Vittorio de Alfaro: Remembering Tullio Regge
(Torino, July 11 1931 – Orbassano, October 23 2014)

While I start remembering Tullio Regge, a pleasant thought comes to my mind, after a period of so many tens of years. It was a faraway time, the night of January 1st 1953. At the Montgeneve boundary with France a lot of us were about to light a bonfire, needed to show that the Italian State was too narrow, that in the end some form of European Union was needed (as it actually happened 40 years later). That night among the crowd around the bonfire I heard a prolonged barking; when asked, I was told it was Tullio Regge, a physicist just graduated. I hardly gave importance to him (back in the crowd), I was just at the start of my second year. Later in 1955 when I too graduated (21,5 years) Tullio was out in the blue (Rochester NY), I was committed (with a certain girl who became my wife) and didn't accept going to Rome at ENI to study nuclear reactors; I ended up at the Polytechnical School (from now on Poli) to study the percolaton of non miscible fluids through a mineral carrot.

I entered the Physics Institute almost two years later, snobbing the carrot built up meanwhile, and married Ilde (also at the Institute) December 2, 1957. Tullio was back from USA in '56 and Wednesday 27 February of the same year had married in Cordovado Rosanna (whom he met in the fall 1954 at Rochester). During all their long and so intense life she loved him with great total ability and was loved by him with the same absolute totality. A story of the american time tells us that Rosanna convinced herself after she told Tullio she liked a very strange object and Tullio instantly answered “a kaleidoscope”. Their home was filled with kaleidoscopes of every possible size.

One evening (end of '57? start of '58?) we were invited at the Regge's who at that time lived in a nice old house built by his father inside another bigger and even older one just across the church Gran Madre. I knew that Tullio was the single assistant to Mario Verde, the professor in Theoretical Physics and that he was a very peculiar person who had got his PhD in Rochester in two years. That evening I played chess as Tullio wished to play (he would get asleep when listening to people) and got able to come to a draw; Tullio got a bit disappointed (later on I always managed to avoid to play again even though Tullio kept asking me).

Tullio easily got rid of his thesis about particles of spin 2, although the intererest in higher spin was beginning to vanish as the theory of spin 2 pions was just due to an imperfection in the stacks examined by Lattes. After Andrea Doria sank close to Nantucket Tullio was back in Italy in August 1956 using an old greek steamboat. I understood in those days of early 1958 that he had produced another, so important paper in collaboration with John Wheeler, a great, complex, rippling and whimsical character who had seen and cleared many different aspects of General Relativity as e.g. the Black Hole theory, a singularity of the Schwarzschild metric. Tullio was not a novice to Wheeler who had already got opportunity to deal with him in USA and, while in Leiden, proposed Tullio to deal with the stability of a Black Hole in the presence of a nearby perturbation. Regge solved the problem fast and clever earning Wheeler's immediate great appraisal: John Wheeler became his great friend, with scientific connections that lasted for his entire life.

During a part of '58 Tullio devoted himself to a strange, interesting task: he extended the symmetry of the Clebsch – Gordan symbols up to a set of (if I am not wrong) 128 coefficients. Immediately he made a bid for the enlargement of another symmetry, the one connecting the analogous set of Racah (3j) coefficients. However he couldn't succeed and for around a month just became furious beyond imagination. Then one morning I found him typewriting as a fool on a very old bureau that encircled him along three sides. That night he had dreamed about the extension of the symmetry and was at the Institute already at 7 in order to write down the paper before, as he told me, he forgot the solution.

He had in his mind, though, other very strange ideas, at least for me: one day he questioned me, all of a sudden, about an angular momentum 7.2+3.5 *i*. I, uneasy, replied that the angular momentum of any

particle was an integer or half-integer number (in units *h/2 pi*), and that was all. But I had no idea of how deep his purpose was. I know that one day in early August, in Varenna, he tried to explain to Gunnar Kallen his idea about a continuous angular momentum; however he realized immediately that Kallen was pulling his leg treating him as a fool, and enraged gathered wife and son and left Varenna breaking down his participation in the course.

He was in Germany, at Munnich, six months or so. During that stay he talked with Kurt Symanzik about extending the angular momentum in the complex plane; that certainly was not a crackpot idea (although an entirely new one) since he was extending the partial wave equation. His problem was about keeping the complex angular momentum analytic in a half plane. Symanzik told him that the great Arnold Sommerfeld had a long time earlier solved that problem: among the infinite number of solutions one has when passing from a discrete to a continuous state, there is one and only one solution that is analytic in a right half plane. Tullio found Sommerfeld – Watson's paper in Sommerfeld's book about differential equations in physics and immediately produced a new, relevant paper: the angular momentum was transformed into a continuous analytic function in the right complex half plane and Tullio studied its properties.

As luck (or rather, lack of it) would have it, his work wasn't instantly spotted: notations in that article, perhaps a bit in the mood of Sommerfeld's paper, were unusual; the paper, published in 1959, had no consequences at the moment. Later on, in 1962, with Sandro Bottino and Anna Longoni Tullio published another, very long, paper with appropriate notations; in it complex energy and angular momentum were investigated thoroughly in Potential Scattering. Let us have a superposition of Yukawa potentials; under this condition the partial wave expansion of the scattering amplitude *f(E, cos theta)* can be extended up to the imaginary axix of the complex variable *l+1/2* (apart from a possible number of poles in the right half plane). These properties in the end yield a result that is exactly equivalent in Potential Theory to the double dispersion relations of the scattering amplitude in the invariant energy and momentum transfer, as proposed by Stanley Mandelstam but never checked in field theory. This was, in essence, the result of the long paper by Bottino, Longoni and Regge.

