universal theory (there is no coincidence to justify since everything that is possible has already

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been realized). It also acts as a drawback, complicating its description. Space is obliged to mingle with all kinds of Universes, piled on top of each other, higgledy-piggledy.

Alex Vilenkin shows an illustration easily confused with a geographic map, continents, oceans, islands; everything except a recognizable shape. It's like a projection of an unknown planet. He claims this is a model of the Universe. Our Universe, that which we observe, is represented by a darkened circle in the stable region. This region is



a composition of the global aggregate. The latter is composed of stable regions in which structures form, as well as of stable regions which are however unfit for the organization of matter (where vacuum energy dominates the density of the matter, or where nothing can be condensed), and of unstable regions, which are in full speed inflation (super-fast expansion). In short, a complex and chaotic patchwork reminiscent of a Hieronymus Bosch painting.

Hence the Copernican principle, in continuous propagation ever since Copernicus unseated the Earth as the center of the world. In general, this principle simply says that we should never think that we are unique (it's also called the principle of mediocrity). Each time we took ourselves to be the center of things, no sooner did we fall from our pedestals. Habitually, we have had to admit that there is nothing special about our planet, our star, our galaxy, and even now our Universe. It's lost in a vast array of other universes, each possessing all possible and imaginable characteristics.

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If this isn't scoop, I'll eat my camera.

Vilenkin's talk provokes hearty reactions. Not only did he use the term "anthropic" but he used it as an introduction to speculations of the most gratuitous sort. How can we prove that our Universe is nothing more than a single kernel in a tub of popcorn? In vain, he presented a handsome set of equations to support his demonstration, though they fall short of proving anything. We hardly know the size of our own universe, let alone others, you understand...it's too early really. Maybe in the twenty-eighth century Alex Vilenkin will be seen as a visionary. But for now, he's out in left field. The skeptic and offended voice their reactions, as a happy Olivier films everyone's anger.

What a sport this cosmology is! I'm sure they didn't know when they invited us that we'd be filming their fights. Things got rougher when Gia Dvali and Slava Mukhanov heated up. It must be a Russian thing.

What a film we're in for.

### *Tactical Change*

At breakfast I decide to get things rolling, in hopes that the next interviews will go smoothly. We set our sights on Cedric Deffayet, another young, adorable Frenchman. Edgard bragged about his superior pedagogical abilities. No more improvisation. I suggest that we talk during dinner, to plan things out. I think he'll be more comfortable and convincing if he kind of knows what

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to expect. Well he can choose what to talk to us about...extra dimensions, strings? Let's say I helped him choose, but we agreed at least. We all converse so much during dinner that dinner itself becomes a problem. We hardly find time to chew or swallow; furtively, as if it were a vice. So little chewing can lead to digestive pangs later in the evening...let alone you have no time to enjoy your food. Nothing but self-sacrifice this scientific stuff! It's worth it, because between his elusive bites of food, he succeeds in explaining compactified dimensions very clearly – using his napkin as a prop.

First and foremost we have to establish what the string theory deals with. It replaces point particles with vibrating strings. The specificity of each particle lies within the string's vibratory modality. There are no protons, no neutrons, and no electrons; there are just different vibrations of the same "object," the string. But what is a string? A miniscule "thing" principally characterized by its length (thus allowing it to vibrate). The

rest is not so important. We can imagine two kinds of strings. Open, meaning that their extremities are unfettered (like the end of a thread), or closed, meaning that they form a buckle (like a rubber band). Both models can vibrate, and they can do this according to different kinds of modalities, called harmonics, which are contingent on their level of energy (like a stretched rubber band that vibrates differently according to the pressure applied).

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There's the general idea. This new theory resolves lots of problems (and in turn creates new ones). It's so streamlined, mainly because it gives up on the notion of point particles. Really, if an elementary particle is reduced to a point, it almost negates its reality. Geometry deals with points, and God knows that Geometry is illusory. The world is not made of such abstractions. As if fundamental physics were? A string has one enormous advantage: it stretches. It occupies space. We can touch it (well, if we had a long enough arm, and a small enough hand). It would seem that this small adjustment makes a world of difference, and is all that is needed to open the door to in the reconciliation of general relativity and quantum mechanics. We'll leave it there for now. Cedric Deffayet looks convincing. He's good-and-ready, and I am hopeful as I bring him to my colleagues.

Olivier wants to change up the scenery. We are not going to interview everyone on the same terrace...as splendid as it may be. This morning he came across a spot overlooking the village; he asks our physicist if he minds walking ten minutes to be filmed in the middle of nature. We have to take advantage of the few young people that we want to interview, hence the acrobatics. We won't ask the older folks to climb.

