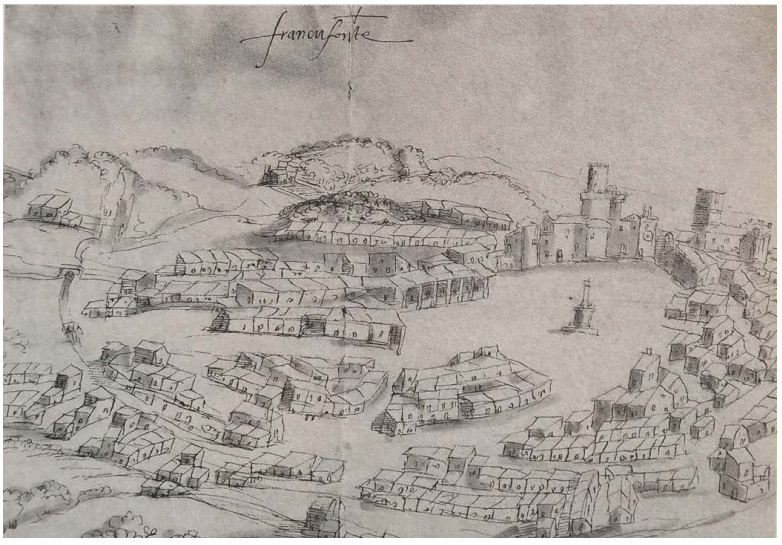
MY INTELLECTUAL TRAJECTORY: FROM THE CLASSICS TO THEORETICAL PHYSICS

Francesco Iachello

I was born in 1942 in the small town of Francofonte, Sicily, in a family of landowners. My family owned several estates, called *latifondi* from the Latin *latus fundus*, literally "large estate."



The town of Francofonte, Sicily, in the *Riveli* of 1569. The castle and the church on the upper right corner were destroyed in the earthquake of 1693 and rebuilt in the middle of the eighteenth century. (From the author's family's archives.)

Francesco Iachello is the J.W. Gibbs Professor Emeritus of Physics and Chemistry. A graduate of the Politecnico di Torino, Italy (1964) and of the Massachusetts Institute of Technology (1969), he came to Yale as a professor of physics in 1978, after a professorship at the University of Groningen, The Netherlands (1974). He was named J.W. Gibbs Professor in 1991 and professor of physics and chemistry in 1993. His work has been dedicated to the study of symmetry in science. On this subject he has written four books and more than two hundred articles. He is the co-discoverer (with Akito Arima of the University of Tokyo, Japan) of the interacting boson model of the atomic nucleus (1976). He is the discoverer of a new type of symmetry called supersymmetry in nuclei (1980). For his work, he has received many honors and awards, including, among others, the Eugene Wigner Medal from the Fundamental Physics Foundation (1990), the Tom Bonner Prize (1993) from the American Physical Society, the Lise Meitner Prize from the European Physical Society (2002), the Enrico Fermi Prize from the Italian Physical Society (2010). He has also received several honorary doctorates, including, among others, from the University of Ferrara, Italy (1992); the University of Sevilla, Spain (1993);, the Hebrew University, Jerusalem, Israel (2016); and the Technical University, Darmstadt, Germany (2017). He is a member of several academies worldwide. Although he is a theoretical physicist, his interests extend to many other subjects, including music, especially Renaissance and Baroque music, and literature, especially Italian and Spanish poetry of the twentieth century.

Despite the fact that until the landing of Allied Forces in Sicily in July 1943, this was war time and post-war time from then on, I grew up in a very privileged way. I was a precocious child. By the age of four I knew how to read and write. I did not go to elementary school. I had a tutor at home. During this early time of my life, I was also exposed to music. We had regular concerts at home. I still now remember my mother dressed in an evening gown playing the piano in the music room of our home and a young tenor singing the aria "Una furtiva lacrima" from Donizetti's *L'elisir d'amore*.

