Profile of Claudio Bunster

In life and work, Claudio Bunster prefers extreme challenges. Bunster, a physicist who contemplates brain-warping theories of space and time, returned to his native Chile from the United States precisely when most intellectuals would have stayed clear—during the middle of the Pinochet dictatorship. Shut out of the universities by the military government, he broke the conventional mold by founding a research institute that he then moved from Santiago, the capital, to Valdivia in southern Chile, against the flow of minds and money. He led the presidential science advisory committee during the administration of Eduardo Frei, and served on the Dialogue Board of Human Rights to reconcile Chilean military and civil society.

For his achievements, Bunster was elected to the National Academy of Sciences in 2005. In his Inaugural Article, which appeared in the July 24, 2007 issue of PNAS (1), he showed that after a black hole swallows a magnetic monopole, the space–time singularity starts rotating.

Claudio Bunster

Learning Physics Despite the Hurdles

During high school in Santiago, Bunster taught himself physics. He had to. "My teachers were extremely boring," he says. At first, he did not know what physics was, just that he liked the name. There was something magic in the way "física" rolled off the tongue. Then he became intrigued more and more by the nature of time. When he was 15, he found a book on relativity theory in a bookstore. "I remember being astonished to think," he says, "that when I saw a leaf in a tree moving with the wind, I was observing the past, since it had taken some time for the light to travel from the leaf to my eye."

When he entered the University of Chile in Santiago in 1965, he enrolled in the new and experimental "Institute of Sciences," an oddity in the system of Chilean universities that, even now, he considers "little Soviet Unions": stolid, inflexible bureaucracies that never take risks.

Nevertheless, he pursued on his own what he calls *the* problem of classical electrodynamics: the electron, a charged particle, interacts with its own field. The self-energy stored in this interaction is infinite if calculated by standard methods. "It seemed to me that one should eliminate the concept of field altogether," Bunster says.

When someone told Bunster that John Archibald Wheeler and Richard Feynman had done just that and published their results in a 1945 paper in *Reviews of Modern Physics* (2), he rode buses all over Santiago trying desperately to find back issues of the journal. He finally found what he was looking for in the library of the Institute of Cosmic Rays. "I read the paper with emotion," he says. "There it was, not only done, but done with a style I had not seen before. Deep, elegant physics that read as literature. Equations written with words instead of symbols. Generosity in giving credit to the work of others."

Then the book *Geometrodynamics*, a collection of articles by Wheeler and colleagues (3), fell into his hands. "I was mesmerized," Bunster says. "Here was a contemporary theoretical physicist doing general relativity as frontier science, mixing gravity with the rest of physics—daring, magic! I thought I should find a way to study under that man." Wheeler, one of the most prominent physicists of the century, was a professor at Princeton University, the global epicenter of physics, a continent away. It seemed impossible that Bunster would ever be able to approach him.

Exciting Times

Just when Bunster thought he would never get to Princeton, he "had an unbelievable piece of luck," he explains. In a footnote to one of Wheeler's papers, the theorist acknowledged a French mathematician named André Avez. Bunster knew that Avez happened to be in Santiago at the time. Through his mathematics teacher, he arranged an introduction. Avez and Bunster had lunch and spoke for several hours. At the end of their conversation, Bunster recalls Avez saying: "Well, I will write on your behalf to Princeton. The food there will not be as good as in Chile but you will learn the best mathematics and physics in the world." Several weeks later, Bunster received a letter from Wheeler himself indicating that he had requested the Graduate School Office to mail Bunster an application package. Bunster still remembers Wheeler writing that he knew of "the many things [Bunster] had already learned and the many books [he] had already read." But Wheeler warned that competition to get into the Princeton Ph.D. program was fierce.

"I applied, and waited anxiously for the postman every day," Bunster says. "I even went to the corner to intercept him. And then, one day, the letter arrived." He had been accepted.