Our man and caravan start out, under the heavy sun. We are all, save the physicist, loaded up like sherpas. Ten minutes up hill is certainly enough to sweat. We're quickly out of breath. I imagine that our victim

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must already regret this. When we arrive to Olivier's early morning find, we realize that there isn't the faintest bit of shade. It must have slipped his mind, because it is high noon. We'd need a hell of a tree to shade all of us...all we see are bushes. Do we continue? Or forget it? I feel like I am smack-dab in the middle of a *Three Stooges* episode: Larry, Moe, and Curly make a documentary. Luckily we didn't drag along any of the grandpas. For five minutes we traipse along the rocky way, searching, really searching. Olivier finds a sapling that will do. You can still see the village through a small opening in the brush. Our interviewee settles between a stump and some rocks, under the motive quasi-shade of the sparse foliage. We four are precariously seated among the boulders, struggling to tolerate the sun. So much for a trial run.

Alexandre fashions a hat out of the round lip of the reflector, trying to stave off sunstroke. It looks like a Phrygian cap: tall, narrow, open edges around the cheeks. I'm sure if he had a mirror he'd prefer sunstroke. It takes us a while to set up the equipment, and to situate ourselves in these tortured surroundings. I'm seated facing the sun. I have to keep my dark glasses on, and it doesn't put our interlocutor at ease. He is tense. He dabs his wet forehead, trying to crack an awkward smile. He sits on a not-so-flat rock, using my empty backpack as a cushion, he fights the opposite-leaning slope, folded over, while the insects wise up to his presence. I'm not sure if these conditions will produce a brilliant talk.

And the show going on in front of him surely isn't reassuring: two precariously-balanced technicians, one accessorized Tibetan Lama, and a journalist wearing opaque black glasses. We're disconcerting at best. Not to mention the glaring white reflector made to compensate for variations in light (through a constant glare). I'd bet he'll say anything to be elsewhere.

**Cedric Deffayet**

*Elisa:* We always hear about extra dimensions, what do cosmologists mean by that?

*Cedric Deffayet:* In life we experience three spatial dimensions, three of them are all around us, then there is time, therefore we live in a four-dimensional space-time. We can easily imagine that there are many more than four dimensions in space-time: five, six, as many as we want, but it is impossible to visualize what that means. We can use an analogy, a simple model, like a two-dimensional piece of paper. A sheet of paper has two dimensions, and we can "plunge" it into the space around us which has three dimensions. At that moment, from our point of view, the third dimension is perpendicular to the sheet of paper. Now, from the piece of paper, I can make a cylinder, thus curling up one of the dimensions of the sheet. If I tighten up the paper, I end up with a very thin cylinder. Of the original two dimensions there remains one dimension that is not curved, that is: the length of the cylinder, and a curled up dimension, the circumference of the cylinder, which is very small. And if I look at it from afar,

I see a single dimension, not one that is curled up; the other is too small for my eye to detect. I'm under the impression that it's straight object, and not a surface. This is

precisely the same idea found in cosmological, extra-dimensional models. If space-time extra-dimensions really exist, they can be very, very small, curled up on themselves. There would be four “large” dimensions plus a certain number of other curled up dimensions, so small that we can’t see them.

In general, in string theory, we use ten or eleven dimensions in all, meaning six or seven extra dimensions beyond the space-time’s ordinary four.

In addition, there are other, more exotic models (if that’s possible) which suppose the existence of extra dimensions, without having curled up dimensions, quite the opposite, they can be flat, infinitely large, and despite it all, they can escape us. This is a fairly new possibility, and it’s something that is being actively examined by some participants in this conference.

*Elisa:* How could a dimension be large and still escape us?

*Cedric Deffayet:* You have to imagine that we are “directionally blind.” Take the paper example again. If a flat being exists on the surface of the paper it doesn’t “see” a vertical dimension, albeit present and large. Why? Because it is “stuck” to the surface, “confined” to two dimensions. In the same fashion, you can imagine that everything we know is “confined” to three ordinary spatial dimensions. A virtual prisoner,

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and if “something” happens in other dimensions, we don’t “feel” anything.

*Elisa:* You talked about string theory...can you explain it?

*Cedric Deffayet:* It is a theory which explains objects called strings. These objects have one spatial dimension, a length, and they move in space, therefore they describe a two-dimensional surface. You can say that these objects replace point objects from classical

physics. Thanks, in part, to this replacement we can resolve formerly insolvable problems. However, there are several kinds of string theories. Some of them describe open strings and other closed strings.

*Elisa:* Is there any common thread between strings and the old world. The world of electrons, protons... ?

*Cedric Deffayet:* There is a commonality, yes. In the sense that the different particles that we know are described in this string theory as agitations of strings, which could be understood as vibrations. For example, a violin string can vibrate in ways which create different sounds. Then, each vibration corresponds to a particle. A string that vibrates in a certain way corresponds to an electron, and a string that vibrates in another to a proton.

*Elisa:* I hear the word *brane* a lot. What does it mean?

