

Editorial

Jean Cleymans: Scientist, Mentor, and Friend Extraordinaire

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1. Evolution of a Friendship

When in 1988, I decided to start working on the physics of quark-gluon plasma and relativistic heavy-ion collisions, I was reasonably well-entrenched in my chosen field of low-energy nuclear reactions and break-up of light nuclei, having worked for over 17 years in that field. I had to first brush up on the details of my high-energy physics concepts and then become acquainted with the field in general, before starting my work on electromagnetic probes of quark-gluon plasma, for which my experimental colleagues were preparing to build detectors. The most useful introductory sources included a review by J. Cleymans et al. [1], the crisp and brief yet exhaustive book by B. Müller [2], and *Applications of Perturbative QCD* by R.D. Field [3], to which I often returned and sent students, whenever I had doubts. “QCD” stands here for quantum chromodynamics.

After these introductory readings, I started working on photons and dileptons and read several papers by Jean on low-mass dileptons from the bremsstrahlung of quarks and gluons. One important point of these papers was that they provided details allowed me to derive every step and reproduce all the results, without any difficulty, and then proceed to use those treatments for my own studies. During the summer of 1993, I attended an extended workshop at Santa Barbara, where Jean was also present. Unfortunately, I had only a very brief overlap with his stay. However, during his talk on the topic of low-mass dileptons, I asked him a question.

We were still in the days of overhead projectors and transparencies. He just went to the whiteboard and in his extremely clean board work and elegant handwriting, worked out the entire derivation. I was stunned. I can hardly take a class without holding notes in my hands, and I still write down all my points on the slides for my talks. After the talk, I went to him, introduced myself, and told him that I was reading his papers and conducting some follow-up work as a result, adding, “Sir, you must be a very popular teacher!” He blushed—as only he could—and which I was to witness again and again during years of association, and it started a friendship and collaboration with a scientist extraordinaire, who became my mentor and a close friend and confidant for years to come. A student, Dipali Pal, wrote several papers on low-mass dilepton production, and we benefitted from more discussions with him on these.

Our discussions continued over e-mails. It became intense and very fruitful when Helmut Satz and Xin-Nian Wang planned a collaborative project on hard probes, inviting several of us to CERN (European Organization for Nuclear Research, Geneva, Switzerland), LBNL (Lawrence Berkeley National Laboratory, Berkeley, CA, USA), Trento, Jyväskylä, and Lisbon, in turn, to work on our predictions for many hard probes using perturbative QCD calculations [4], which provided a strong platform for a lasting association for many practitioners of hard probes of quark-gluon plasma. Many of these associations were further cemented during various conferences and workshops. Jean came to most of the International Conferences on Physics and Astrophysics of Quark-Gluon Plasma, which we organised in India, and we benefitted from his valuable advice in organising these events.

In early 1996, Jean invited me to Cape Town (Figure 1) for a visit lasting about a month. Without me knowing, he had also invited Krzysztof Redlich for a part of that period. I knew Krzysztof from his famous paper [5] but had no previous acquaintance with him.



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Both were excited about our paper on single photons in S + Au collisions [6], and very intense discussions started about all the inputs of that work.



Figure 1. Jean Cleymans in the balcony of his office in Cape Town.

However, let me pause here to recall the hospitality of Jean during this period. Almost every day, he took us out for excellent dining, and on weekends, he drove us down to some of the most beautiful places, of which there is no scarcity in Cape Town. His wife, Ria, and daughters, Silvie and Silke, extended a very warm welcome to us and won our deep affection and admiration by their patience with three grown-ups arguing most vociferously about the applicability of hydrodynamics, formation time, and production of photons, and none of them yielding an inch of space! I wish to put on record the extreme patience shown by Ria during these discussions, which often lasted till late in the evening, and I would like to express my gratitude to the family for sharing Jean with us.

2. More on Our Scientific Collaborations

These discussions resulted in incorporating a new equation of state for a hot hadronic matter, which included all the hadrons in the particle data book in chemical equilibrium and led to two publications [6,7]. The first one [6] was later to form the basis for an explanation of single photons in Pb + Pb collisions at CERN SPS (Super Proton Synchrotron), BNL RHIC (Brookhaven National Laboratory, Relativistic Heavy Ion Collider, Upton, NY, USA), and CERN LHC (Large Hadron Collider) in terms of the formation of quark-gluon plasma, and the second [7] provided a prediction for the variation of the number of photons produced as a function of charged particle multiplicity in such collisions [8], experimentally confirmed some time ago.