At the age of eight, on the occasion of the Holy Year 1950, I was sent on a pilgrimage to Santiago de Compostela, on the western tip of Spain. This was a family tradition dating back centuries of sending the first-born male child to Santiago. We traveled by train the two thousand kilometers from Sicily to Spain, on foot the last 100 kilometers, and climbed on our knees the stairs of the sanctuary. Spain at that time was a closed country under Franco, still not completely recovered from the civil war. On the way back we visited Pamplona, Loyola, and also went to Toledo. The Alcazar de Toledo still in ruins made a big impression on me. At the age of nine, I was sent to a boarding school run by the Jesuits in the town of Acireale on the slopes of Mount Etna. This was a strict school which required students to be part of the noble class. My education there was mostly in the classics, with particular emphasis on ancient Greek and Latin. One day per week we had to speak Latin. If we were caught speaking Italian – or even worse, Sicilian – we were given a coin with the sentence "*Accipe obolum vulgare loqui*" (take the coin for speaking vulgar), and, if, at the end of the day, we still had the coin, we were punished. By the age of sixteen I was able to speak Latin and to translate from Greek to Latin without going through Italian. During these years, I would spend nine months at the boarding school and three months at home. At the age of eleven, as part of my education, I was sent to Fribourg, near Lausanne, in the French-speaking part of Switzerland, to learn French, which had been in previous centuries the language of the nobility. Following a family tradition, I became interested in archaeology and participated in excavations in Corinth, Greece, and in southern Italy. I also spent one summer on a boat sailing through the islands in the Aegean Sea, from Mikonos to Santorini, from Lesbos to Chios, from Rhodos to Crete. I also took advantage of summers to read as much as possible from my family library. We had a collection of over 2000 volumes, including several first editions. In addition to the classics, some in sixteenth- and seventeenth-century editions, and to all of the Italian literature, including a beautiful edition of Dante's *Divina Commedia* illustrated by Gustave Doré, we also had complete editions of French classics: Molière, Racine, and others, all of which I could read in the original language. Another book that impressed me at the time was an Italian 1901 translation of the book *Kunstformen der Natur* by the German author E. Haeckel published in Leipzig in 1899. This book introduced me to the role of symmetry in nature, a concept that I would use later in my career. It was part of the science section of our library, which also included a translation of all works of Darwin. This part of my life ended with my graduation in the early summer of 1959 from the Liceo Classico Pennisi, cum laude and one year earlier than normal.

At the end of the summer of 1959 I moved to Torino in northern Italy to attend the polytechnic school, where I had been admitted earlier. The polytechnic school was an engineering school considered to be the best in Italy. Attending that school meant a major change in my intellectual trajectory. The reason for this change in trajectory was that my parents had passed away and that our land was to a large extent expropriated in the years following World War II as a result of the so-called Piano Verde (green plan), according to which the land was taken from landowners and distributed to peasants. This was the end of the "feudal" society which had regulated the life of my family for centuries and of most of the income for me. I needed to do something "useful" and the engineering school would provide such a venue. The first year in Torino was difficult, being away from the comfortable life of the Sicilian gentry and in a totally new environment. After that year, I adapted very quickly to the new situation and became one of the best students at the polytechnic. Life in Torino was very pleasant with many cultural activities going on, theatre, concerts, opera, etc. Already in the fall of 1959, soon after my arrival in Torino, I went to La Scala in Milan to attend the recording session of *Norma*, an opera by the Sicilian composer Vincenzo Bellini, where Maria Callas was singing the title role. From the time of my arrival in Torino, I became addicted to opera and attended many performances at Teatro Regio in Torino, Teatro La Scala in Milan and Teatro Carlo Felice in Genova. I also maintained some of my previous interests and wrote poetry, which, incidentally, has been recently published in book form. I graduated from the polytechnic in the spring of 1964 with a doctoral degree in nuclear engineering (Dott. Ing.). My thesis was on the design of a diffusion plant for the enrichment of uranium-235 from uranium hexafluoride, UF6. This plant, similar to a plant in Oak Ridge, Tennessee, was supposed to be built in Italy, which at that time was involved in a major nuclear energy program. The plant was never built, but in the process of writing the thesis, I acquired considerable knowledge in nuclear technology. In the late spring of 1964, I was awarded the Chiaudano Prize, as the best Italian engineer of that year.

During the second part of my years in Torino, I started being interested in mathematics and physics. I thought that engineering was too "practical" and that I needed to do something more "theoretical." This was a second change in my intellectual trajectory. During this time I published my first scientific papers, two in the *Atti dell'Accademia delle Scienze di Torino*, at the age of twenty, and one in the *International Journal of Nuclear Physics*, at age twenty-two. Two weeks after graduation, a competition (*concorso*) was set up, which I easily won and became assistant professor in the physics department of the Polytechnic of Torino, at age twenty-two. Physics in Italy had a long tradition going back to Galileo, but most of the scientific community in Italy had been depleted during World War II, with Fermi, Rossi, Segré, and others emigrating to the US and Pontecorvo, Rasetti, and others going to the Soviet Union. The late 1950s and early 1960s were the time when a new generation of physicists was formed. In 1965, I met Sergio Fubini and Tullio Regge, who advised me to go the US

and enroll in a PhD program there. In 1966, I was awarded a Fulbright Fellowship and came to the US to do a PhD in theoretical physics at MIT. In the meantime Fubini had become a professor at MIT and Regge at the Institute for Advanced Studies in Princeton, New Jersey. I decided however not to do a thesis with Fubini but rather with Herman Feshbach.