*Cedric Deffayet:* In extra-dimensional theories we consider ordinary matter to be localized.

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on a four-dimensional “surface”: three space and one time. This “surface” is entirely embedded in a space-time with more than four dimensions – exactly like the two-dimensional piece of paper that is embedded in our three-dimensional space. In this general sense we call surfaces *branes*. Thus, it deals with any kind of surface embedded in a larger space, so the words “surface” and “space” are connoted, because in everyday speech they refer to bi- or tri- dimensionality. While *branes* can have as many dimensions as we want, and it is embedded in a space-time which has more dimensions than itself. And because of this, strings themselves are *branes*, thus they are one-dimensional objects which are embedded in a vaster space-time.

*Elisa:* Therefore, in this version the whole Universe would be subgroup of a larger grouping?

*Cedric Deffayet:* Yes, meaning that our Universe, the one which we daily encounter, would be a kind of surface, a *brane*, which is embedded in a vaster *space-time*. There are “transverse” extra dimensions, which are curled up and very small or quite the contrary, infinitely large. Our Universe would thus be only a small part of the reality.

Cedric Deffayet tried hard, but he remained nevertheless tense. Compared to his lunchtime presentation, his delivery was more hesitant and decidedly less clear. Even the curled up dimension explanation (I had even thought of giving him a piece of paper) lost its oomph. It seems like that interview was the test-run, and not the earlier one. Maybe preparing wasn't

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such a good idea. He didn't dare repeat what he had told me before; he branched out on some dangerous variations. Really, Alexandre's improvisation might just be an old pro's trick.

When the interview was finished and all the material was put away, I say so everyone can hear: “Tonight we'll have Dvali.” “Ok, we'll do Dvali.”

I threw the idea out there, without thinking, because we have to move forward. A second later I realize that it scares me. How am I going to maneuver such a bullish fellow? He could throw us for a loop. Will it be possible to channel, frame, dominate, and especially bring his lofty discourse back down to earth? And in a foreign language to boot. It has to work. It has to, it has to.



*Singularity, pray for us*

The afternoon's first talk was given by Larry Ford, an American accompanied by his wife (but she is out sunbathing, the cheater!). Larry Ford is going to explain the status of the singularity in the standard cosmological model.

The singularity is the codename that cosmologists give to the "Big Bang;" its name is too tarnished for their liking. It's the strict mathematical reality that the words "Big Bang" correspond to. A singularity is a moment where a mathematical function takes an infinite value. If you draw its curvature, it climbs and falls sharply and vertically. That's it. There's nothing more to the Big Bang than a little mathematical sour note. If you observe the Universe against its grain,

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meaning going back in time, there is a moment when magnitudes like temperature or pressure become infinite. Fatally, since the Universe is expanding. If we project the film backward, it does the opposite and contracts. And if it contracts, there has to be a moment when all the elements bang into each other. And if all the Universe's matter is assembled at the same moment, in the same place, you'd be sure that there is a problem. The laws of physics show simply that temperature and pressure become infinite. Of course, this means nothing. Physically speaking. A mathematical value can take on an infinite size. A physical size cannot. That doesn't make sense. How can you materially obtain an infinite temperature? Very high, as high as you wish, yes, you can, but infinite, no. Therefore, at the point where mathematical functions describe the Universe through infinite values, physical theories disintegrate, and exist no more. You could say that its relevance negates itself. What is left? A theory that describes the Universe but ignores its beginning. It isn't

that the initial moment is too far or too difficult to understand, but rather it's the fact that the theory derails as soon as it tries to explain its origins. It's really a shortfall. Thus the Universe is always understandable, except at the precise moment of its appearance.

Really, how it came from nothingness, if it is singular, could be not-so-exceptional. Each morning our conscience wakes from nothingness. It can remember each of the states since waking, but it can be perplexing to figure out what happened immediately preceding. We have a big bang each day (two for those who nap) – that should render less bizarre the mysteries of singularity.

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Enough with the jokes. Larry Ford's questions are among the most fundamental that can be asked. He asks if the total failure of the theory is apparent or real. Meaning: is the appearance of singularity due to the way in which the theory is formulated – a malfunction of its creators – or is it a sign of the fundamental and inevitable impossibility of capturing the initial moment?

In the first case, the theory trips over the rug because it's shaky on its feet. In the case of the second, it trips because there is a hole in the middle of the rug.

In the first it produces its own problem (like so many of us). The second forces out an inherent problem with the Universe.

In the first case, the singularity is an artifact (an illusion, a booby-trap). In the second case, it's fundamental, structural, objective.

This could go on forever. You've understood that the question doesn't lack merit.

I know I won't be able to explain like Larry Ford does. Let's jump straight to the conclusions (no easy task). Hawking and Penrose were able to show that the singularity is

fundamental (the hole-in-the-rug version) if two conditions are united. The first: space-time corresponds to the definition given by classical physics (Einstein's). The second: it has to be matched with stress-energy tensor that satisfies a certain energy condition.