Times were exciting at Princeton. Wheeler's group consisted of 8 or 10 students and postdocs, with others "orbiting around." The eminent professor had just coined the name "black hole" for the space–time singularity that forms when a star collapses on itself and crams so much mass into so small a space that the intense gravity prevents light from escaping.

Although astronomers have now found many promising candidates, when Bunster was in Wheeler's lab, black holes were pure theory. The equations predicted them, but no experimental evidence had been found. "The black hole has come from conjecture to maybe being responsible for the structure of the universe," Bunster says. Being such extreme objects, black holes naturally attracted his attention when he joined Wheeler's group. Another topic that fascinated him was quantum gravity, the branch of physics that seeks to unify quantum mechanics with general relativity. "I was interested in looking at space–time as a derived—as opposed to fundamental—concept," he says, pointing out that today many contemporary physicists look to string theory to explain the basis for space and time.

"Space–time is like a layer cake made of pancakes," he says. "Each pancake is space at a given time. And therefore, in quantum mechanics, Wheeler said there could be no space–time, because there is no precise history of space. He invented something called 'superspace,' which was a big space in which each point was a three-dimensional space." In

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his doctoral dissertation, Bunster showed how what we experience as space and time would emerge in the classical limit of quantum superspace.

Bunster spent one year after completing his doctorate as a postdoc in Wheeler's group before being promoted to assistant professor. There were some very bright minds around. Bunster often discussed ideas with the legendary Freeman Dyson. "I treasure those conversations with him," he says. But his most productive collaboration was with a young Italian named Tullio Regge. "He had very original ideas, and so at a young age he became a professor" at the Institute for Advanced Study (IAS)—a center for theoretical research in Princeton, NJ. At this time, and until 2005 (when he discovered the identity of his biological father), Claudio Bunster was known as Claudio Teitelboim. Many terms in the field of quantum gravity bear the Regge–Teitelboim moniker: the Regge–Teitelboim model, Regge–Teitelboim equations, and so on.

Torn Between Two Worlds

Wheeler left Princeton for the University of Texas at Austin in 1977. Soon after, Bunster joined Regge, Dyson, and others at the IAS. It was a top-notch forum, he says, "where one was welcome to pursue crazy lines of thought." Also, the IAS was very flexible with duties—there were no classes to teach—and permitted Bunster to travel home regularly so he could lay the groundwork for a research institute that he planned to establish there. In Chile the political situation had imploded.

On September 11, 1973, the military overthrew the government of Salvador Allende. At first a junta governed Chile, and then Augusto Pinochet ruled alone with a ruthless hand. Chilean expatriates were aware of the turmoil in their country and Bunster was torn between the crisis in his homeland and the intellectual haven of Princeton. "It was the end of an illusion," he says of the coup, "and with hindsight it's easy to see that [the Allende plan] would not have worked, but there was an illusion of change, and then all that collapsed and there was all this brutality. The sense of impotence, being away and not being able to do anything about it, was very strong."

During this time, Wheeler had not forgotten about his former student. Indeed, he tried very hard to persuade Bunster to join his group at Austin. A magazine called *The Texas Monthly* began to appear regularly in Bunster's mailbox on Wheatsheaf Lane in Princeton. The chance to rejoin Wheeler was an offer Bunster couldn't refuse, and he moved to Austin in 1980. He was productive in Texas for a while, but Chile began to loom ever larger in his thoughts. So he negotiated a deal in which University of Texas, Austin, allowed him to spend half the year in Texas and the other half in Chile. With seed money from the Tinker Foundation, he founded an independent research institute in Santiago called the Centro de Estudios Cientificos de Santiago (CECS).

Unfortunately, the University of Texas, Austin, arrangement did not work out. "Half a man is less than half a man," Bunster quips. He returned to the IAS at Princeton, which he knew was generous with its flexibility. For several years, he shuttled between Princeton and Santiago. But as the CECS became a more concrete entity, he increasingly felt the gravitational pull of Chile, where, even though banned from teaching at the universities, he eventually settled for good.