Coming to the US was a major change in my life. I arrived by boat from Le Havre, France, to New York in the late spring of 1966. Coming out of the boat someone approached me offering a hotel. I did not know where to go and therefore I accepted the offer. It was a small hotel in lower Manhattan. I could not sleep at all. During the night there was a continuous in-and-out of people, both males and females, often screaming loudly, a very different atmosphere from what I was used to. Only the next morning I understood what was going on. From NYC I moved to Franconia, New Hampshire, where I was meant to spend the summer learning English. Here I was *au pair* to a wealthy couple from Boston, Massachusetts, in their summer house in New Hampshire. My task was to take care of the house. Mrs. Davis, who was from a Bostonian old-money family and was used to seeing poor Italian immigrants from Boston's North End, could not believe her eyes seeing a young Italian who knew much more than she did in art, literature and music and who was more sophisticated and educated than her husband. In the late summer of 1966, I moved to Cambridge to start school at MIT. Boston and Cambridge had in those years a very vibrant intellectual life, and I quickly got involved in it. My girlfriend, Barbara, was studying music at Radcliffe, playing the cello. She later became curator of the Music Instrument Collection at the Boston Museum of Fine Arts. The person with whom I shared the apartment, John, was studying art history at Harvard and was writing a thesis on Baroque architecture in Sicily, especially in Noto, the so-called "Golden Honeycomb" because of the color of the stone used in the buildings. I helped John with my direct knowledge of that subject and went with him to Sicily in the summer of 1967, where I introduced him to one of my relatives whose palace was part of John's thesis. In 1967 I also met Julia Sutton and got involved with her on writing a book on Renaissance music. She later became dean of the School of Music at the New England Conservatory of Music in Boston. I translated for her the musical notes of Fabrizio Caroso da Sermoneta, a sixteenth-century composer of dance music at the Papal Court in Rome. She did the transcription into modern notation of the music which was written in lute notation. As a result I became interested in musicology and in music history. In physics, I progressed quickly to my degree, and received a PhD in theoretical physics in May 1969, less than three years since my arrival in Boston. My thesis was on the bosonization of fermionic systems, a subject to which I would return later. While at MIT I also published as sole author an important paper on scattering theory. My interaction with my thesis adviser, Herman Feshbach, was excellent. Contrary to the situation at that time when contacts between professors and students were minimal, Feshbach treated me as part of his family. I used to spend time at his

summer house at Cape Cod, where I wrote parts of my thesis. This relationship with Feshbach lasted until his death, and he even visited me in 1978 while I was spending time in my estate in Sicily. He always said I was his best student ever.

In 1969, I applied to postdoctoral positions at several institutions in the US and was accepted everywhere. However, I decided I wanted to return to Europe, and therefore I accepted the offer from the Niels Bohr Institute in Copenhagen, Denmark. While in Copenhagen, I expanded my scientific activities by developing new ideas not related to my PhD thesis. I introduced a new relativistic wave equation to describe particles with spin different from one-half described by the Dirac equation. In the fall of 1970, I met my future wife, Irena Holemarova, who was a political refugee from Czechoslovakia and married her in January 1971 in the setting of Hamlet Castle in Helsingor. Copenhagen at that time was a place where political refugees from the Soviet Union and several other Eastern European countries gathered. I became interested in Slavic literature including Russian. My wife had a special gift for languages and spoke, in addition to Czech, perfect Russian and English (and later Italian, Dutch, and German). I remember her reading poems, such as those of the Russian poet Anna Akhmatova, and translating them to me. Cultural life in Copenhagen was not the same as in Boston or Torino. There was the Royal Copenhagen Ballet, to which we went several times, but operas at the Opera House were sung in Danish. I remember taking Herman Feshbach, who was visiting me there, to see Puccini's *Tosca* and being amused when we found out that it was sung in Danish. This period of my life is full of episodes, mostly connected with the political situation in Europe, divided between the Soviet Bloc and the Western European countries. I could talk about this period and about my visits to the Soviet Union, Poland, Czechoslovakia, and other Eastern European countries for hours, but I will skip it for lack of time.