Well, I admit, that was a bunch of gibberish. If you want more details, try Raychaudhuri's equation...the development is worse than the spelling.

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But no need to nitpick. If we consider the two hypotheses to be reasonable, the failure of physics to realize the initial moment is fundamental and definitive. Either way that is a hell of a conclusion.

Which means (I imagine) that the cosmological standard model isn't so bad after all. Some weird stuff happened at the Universe's beginning.

Frustrated in not being able to understand more about what I consider a crucial subject, I take it on myself to ask my neighbor. He explains that the conditions they are talking about are physical and geometrical conditions a priori reasonable and hardly constraining. The energy condition says that the sum of the present energy's density (and pressure associated therewith) is never negative. Violating this condition seems impossible and therefore the singularity is inevitable, not only in the standard model, but in all theories of the genre. And therein is a spark of hope. As we would like to avoid this singularity, we look for what would be capable of violating the energy condition, and we look toward implausible things which could happen on quantum scales. When the Universe was not older than  $10^{-43}$  seconds, and no larger than  $10^{-33}$  centimeters, in more exotic conditions, still unimaginable in the quantum era, perhaps it succeeded in exerting a pressure sufficiently negative to violate this famous condition. Consequently, the

singularity would be eliminated. And then you suddenly have researchers getting twice as enthusiastic, redoubling their efforts, or some such.

Attempting to elucidate the origins of the Universe is all well and good, but it requires reflection. It's strange to imagine that there is a beginning, don't you think? From the moment where all the indications meet to assign a beginning

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to the Universe, we can't help but ask what could have been there before.

The classic response is to say that the question makes no sense because time and space were created at the same time as the Universe. Thus there is no "before". End of discussion.

However, that is hard to believe.

Saying that time starts is a paradox in and of itself. The idea of a beginning necessarily situates itself in a temporality, thus how could it be time itself which starts? Do we say that death dies? No, we don't.

If you are like me, you've stewed over this for some time. There isn't a satisfying explanation, so, if we think about it, there is a picture which could open some doors. It's a classic image. It compares time to north/south directions. You can go back in time (solely in thought, alas), as you can go north, but only to a certain limit, with the North Pole and all. There is no more northerly point than the North Pole. To ask what there was before the Big Bang is to ask what is north of the North Pole. The question doesn't make sense.

Up to here we can see what is nonsense, but we still aren't sure what time is. Let's look at that a bit. So, if I am at the North Pole, we can be assured that no compass will

lead me further north. But it is equally clear that I can continue forward. Simply, any further motion would be in a southerly direction. If there is a singularity, it's tied to the definition of the north, and not at all to the nature of the terrain which is essentially the same everywhere. Now, let's try this: I go back in time in the direction of the Big Bang. Once I've reached that point, I realized that there is nothing impeding

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me from going further back in time. Simply, I then begin to move into the future. If that be the case, was the Big Bang no more than a gigantic bobby pin?

We'd have a clear-cut response to the question: "What was there before the Big Bang?" The future of course!

Please note: these ramblings are personal and do not have anything to do with the very learned Larry Ford, whose reasoning was too much for me to follow. Hmm, it seems to be over. My reverie is interrupted by a hearty applause.

This time the debates are less fiery. Whereas the two orators from this morning toyed with concepts whose audacity was in proportion to their fragility, Larry Ford flirted with the theoretical establishment, the standard model (the most intimate and mysterious). The gazes have been blank; the interjections are delivered in a philosophical tone. If the Big Bang is irremediably outside of science, then is the Universe like a galloping horse from which we can't dismount, unable to admire it at a standstill?

*And you, what are you quantizing here?*

The title of the following talk sounds like music to our ears after that headlong metaphysical plunge: "Beyond Gravity."

Of course it's about gravitation and not human nature. Bei-Lok Hu (an American of Chinese origin) suggests evaluating the status of attempts to quantize gravitation.

Why does gravitation have to be quantized? No, before that, what does quantize mean? Quantize means

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to render something quantum (and not quantitative); describing a phenomenon with elementary manifestations (of the discontinuous sort), which happen in steps. This image of quantum mechanics describes energy in the form of quanta (one quantum, two quanta). A quantum of energy is the smallest quantity of energy imaginable. Half a quantum is not possible; it's an all or nothing kind of thing. It's similar to a monetary system, where all sums of money are, by definition, multiples of the smallest denomination (a penny). Which means that you can't deposit 1.2558 dollars, euros, or pounds. It's impossible; you have to round to 1.25 or 1.26.

Why then do we have to quantize gravitation, meaning, why do we have to describe it as a phenomenon which acts in a stepwise manner and not in a continuous manner? In order to make it compatible with other fundamental forces (which are already proven to be quantum themselves).