Jean invited me to Cape Town, twice again—once for the excellent Strange Quark Matter meeting in Cape Town in 2004, held inside a pre-apartheid era prison (!), and then for a longer visit—both under an Indo-South Africa Collaboration program that we had established. Rekha, my wife, joined me during my later visit and considers it the most enjoyable and satisfying foreign trip she ever made with me (Figure 2).



Figure 2. Rekha, the author, and Jean: Table Mountain, Cape Town.

I was to meet some of his brilliant collaborators—Duncan Elliot, David Hislop, Bruce Becker, Sarah-Louise Blyth, Mark Horner, Spencer Wheaton, Azwinndini Muronga, and Zebulon Vilakazi—many of whom became our friends for life. Zebulon and Azwinndini were also to visit India later.

Alas, a plan to watch a Cricket Test Match at the famed Eden Gardens Stadium in Kolkata with Duncan could not materialise due to his very untimely death in a mountaineering accident in the Andes. Jean also organised that I deliver lectures at iThemba Labs, the University of Stellenbosch, and the University of Western Cape, which were very valuable experiences for me and won me many new friends.

Jean was extremely popular with our students, and several of them worked with him as post-docs. Some of these collaborations started over discussions during lunch or dinner. Thus, Raghunath Sahoo, while still a PhD student, had made a very interesting observation that transverse energy deposited in nucleus–nucleus collisions divided by the number of charged particles produced at SPS energies was independent of the centrality of the collisions. The value was slightly larger but also near-constant at RHIC energies. We were having lunch at an unusual restaurant designed similar to a truck driver’s dining place when Raghunath used paper napkins to explain his experimental findings. Soon, it was realised that since most of the particles were pions, and the measurements were at a given rapidity (near zero at RHIC), this could possibly be understood in terms of the famous paper of Jean with Krzysztof, which showed that $\langle E \rangle / \langle N \rangle$ (where E denotes the total energy and N denotes the number of particles produced) for nuclear collisions at all energies from SIS (Schwer-Ionen-Synchrotron, Darmstadt, Germany) energies to LHC was about 1 GeV/nucleon [9]—thus started a collaboration, which expanded to include the Tsallis statistics to describe all the features of particle production in nucleus–nucleus, proton–nucleus, and proton–proton collisions at relativistic energies, in a long series of papers. Jean visited the Indian Institute of Technology, Indore, where Raghunath had joined and established a very vibrant group to meet his young collaborators there, who remember his inspirational visit with awe and affection (Figure 3).



Figure 3. Jean Cleymans at Rani Roopmati's Palace, Mandu (near Indore).

The list of students from India who worked with him is large—Danish Azmi (Figure 4) and Trambak Bhattacharya were post-docs with him, and several others worked closely with him and made valuable contributions. Many of his collaborations with students from India started when they approached him with some questions. This happened with Natasha Sharma and many others. His friendly and generous nature made him extremely approachable, and he revelled in the achievements of the students, which further endeared him to them.



Figure 4. Jean Cleymans with Danish Azmi and the young Azmi, Cape Town.

3. A Glimpse of Jean's Scientific Contributions

Several others will write more extensively and eloquently about his scientific contributions. I, for one, consider many of his studies to be among the most valuable and having a lasting effect on the field—namely, his pioneering and exhaustive work on the application of Tsallis statistics for a quantitative and detailed description of particle production in relativistic collisions of nucleons and nuclei [10]; his observation that particle ratios in such collisions provided a robust measure of chemical equilibration between them [11]; his paper [9] in which he established the boundary of (chemical) freeze-out in such collisions for all centre of mass energies; and his study with Jorgen Randrup [12], which used the large body of his studies on ratios of particle production and their momentum distributions to establish that the maximum freeze-out density has a baryonic chemical potential of 400–500 MeV, which is above the critical value, and that it is reached for a fixed-target bombarding energy of 20–30 GeV/A; this provided a most convincing justification for FAIR (Darmstadt, Germany) and NICA (Dubna, Russia) facilities as well as a hope for a bountiful harvest of exciting results for the nuclear equation of state to study neutron stars.