In 1971, after completing the postdoctoral two-year term, I returned to Italy and accepted a position of associate professor at the Polytechnic Institute. This was mostly a teaching position and not much to my liking. The next big turn in my intellectual trajectory occurred in 1973 when I was visiting the Kernfysisch Versneller Instituut in Groningen, The Netherlands. Here I was offered a senior scientist position at the Nuclear Physics Laboratory. This was a brand new laboratory with an up-to-date cyclotron performing cutting-edge experiments in nuclear physics under the direction of Rolf Siemssen. I decided to accept the position and moved to Groningen at the end of 1973. Here I started working again on the subject of my PhD thesis but including now the knowledge of symmetry that I had acquired since 1969. While preparing a talk at the International Nuclear Physics Conference in Amsterdam in 1974, I formulated a new version of the interacting boson model and developed it with the Japanese physicist Akito Arima (later president of the University of Tokyo, and minister of science and education) who was visiting Groningen at that time. The interacting boson model, with its ability to provide a classification of all nuclei in terms of dynamic symmetries U(5), SO(6), and SU(3), was an instant success. By 1976, my work was known all

over the world (Europe, Asia, North and South America, and Australia) and I was asked to give talks at all major European universities from Spain to Sweden, from the UK to Greece, from France to the Soviet Union. As a result, I was given an extraordinary professorship (*Bijzonder Hoogeleraar*) at the University of Groningen, one of the youngest (age thirty-four) people ever to receive this honor in The Netherlands. While in Groningen, my son Giovanni was born (1974). During this period, there was not much intellectual life but mostly family life. Groningen, situated in the northern part of The Netherlands, was at that time strictly reformed Lutheran or Calvinist, and any form of art was considered to be frivolous.

In 1977, I went on a tour of American universities. I was based at Argonne National Laboratory, just outside Chicago, in Argonne, Illinois. During the spring and summer of 1977 I gave talks in at least twenty American universities, from Cal Tech and UCLA on the West Coast, to Penn and Columbia in the Northeast, from the University of Washington and University of Oregon in the Northwest, to Florida State and Georgia in the Southeast. In the same year 1977, I met, while he was visiting Argonne, D. Allan Bromley, at that time chair of the physics department at Yale. The physics department was trying to find a successor to Gregory Breit, and Bromley offered that position to me. However, I was not interested at that time in leaving Europe, where I had a prestigious position and a comfortable life. It was only in 1978, after several phone calls from Bart Giamatti, then president of Yale, that I accepted a full professorship at Yale, where I have been ever since.

My forty-year career at Yale has been marked by several achievements and events which would take several hours to present. Here I will mention only a few. Among the achievements in the period soon after my arrival at Yale, I will mention the discovery of supersymmetry in nuclei (1980), the introduction of the interacting boson-fermion model (1981) and the introduction of the vibron model of molecules (1981). Among the events in this period, I like to mention an extended visit to China in the early 1980s. China was then recovering from the Cultural Revolution, which ended in 1976, and the scientific community there had decided that the interacting boson model would be one of the main subjects of research in physics. Groups of scientists at several Chinese universities, including the universities in Beijing, Nanjing, Suzhou, Hangzhou, and Shanghai, had started working on the interacting boson model in 1977–78. I was therefore invited by the Academia Sinica to visit many of these universities and to spend time instructing researchers there. I flew from Hong Kong to Shanghai, arriving there at dusk. The airport in Shanghai was at that time very small, and the terminal was a small building. (Now, Shanghai is one of the largest airports in the world.) A car picked me up at the tarmac and, without going to customs, brought me directly to the railroad station, literally to the door of the train. From there I started the journey through China along the Shanghai-Suzhou-Nanjing-Beijing railroad line. I was surprised to find out that in Chinese trains there were three classes, called soft sleeper, soft seat, and hard seat. During the travel, I was accompanied by a pretty escort who spoke perfect

English and was translating for me. The journey from Shanghai to Beijing took an incredible amount of time, as trains were traveling at a very slow speed. (Nowadays there is a bullet train covering the travel in hours instead of days.) My main host in China was Yang Li-Ming, who, because he had been educated in England in the 1930s, was sent to forced labor during the Cultural Revolution but had been reinstated in his professor position after the death of Mao Zedong (1976). In addition to giving talks at various universities, I was accompanied in a cultural tour of China, including travel to Xian to view the recently discovered (1974) army of terracotta warriors. I was taken to see a Beijing opera, the revival of which had just started and about which I had read a lot, especially its connection with Italian opera which had occurred when Matteo Ricci had moved to China at the end of the sixteenth century (1583). I was impressed by the colorful settings and by the high pitch of the singing. Travel in China at that time was an experience that I will never forget.