There are only four forces in nature, not one more (at least right now). Electromagnetic (electricity which acts on an atomic and molecular scale, which governs all of chemistry and biology), weak force (this is present in the nucleus or an atom, and explains certain types of radioactivity), strong force (which holds the components of the nucleus together), and gravitational force (which acts at a macroscopic level, and keeps us on Earth).

The dream of a modern physicist is to show a hidden fundamental commonality behind these four forces. Namely:

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that the four forces will be four different faces of one principle. The principle in question would show itself to have been exploded in four (in our current state), as it would have been unified during the time when the Universe was still very hot. This allotment also has a pretty little name: “broken symmetry.”

What is a broken symmetry? Let’s take the everyday example of phases of water: from liquid to gas, and from liquid to solid in cold temperatures. It is always water, but from one state to another it loses more and more of its original symmetry. In vapor, all the water molecules are free and do not respect any organization. The symmetry is maximal. In its liquid state, the water molecules are more or less linked, more or less oriented, in a loose but real way. The symmetry has diminished. In ice, water molecules are rooted in crystalline structures where each one has a determined place and orientation. The symmetry has fallen to its minimum.

According to a similar logic, as the Universe froze it could have experienced “transitional phases,” during which a unique, initial force would be “crystallized” (so to speak). The best indication of this is that electromagnetic and weak forces have already proven their unity above certain temperatures. Abdus Salam, Steven Weinberg, and Sheldon Lee Glashow won the Nobel Prize for Physics in 1979, for having shown that through very high heat the two forces are indistinguishable from one another. And we hope that by going higher in temperature range, it will be possible to unify all the forces.

But for that, you'd at least show some semblance of familial likeness. Even so, gravitation as

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Newton then Einstein explained it, does not look like the others. It's a continual process, and not a stepwise one. Hundreds of physicists have been trying, unsuccessfully, for decades to force gravity to act stepwise, to quantize it. There has been growing perplexity, and numerous efforts aiming to analyze this failure. Is it impossible or are we going about it all wrong?

Bei-Lok Hu made the following proposition: we have not yet thought about what needs quantizing. We dive into quantizing the gravitational field – in the form of mediating particles called gravitons – without asking if it is really the right variable. There could be a kind of optical illusion which leads us to take the gravitational field for a fundamental concept which it may not be. His advice is that we choose the right subject before quantizing.

Admittedly, more than once, we've taken as basic notions emergent phenomena which were camouflaging other components. We hailed the atom as the ultimate component of matter, before learning that it contained all sorts of stuff. We took galaxies as the ultimate structures of the Universe, yet they are grouped in several levels. Science has often been the art of not seeing the forest for the trees.

For Bei-Lok Hu, the gravitational field could be a collective variable (emergent, resulting) in which you have to look for more elementary components.

At this stage it's a pipedream. But, all that matters is that we are not twiddling our thumbs. It's been so long that physicists have been delving without results, maybe



it's just a matter of actually stopping, and re-asking the question: what are we looking to do? Like the Chinese proverb says: "One step back and everything spontaneously broadens."

Maybe we'd realize, like certain hurried surgeons, that maybe we are doing the right operation, just on the wrong person.

No time to lose before dinner. We have an appointment with the impressive Gia Dvali. He responded to my request kindly, almost timidly, so much so that I wondered if he were the same beast from this morning.

We'll do the interview on the terrace in the boys' room (the one that overlooks the valley). Late-afternoon light will be perfect. Before starting, I remind our acrobat that we are making TV for average-Joes and Janes, so he should try and talk to us as he would his grandmother (hoping that she hadn't won the Nobel Prize for physics). He agrees with a nod of his head, and waits for it all to begin. He seems very calm, though his posture shows off his force and agility. If he stamps his feet, I'll panic. Miraculously, right off the bat he is clear. My fears wane as I realize that what he is saying is generally accessible. And not only accessible but brilliant. You'd say that he's been doing this all his life. Easy terms like strings and membranes? No problem, he explains them with everyday images. Extra dimensions? A six-year-old kid could understand. Even vacuum energy seems suddenly clear. How did we not get this earlier?

We are dumbfounded by his delivery, his ease, his clarity. If it were up to me, I would make an hour-long special just about him. And he even has a great physical

presence: warm gestures, good rhythm, and composed voice – even cinematographically he’s a real treat.

### **Gia Dvali**

*Elisa:* What is cosmology?

*Gia Dvali:* It’s a branch of physics which studies the formation of the Universe...in short we ask why the Universe is as it is. If it has a beginning or if it is eternal. We don’t understand how it can be so homogenous: no matter where we look, everything seems identical, the laws of physics, the density of matter. It’s unsettling. We live in a highly improbable Universe. There are a lot of mysteries to resolve.

*Elisa:* Your presentation was very technical, what did you talk about?