His contribution to establishing a theoretical and experimental school for the study of relativistic heavy-ion collisions and particle physics in South Africa is too well-known. He trained his students well and thoroughly, and they were welcomed at all laboratories across the world; they have surely by now established a collaborative network of their own. Jean established the University of Cape Town—CERN Centre, initiated a collaboration with the ALICE Collaboration (CERN), and set up a grid computing facility there. Zebulon Vilakazi went on to head the South Africa—ATLAS Collaboration (CERN). Jean further initiated an extensive collaboration with the Joint Institute of Nuclear Research, Dubna, towards the building of NICA (Nuclotron-based Ion Collider fAcility) and its future utilisation.

His generous hospitality and great standing in the field (Figure 5), so evident from numerous awards and honours, also brought scientists from across the world to the many prestigious conferences he organised, which opened the world to the students of South Africa.



Figure 5. Ria and Jean Cleymans at CERN.

I worked for about a year after my retirement on a book entitled *Climate Change and Energy Options for a Sustainable Future*, which drew extensively on years of my efforts at

science outreach and efforts at dispelling fears about nuclear energy. I shared a draft copy of it with him, well before it was published. He liked it immensely and praised it whole-heartedly when I had a video chat with him around mid-February 2021, when the book was about to be released. He ordered several copies of it to be given as a present to friends and relatives. He wanted to make a present of one of these to Ria on her birthday. It arrived on her birthday, but Ria and I will always regret that he was not there to present it to her in person (Figure 6).

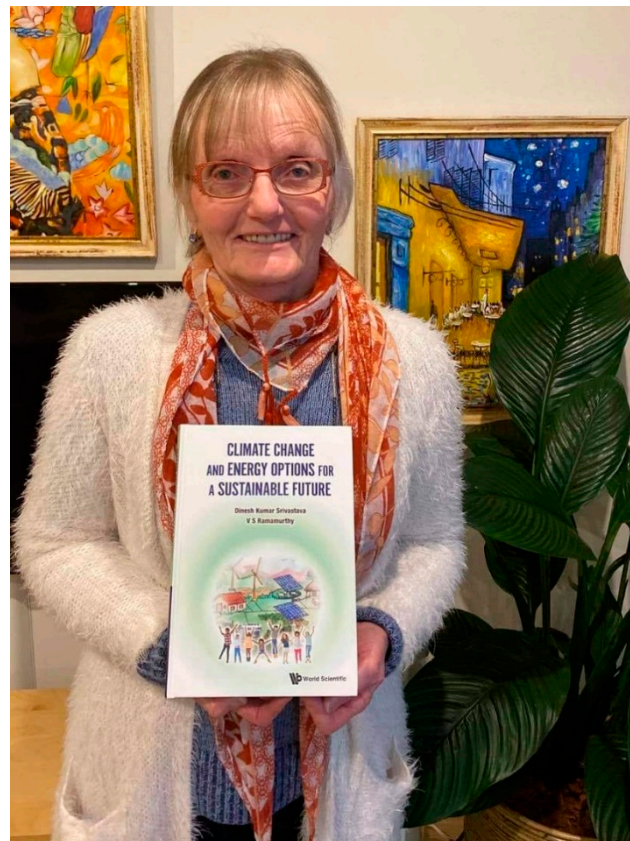


Figure 6. Ria Cleymans.

4. Epilogue

I have only talked about the scientific contributions of Jean Cleymans (Figure 7). His sense of humour was legendary. His patience while training students was phenomenal. He was extremely well-read, had a vast and deep knowledge of history, literature, music, and culture, and spoke several languages. He introduced me to several excellent authors and historians. This opened another facet of his and his family to me. As I occasionally indulged in writing short stories in English, I would give them to him and Ria and invariably receive warm and affectionate comments. Ria remains one of the closest friends and a confidant of my wife, Rekha.

It is also extremely tragic that Ria lost her elder daughter, Sylvie, soon after Jean's passing. My family and I hope that she and her daughter, Silke, find the courage and strength to bear this double tragedy and loss.



Figure 7. Jean Willy André Cleymans (5 August 1944–22 February 2021).

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Acknowledgments: This is a very personal homage to Jean Cleymans, a dear friend, a brilliant scientist, a generous and caring host, and a great human being. His scientific contributions have been discussed here very briefly. The honours that Jean received from across the world, and in South Africa, are all too well-known. I have used photographs taken by different friends at different times, from my collection, and I do not even remember who took these pictures. I thank them all in advance and apologise for not seeking their permission before using these. I would also like to apologise to the friends and colleagues whose names I have forgotten to mention in my grief.

Conflicts of Interest: The author declares no conflict of interest.

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