After his first solitary draft of his work Tullio was dedicating himself to something else: discretization of General Relativity, or, “General Relativity without Coordinates”. Let me explain how the thing works. Suppose you have a continuous two dimensional surface; approximate this surface through suitable slices of flat two dimensional triangles; extend the method to the case of a continuous non pseudo euclidean space-time in four dimensions and you will get an idea of how it works. This one too is an essential paper: even recently it was currently used!

Meanwhile Chew and Frautschi had laboriously decrypted Tullio's first paper on the subject and, having inverted invariant energy and momentum transfer, had singled out what they called “the Regge Poles”. Tullio however, who in 1961 was at Princeton University, while happy because of the popularity his work had received, was thinking something else. He couldn't win the chair that year because he hadn't presented in time his application (different from what some people say), but made up for lost time winning Relatvity at the University of Turin on December 15 1962. After having written a few papers with various young colleagues, in October 1963 he landed at the Institute for Advanced Study (Princeton NJ) where he wrote with me (I was at the same Institute) “Potential Scattering” for many months. The book was published at the start of 1965 by the editing house North Holland and obtained an exceptional result, was translated into Russian by Isdatelstvo Mir and in Japanese by Kodansha. The original english book was rapidly sold out (even in recent years ir was privately reprinted).

On November 22 1963 John Kennedy was killed. It was perhaps not even two o'clock p.m. when Tullio and I, coming back greatly upset from the main building, caught sight from the window of Freeman Dyson who, unaware of the tragedy, was very busy looking into a journal. All at once we entered the room without knocking; Tullio apostrophed him in great agitation “Kennedy was shot”. Almost not raising his eyes from his journal Dyson asked “was he hit?”. “Yes”, we answered unanimous, stalled by total lack of reaction on his side. “Is he dead?” Tullio answered again “yes”, with that little amount of

energy he still got. “I see”, said Dyson going on with his journal as cool as ever. At that point both of us, instantly passing from announcers to listeners, anxious asked him “What will happen now?” at what Dyson, always in the same attitude, answered “Johnson will be president”. We took to our heels sad.

Tullio went back to Turin in July 1964 while I remained at the Institute up to December 28 for various reasons (and brought back with me the final copy of the book). He was again at the Institute in the fall 1965 as Faculty Member. In the summer of 1966 I had taken him inside the deep cave Bosco dei Pini, close to Triest, together with Pino Furlan and my cousin Fulvio, almost two meters tall; Tullio cherfully went down to the part he could rather easily go. Just keep in mind that the cave was very long and deep, more than 300 meters, and filled with stalactites and vertical jumps; we had a rope and he let himself be lowered after being well roped up). Then, at the moment of starting back, he spread down relaxed and declared to us, tranquil, that he wouldn't move and it was our turn to push and pull that very big man up for hundreds of meters of cave, going uphill among stalactytes and stones of all dimensions that made extremely painful Fulvio's life (he was pushing from below). He took two good hours to get raised and was filled up with big skratches because his shirt was lifted during his ascent.

Tullio Regge quit being Faculty Member and was back in Turin in 1978, already going on in crutches. A snapshot taken in the summer 1986, showing him listening to exams in the street just outside the old Institute building, made the tour of the town. He was pressing for the new department to be opened. He had worked with Giorgio Ponzano on the asymptotic behaviour of Raca's coefficients and was working with Mario Rasetti on the theory of Fullerene, and with D'Auria, Fré, Sciuto, Gliozzi and many other people on Supergravity. Later some works were written with Janet Nelson and a couple with Riccardo Zecchina.

It is now, though, time to stop talking of his many papers, now that you have got an idea of the person. From 1989 to 1994, now constrained to a wheelchair but as usual always entirely present to himself and smart as ever, he was member of the European Parliament and, thanks to his knowledge of many languages (he learned rapidly some of them) got acquainted with many people (even the reverend Paisley !). He was able to introduce special assistance for handicapped people and was member of the Committee for Research and Technology. He even got into the problem of UFO, the Unidentified Flying Objects (there was a revamp of showing up in Belgium), working with those who allegedly saw them; his first report was unanimously approved. Later on, two labour UK people started making fuss about Tullio's report (and yet its approval had lasted less than 30 minuts)! He was back by 1994 and, having been requested with great enhtusiasm by Zich, the rector, went back to the Polytechnical School, his starting place in 1948, with all honours dedicated to a great man who was never puffed up and knew how to speak to each person. The Polytechnical School appointed him Emeritus Professor after he retired in 2003.

I also shall avoid to dwell on the prizes, from the Dannie Heinemann in 1964 to the Città di Como ('68), to the Einstein ('79), to the prize Presidenza del Consiglio ('88), to the Marcel Grossmann ('97) and Pomeranchuk (2001); and on the medals, Cecil Powell ('87) and Dirac ('96). Not too many, all together, for such an important personality.

Apart from being member of *n* first class academies (including the Soviet one, now Russian) we note also his long and extremely active presidency of the italian Association for Research and Prevention Handicap. Among an infinite number of articles on journals and daily newspapers there is (I am quoting only one) his talk on La Repubblica of April 17 2001 about the “progress at zero risk” (you may read it easily). There is too the series of books dedicated to scientific questions but directed towards everyone, as the Dialog with Primo Levi and all the other I have no time to talk about. And if he didn't get the Nobel Prize, it was a result of the general situation and of the way some things went on. If e.g. the story of the resonances would be given higher favour (as it happened a certain moment) perhaps he would have got it, in spite of the fact that his papers on mathematical physics wouldn't mind about the theory of particles. What he developed is anyway at the highest level and Tullio remains our great scientist: the Nobel prize is always connected to a series of complex situations independent from the will of any single man in science.