In the 1980s the interacting boson model became one of the most studied models in physics, and I started receiving many prizes and awards. Among these, I would like to mention the Eugene Wigner Medal of the Group Theory and Fundamental Physics Foundation, which I received in Moscow, Soviet Union in 1990 on the occasion of the biannual Mathematical Physics Conference. While in Moscow, I stayed in one of the Stalin-era hotels. These hotels, built in the 1950s, had very large rooms, high ceilings, and were almost completely empty of furniture. We were served caviar from the Volga and champagne from Crimea. Altogether, the visit was very different from my previous visits to the Soviet Union in the 1970s and 1980s when I was always accompanied by an escort, usually a KGB agent. This time, I was allowed to go out of the hotel without an (obvious) escort, and I was able to go to the Tretyakov Gallery to see the collection of icons and even to a performance at the Bolshoi Theater of Tchaikovsky's *Sleeping Beauty*. After returning from Moscow, I was awarded in 1991 the J.W. Gibbs Professorship at Yale. In view of the success of the interacting boson model, I also started receiving nominations for the Nobel Prize. Although nominations to the Nobel Prize are supposed to be secret and made public only after fifty years, several nominators nonetheless informed me of the nomination. According to rumors, in 1996, Arima and I came very close to receiving the prize but did not get it. The year 1996 was also when my wife Irena suddenly passed away while we were on vacation at our summer house in the Dolomite Mountains in northern Italy.

During the early 1990s I also received several honorary degrees. Two of them are particularly dear to me, those from the University of Ferrara, Italy (1992) and from the University of Sevilla, Spain (1993). Honorary doctoral degrees are, in Europe, special events and not part of commencement ceremonies. They are given only rarely and for some special occasion. The degree in Ferrara was given to me on the occasion of the six hundreth anniversary of the foundation of the university. The University of Ferrara had awarded in previous centuries honorary degrees to several important people, including in May 1503 to Copernicus, who actually had spent eight years in

Italy, at the Universities of Bologna, Padua, and Ferrara, culminating with the degree in Ferrara. The award ceremony took place in the fourteenth-century building siege of the old university and the party at the Hotel Duchessa Isabella, named after Isabella d'Este, one of the most famous women of the Italian Renaissance.

Receiving the medal and parchment at the Honorary Doctorate Ceremony in Ferrara, Italy, 1992.

The degree in Sevilla was given to me on the occasion of the five hundredth anniversary of the discovery of America by Christopher Columbus. This was a two-day event. The award ceremony took place in the old university building where I received the white gloves as a symbol of the purity of science, the gold ring as a symbol of Spanish nobility (*hidalgo de Espana*), and the parchment with the diploma. The *laudatio* was given by Manual Lozano Leyva. My acceptance speech was in Spanish and was published in the Annals of the University. The party the next day, which included as invitees many dignitaries, was at the Hotel Alfonso XIII, one of the leading hotels in the world. Both of these events in Ferrara and Sevilla will remain in my memory forever.

Receiving the white gloves and golden ring at the Honorary Doctorate Ceremony in Sevilla, Spain, 1993.

The last few years of my intellectual trajectory, from 2000 on, have been characterized by further discoveries and awards. In 2000, I discovered a new type of symmetry, called "critical symmetry," for systems at the critical point of a quantum phase transition. Also in 2000 supersymmetry in nuclei, a concept I had introduced in the early 1980s, was confirmed in a series of experiments at several laboratories in Europe, especially at the Maximilian University in Munich, Germany. This confirmation stimulated further nominations to the Nobel Prize in the years 2002 and 2003. Among the awards received in this period, I would like to mention the Lise Meitner Medal of the European Physical Society (2002); the Enrico Fermi Medal of the Italian Physical Society (2010); and among the honorary doctorates, those received from the University of Bucharest, Romania (2005); from the Hebrew University, Jerusalem, Israel (2016); and from the Technical University, Darmstadt, Germany (2017). Because of the lack of time, I will not dwell on these achievements and awards. I will instead come to an end of my talk and say that I will be glad to present this part of my intellectual trajectory in some other occasion at the Koerner Center.