> **"I had shown independence of thought and a willingness to go into battle."**

"It cannot be a coincidence that I did so during the hard times of the Pinochet dictatorship," he says. "Not because I was in favor of it. Quite the opposite. I felt that precisely at that time I could be more useful, and this could be best accomplished by having an independent place where colleagues from all over the world could visit and bring some light into the darkness."

The Pinochet regime would have preferred darkness. "Sometimes one could feel the presence of a government agent lurking around," Bunster says. But the CECS was tolerated, perhaps because of its lack of a conventional political agenda. "There were phone threats, but for those times that was peanuts," says Bunster.

Building a Ship of Small Draft

Bunster used the IAS—an example of a center of excellence where international visitors would be welcome—as inspiration for building the CECS. But beyond the ideals of excellence and openness, the CECS, which was set up in a rented house in the Santiago suburbs, was not a heavily planned venture. Its motto is a quote from Captain James Cook: "If you plan to make a voyage of discovery, choose a ship of small draught."

"Big ships cannot go into shallow waters or narrow passages," Bunster explains. "They are not easy to maneuver. The universities are not ships of small draft in Chile."

The CECS has three main areas of concentration: theoretical physics, molecular physiology, and glaciology and climate change. "We say we are interested in the cosmos, the planet and life," says Bunster. "You know, it sounds very much like a policy but it was just a string of coincidences. Instead of choosing research fields, the focus was put on finding first-rate people willing to take risks and open new paths. The people were primary, not the fields. The rest was the magic of life." These days the CECS is home to 15 leading researchers, plus postdocs and graduate students for a total staff of 80. Apart from Bunster's status as director, the institute's governing structure is horizontal—all scientists bear the title of "researcher" and have equal standing. Leadership is exerted by achievement and stature, and not by bureaucratic rank, Bunster says.

In 2000, Bunster organized the institution's move from Santiago to the southern city of Valdivia. "This country is very centralized, and the migration of a group of first-rate people from the capital to the south goes against the usual stream," he says. "It was a revolutionary move, and it worked very well." Drawing on his contacts from his time at Princeton and University of Texas, Austin, Bunster has built the CECS into an internationally recognized retreat. There is no tenure and no permanent source of money, but the researchers often feel exhilarated by their freedom. A sense of solidarity prevails.

"Sometimes there is an Antarctic exploration and one has to choose between a new transgenic facility or going to the south pole," explains Bunster. "So the biologists say, well, go to the south pole, we'll do our lab next year." Money does remain an issue, though. "The Center is fully equipped," Bunster says, "but we had a budget for six years that burned in three because we did the work planned for six and more. We think that life is too short. So I am at the moment trying to keep the boat moving."

Public Service and Science

Once Bunster returned to Chile, he could not help but become enmeshed in public service. After a plebiscite denied Pinochet a further role in the Chilean government in 1988, Patricio Aylwin was elected the new president and served until 1994 in a period during which Chile made the transition from military to civilian rule. Then, when Eduardo Frei came to power in 1994, he named Bunster as his science advisor and head of the presidential advisory committee for scientific matters. Bunster believes Frei chose him because "I had shown independence of thought and a willingness to go into battle." This was an opportunity to revamp national science support, and Bunster took the initiative, developing the Presidential Chairs on Science: prestigious, well funded research positions. A committee of distinguished foreign scientists (to bypass established local power groups) chose the honorees, who received their awards from the Chilean president himself in a ceremony at the presidential palace. "It was also novel," Bunster says, "that there were very few strings attached. The money was not minor by Chilean standards"—$100,000 US a year for three years.