*Gia Dvali:* The idea is very simple. We believe that we live in a three-dimensional world, but there very well could be extra dimensions. We do not see them since we are “confined” in our three-dimensional space. Exactly like flat beings on a city map. Our space, the one which situates all we can see, is a *brane* which is contained in a larger space. Only one phenomenon exists that is capable delve into extra dimensions; gravitation.

It has also been suggested that there are very small and curled up extra dimensions.

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In such theories, we have to detect a change in the behavior of gravity on very small scales.

*Elisa:* Are there experiments like that?

*Gia Dvali:* Yes, several. The most recent results hail from Seattle, where a group showed

that Newton's law is always valid between two bodies at two-tenths of a millimeter. For now we've no idea what happens at smaller distances.

*Elisa:* But why do we speculate about the existence of extra dimensions?

*Gia Dvali:* Because they allow us to resolve two kinds of problems. The first is the problem of hierarchy. We admit that gravitation is incredibly weak, and that we do not know why. Weak in comparison to other forces. Since gravitation keeps us on Earth, we have a tendency to believe that it is strong. But, that's false. We are grounded because the Earth is immense, not because gravitation is strong. Gravitation does not become significant except for literally astronomical masses: planets, stars, galaxies. But if you want to compare gravitation with, for example, electromagnetism, you'd take two protons and measure the two kinds of force between them. You'll see that the gravitational force is billions of billions times weaker ( $10^{32}$  times to be exact). This huge disparity poses a special problem for those who seek to unify the four fundamental forces of physics. How can you show that the four fundamental forces are four faces of a single phenomenon, if one of the four is ridiculously weaker compared to the others? It's a hierarchical problem. And extra dimensions

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supply an answer. If we live on a *brane*, and all of our interactions are confined to it (except gravitation), then gravitation is scattered in the extra dimensions. And then we only see a small part of it. In reality, it's not weaker than the others, just "diluted."

*Elisa:* You've explained the problem of hierarchy, but then how does gravitation act differently from other interactions?

*Gia Dvali:* You're right. I'll hypothesize that we live on a membrane which is part of a large-dimensional space. Then I'll say that gravitation makes it out, but the other interactions do not. Why can I say this? Is gravitation a special force?

Yes, we can say that gravitation IS a special force. You're going to understand why the other interactions are confined on the membrane. Okay, so take the example of waves on the ocean's surface. They are agitations of the ocean's surface. The only place that we find them are...on the surface of the ocean. You've never seen waves fly away have you? So, normal interactions which affect normal particles, like protons, neutrons, electrons, really all that we are made of (including photons), can be seen as waves produced on the surface of a membrane. They are agitations on the membrane we call home. So, evidently they cannot leave the membrane.

Now, what distinguishes gravitation? Gravitation is the only force which finds its origin in energy. All entities possessing energy (or a mass, since they are one and the same) are a source of gravitation. That's why

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you can't consign gravitation to a certain region of space. Or the space itself would shrink to that region.

Follow me here. By definition, if a space exists, it means that something can go there. If absolutely nothing can go to this space, then it is not a space. If something can go there, then gravity is there as well. No matter what you send: a signal, information, an object...it contains energy. Everything transports energy. Therefore, everything that exists, and can go in this space, is a source of gravitation. Gravity has the universal

property of existing everywhere that space exists. And that's why it can't be confined to a membrane.

*Elisa:* How about the second problem you mentioned?

*Gia Dvali:* Yes, well, it provides an even more important motivation for the extra dimensions; I'm referring to the problem of the cosmological constant. What is the problem? When we observe the Universe around us, it is practically flat. There is no strong space-time curvature between galaxies. We have been able to verify this with a high level of precision. Which means that there is very little energy in the Universe, including vacuum energy. Because energy bends space-time. That is a huge problem for particle physics. We don't understand why vacuum energy (as we observe it) is so small. If we calculate it, using the standard particle theory (which is especially weak), we find that vacuum energy is huge. It surpasses sixty orders of magnitude (ten to the sixtieth power) the

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value we observe in the Universe. It's colossal. What do we do? One of the ideas which have particularly motivated me in my work is this: if infinite extra dimension exists then we can understand why our four-dimensional space appears to be flat. In fact, if we live on a membrane that is part of a larger space, then the curvature that we see is only that of the membrane. But vacuum energy manifests itself by not only bending the membrane, but also by bending all the other dimensions that we cannot see (because they are rather bent). Calculations have confirmed this possibility. That's why we should take extra dimensions seriously.

*Elisa:* What is the tie between membranes and string theory?