Bunster was able to further expand this support. During one of his regular stays at the IAS, he had a conversation with Phillip Griffiths, then IAS director, about taking the Presidential Chairs to a higher level by giving support to groups rather than individuals. Griffiths, who was interested in fostering science in developing countries, had the support of James Wolfensohn, then president of the World Bank. With a World Bank loan, Bunster was able to kick-start the Millennium Science Initiative (MSI), which makes grants to centers of excellence in Chile, currently on the order of $2 million US per year for 10 years. The CECS has received MSI funding since 2000. Following the Chilean prototype, the MSI has been extended to several other countries.

At the end of his administration, Frei established the Dialogue Board on Human Rights to break the barrier between the military and civil society. "Democracy was weak," Bunster says, "and I strongly believed that one should talk to the military, rather than keeping them isolated." Bunster was nominated to the Board and thought hard about how science might help reconcile the military to the people. One avenue that seemed promising was glaciology. The military possessed the logistics and transport to enable research in harsh territory.

"When the Dialogue Board was established," he remembers, "I was one of the few people who had not been on the side of the Pinochet government, and yet had a relationship of mutual trust and respect with the military that had grown from working in the field, shoulder to shoulder with them, taking risks together and getting to know each other through long conversations inside a tent with the wind and the snow howling outside." At one meeting Bunster recalls that the Board debated for days behind closed doors, "wondering whether to dig into the brutalities of the past, or, without ignoring those, to focus on showing a road to the future." Pressing for the committee to reach a decision, Bunster told them that "in quantum mechanics, a photon has no reality or meaning until it is emitted by an atom." Thereupon a general stood up in agreement. His branch of the armed forces adhered to the quantum theory, he said. "That was very important, because he was 'on the other side,' " Bunster says. The Dialogue Board was thereby able to send a message to the Chilean people that the barrier had been broken between the military and society. Bunster has since overseen collaborations between the Chilean military and CECS researchers conducting research on climate change in Antarctica and on the Patagonian ice fields.

The Confluence of Extremes

Through all his forays into public service and his work to create and administer the CECS, Bunster has continued his research. In his Inaugural Article (1), he and colleague Marc Henneaux considered what would happen when two extreme objects are brought together: a black hole and a magnetic monopole. Magnetic monopoles (particles at which magnetic field lines would originate, or end, as electric field lines do at electrons and protons) have not yet been observed in experiments, but they keep turning up in calculations. "Black holes are known because they hide things," Bunster says. "So it's quite natural to think that maybe the magnetic poles are hiding inside black holes."

One reason why Bunster might think so is that research has shown that black holes, such as the candidate Sagittarius A* at the center of the Milky Way, rotate. Indeed, the radiation emitted from matter falling into black hole candidates shows that they are rotating. However, "it's not clear where the rotation comes from," says Bunster. He thinks it might be caused by monopoles. "And so we played this game and we let the monopole fall radially into a non-rotating black hole," he says. One might think that the black hole would just swallow the monopole. But the result of Bunster's and Henneaux's calculations was that the black hole began to rotate.

Exactly how to show that black holes really do contain magnetic monopoles is a different challenge, but one that work such as Bunster's may eventually set up for astronomers to conquer. Black holes, quantum superspace, Chilean geography, the fight against oppressive dictatorship: all his life, Claudio Bunster has sought out the extreme, taken its measure, and solved it with innovation and enterprise.

Postscript. On May 12, 2008, Bunster spoke at John Archibald Wheeler's memorial service in Princeton, NJ. Wheeler, Bunster said, often quoted Teddy Roosevelt's exhortation "Do what you can, where you are, with what you have."

"I followed his advice," said Bunster. "At latitude 40S there is a science institute where one can find the footprints of Wheeler in every corner."

Kaspar Mossman, *Science Writer*

1. Bunster C, Henneaux M (2007) A monopole near a black hole. *Proc Natl Acad Sci USA* 104:12243–12249.
2. Wheeler JA, Feynman RP (1945) Interaction with the absorber as the mechanism of radiation. *Rev Mod Phys* 17:157–181.
3. Wheeler JA (1962) *Geometrodynamics* (Academic Press, New York).