*Gia Dvali:* Membranes are an integral part of certain versions of string theory. String theory is built around one fundamental object: the string. The string evolves in space, vibrates, produces different harmonics which correspond to different particles (that we are aware of), and they can be open or closed. In certain versions of the theory, open strings are confined to membranes. They can slide, vibrate, but they cannot leave the membrane (their feet are attached to the membrane). On the other hand, closed strings have no feet, and can move about freely. Now, if you ask the question: to what can closed strings correspond?, and I would respond that only closed strings can represent gravitation. It is a very natural way of understanding why gravitation can go everywhere; it's because it stems from closed strings,

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which are unattached, and thus which cannot be detained. Open strings can give off protons, they can give off neutrons, but never gravitation. They are trapped on the membrane which is therefore a natural ingredient of string theory.

*Elisa:* Is string theory going to replace the standard model?

*Gia Dvali:* No. You have to understand how revolutions happen in physics. Contrary to political revolutions they do not destroy what was in place before. They include it. The standard model is an extremely efficient description of nature. Of the energies that we are aware of, it works perfectly. A string theory has to incorporate the standard model, meaning that string theory has to preserve the standard model when applying it to low-energy. Like how Einstein's gravitation preserves Newton's when applied to low energy.

*Elisa:* Are all theories like Russian nesting dolls?

*Gia Dvali:* Yes. That is physics' charm. Things are stacked on one another. As a result, you can study low energy physics without worrying about understanding the physics of other energies. It's a matter of ulterior steps. When you understand the first, can you start in on the second, which really contains the first. You move on to a more general theory, and the first theory becomes the low-energy limit of a more fundamental description.

*Elisa:* Do you believe that there will be an ultimate theory to unify them all?

*Gia Dvali:* The general consensus

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is that this is possible. It could just be a matter of some trivial notion. That is not to say that the four interactions will end up as one. Things could be much more complicated than that. There could be some real surprises. Things we never dreamed of.

When the dinner bell rang we regretfully had to stop this magnificent presentation, thanking Gia Dvali. Immediately after, he takes to his subdued, timid self (apparently only when he is not talking about physics). He scoots out, and we straighten up. As soon as he turns the corner we all hug. We're so happy we could dance a jig! What a man, what a way of speaking, what an interview! It was overwhelming. So we've got half an hour of film, and not a second to edit out. He is made for television.

*Anyone for cosmology?*

In spite of our fatigue, during dinner we're in good spirits, so much so that Olivier runs over to his camera when he sees something that inspires him. These physicists are workaholics. You'd think that after six hours of talks that they'd be ready to change the subject. Their conversations become more serious, despite the fact that they lack notebooks, blackboards, and projectors. Tablecloths and napkins become office supplies.

The table blackens with ink as they, develop, erase, underline. Olivier only has to walk along the table to capture real gems. He stops at Alex Vilenkin and

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Gia Dvali's conversation, in Russian; it seems that the destiny of the world is unfolding. Alex Vilenkin is still decked out in his black shades. His fragile eyes can't even bear a few photons at a time. With his white skin (rivalled only by that of a vampire), his thick, silver, secret glasses, and his equations in Russian, this man is going to give our report that special something. To change it up Olivier tries out a traveling shot, ending in the kitchen, which is as riled up as the table. It creates an odd poetic effect between the disparate moments of commotion. A dash of cosmological constant here, a hint of crème brûlée there. Each equally important. Mobilizing energies, focusing on looks. Only faces, the cook's as he prepares the sauce for the lamb shank, or a physicist's as he calculates the string-theory coupling constant, with just the faces, you'd swear they are doing the same thing.

Who knows, maybe so?

The discussion makes its way to the terrace. After such a day, how I would love nothing more than to be able to retire my pen for the day and shoot the breeze with an old girlfriend. Just to forget this pack of maniacs I'm with. Leon Brenig taps me on the shoulder. "Did you know that the Casimir effect resolved an old enigma in the world of navigation?"

"The Casimir effect huh...that deals with vacuum energy right?"

"Yes, it explains why two very close planes attract each other in a vacuum."

"And this has what to do with boats...?"



“Do you know why the planes are attracted to each other?”

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“I think it has something to do with the length of waves allowed or not allowed...”

“Right. There are few wavelengths of a quantum field that can exist between the planes. They depend on the distance between the planes; whereas all wavelengths are permitted outside. Therefore, the external pressure is stronger than the internal, and the planes attract one another.”

“I still don’t see the boat connection.”

“It has always been observed that two boats docked side by side have the tendency to gravitate toward each other, and bump. Really, this requires the same explanation. In this case, the wavelengths are the waves’. This time only wavelengths of a certain size are permitted between the boats (those which make it into the distance which separates them). Like a string which vibrates between two fixed points. However, outside there are all possible waves. So, there are more waves outside the boats than in between them, thus why they tend to get closer.

“Wow, the boats make it a lot easier to understand!”

“Yes, nobody had really been able to explain this before Casimir and his vacuum enclosure. Edgard adds: “And he didn’t think of it either. It was someone much later on, who made the connection between the two seemingly unrelated things.”

“And I never saw the link between quantum mechanics and everyday experiences! You often hear that nothing quantum is conceivable in our daily thoughts. We can’t quite

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associate it with an image. But this goes beyond image. It’s the same phenomenon.”

“Generally. The fact we talk about waves in both facilitates it.”

A little later, Alexandre and I go up to the big terrace where uncle Slava is entertaining the bunch – that man either worked at Club Med or he missed a good shot to do so. I have the satisfaction of saying that the professional rhetoric subsides, though they are as avidly engaged as today (with changed subject matter). The talks have moved onto basketball and baseball. Just maybe these physicists are humans after all (well, at least after eleven pm and three glasses of génépi).

When we arrive, Slava starts in on us: “So, what’s this film all about?”

“We are reporting on the conference.”

“And what else?”

“Cosmology.”

“What’s the central theme?”

“The conference and how it plays out!”

“No one will ever want to watch a film about a cosmological conference.”

He’s picking a fight. I let Alexandre handle this one. A joshing Russian and his loud, bad English is more than I can take. Alexandre courageously shoots back: “Of course people are going to watch. It will be a chance for them to attend something that they would have never been able to otherwise!”

“But they don’t give a damn about it, and moreover it’s about as much fun as

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watching grass grow.”

“We are going to prove that it is interesting.”

“How exactly?”

Did he decide to ruin us or what?

“Well, we are going to show how your discussions unfold. Show how it is not consensual, that you all work by trial and error and controversy.”

“It isn’t something they are hankering to watch. They want things to be clear-cut. The public wants its science to be clear.”

“Of course not, that is a myth, and it does science a disservice. In fact, quite the opposite is needed; you have to show just how hard it is to arrive at such certainties.”

He stood his ground. It’s the first time that I have seen someone hold his/her own with Slava. He’s getting riled up. And the other roars with pleasure, adding fuel to the fire. Everyone wants to keep score.

“Let me tell you something. I have spent a lot of time with people who have tried to make cosmology more universally palatable. The results always prove to be pitiful. Now, I don’t want to even waste my time talking to them. If you make a film about this conference, I will be curious to see it. But I’ll tell you now, I don’t buy it. Especially if you don’t have a central theme.”

“We want to capture what really happens, without preconceived ideas, without scripts.”

“Exactly like I said, a real barrel of laughs.”

“Do you find it boring here?”

“Me? No, but I am a physicist.”

“Don’t you think it possible that we transmit your passion and pleasure onto film?”

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“Maybe, but it’s like a sauce, and a sauce is not enough to sell a dish.”

“Reality for a central theme, that’s not enough for you?”

“Hogwash. You’re going to get your ass handed to you. No one can explain what we do here. It’s far too complicated. Who do you expect to be interested?”

That’s it; I throw my hat in the ring.

“Wait a second. You’re right, I don’t understand your talks, but it interests me. I want YOU to explain what you do to me. What would you make your central theme?

“Me? I wouldn’t make a film about a cosmology conference.”

“I’m sure you have some ideas.”

“Maybe, but only if you come and see me with your first film project. We could discuss it then if you like.”

Surprise. The naysayer offers his assistance. Maybe he staged this all out of a secret desire to include himself in decisions about the film?

“For us, you’d be ready to waste your time?”

“Let’s just say that I can give it one last go. Come see me in Munich.”

So, we can’t believe it, but he is willing to help us. Strange. Strange.

All-the-same, his little spectacle doesn’t scream reassurance. We knew it would be difficult, but if the protagonists themselves think we are nuts for trying, then who is going to help us believe?

Yes, a central theme, I see what he is saying. Maybe we need to find a way to ask a question which we can

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answer serially, through different elements. When you film an Egyptian-style archeological dig, the script dictates everything. And really, Alexandre already sketched one out. But a conference like this one has no linearity. It’s a piercing hum, if not a

cacophony. Really, it's a damn mess. Everyone comes with his/her own model, hypotheses, and his/her own way of asking such and such a question. But it is precisely that which we hope to show. The unbelievable all-out effervescence. I've got it, our central theme: a damn mess.

Do we need to impose false order? Making believe that people go from A to D by way of B and C? It would be entirely imaginary. But as we well know, effective narration requires certain sacrifices. Truth is a beautiful thing, but how do we show it? Everyone is searching, feeling around in the dark.

Of course, overall, we could make the point of quantum gravitation: "A crisis, a huge crisis, here are some elements (little didactic modules about general relativity and quantum mechanics), and here are the people who rack their brains trying to figure it out. Can you tell us about where you are in this process Mr. Mukhanov?" What doesn't sit well with me is that anyone can make such a film, at anytime, and anywhere. That doesn't embody all that is Peyresq, it's a class on quantum gravitation. I would rather talk about it because of the Peyresq conference and not the opposite...avoiding a stroll down boring lane. Really, we should have filmed the conversation we just had.