Imprese with Pino: from pre-confinement to pre-collapse

Gabriele Veneziano

Pino was fond of "imprese", challenges he would tackle with no hesitation and carry on, undeterred, till success. Below, the example of a few in which I had the pleasure to accompany (or just watch) him.

1 Berkeley 1969, S-matrix days

I first met Pino in the summer of 1969 at Berkeley where we were both visiting the Lawrence Radiation (later renamed Berkeley) Laboratory with Geoff Chew and Stanley Mandelstam playing hosts. Although we did not manage to work together in that occasion, we had numerous discussions given our common interest in high-energy hadronic interactions. I was approaching the problem from the dual-resonance-model (DRM) side, while Pino was more within the conventional Regge-pole-bootstrap approach. But, most of all, the two of us, as well as our wives, sympathized: it was the start of a long-lasting friendship later extended to our respective children.

Active collaboration had to wait a number of years. Since the early seventies, inspired by the DRM (as it was slowly evolving into string theory) I had been playing with the idea of replacing the ordinary loop expansion with one based on the topology –rather than the order– of Feynman diagrams. On that basis I had proposed in 1973 a topological model for the bare Pomeron (as a cylinder) [1] which gave quite naturally an intercept near (though not exactly equal to) one. It was hard to sell this point of view until, in 1974, Gerard 't Hooft came up with the idea of a large-N expansion in QCD. With a little extension of that idea I was able to justify precisely the reorganization of perturbation theory I had been preaching unsuccessfully about.

In 1975 I wrote my first paper with Pino showing, under some general assumptions, that the (also topologically defined) bare triple-Pomeron coupling could not vanish at zero momentum transfer [2]. Combining this result with a bare-Pomeron intercept slightly above one, would lead to the so-called supercritical Pomeron as input to Gribov's Reggeon field theory. It is still, I believe, the most appealing set-up for exploring high-energy soft hadronic physics (e.g at the LHC) along the lines of [3].

The preprint carries a Weizmann Institute number (WIS-75/8-Ph). Indeed, I had been back to Israel since 1972 while spending extended summers at CERN. Pino appears as being

at CERN (as a two-year fellow I guess) while on leave from the University of Parma. I'm pretty sure the paper was initiated at CERN in the summer of 1974 and completed in early 1975 at the Weizmann Institute during a visit by Pino and Sonia. I have a few recollections of that visit such as a nice picture of the four of us eating mid-Eastern food in a Tel Aviv restaurant. I also remember very well that, when Pino kindly asked whether he could bring something for us from Italy or Geneva, I told him: "just a few kilos of spaghetti!": at that time Israeli pasta was uneatable for an Italian ...

The topological reorganization of perturbation theory applied to both the DRM and QCD but, with Pino and Marcello Ciafaloni, we made abstraction from those particular theories and worked out [4, 5] some general consequences of what became known as topological unitarization. After the above-mentioned paper by Pino and myself, two long papers with Pino and Marcello followed up on applying that same framework to Reggeon Field theory and its "cutting rules".

2 Swithching to QCD: Pre-confinement and Herwig

The idea of large-N expansions in QCD has been a turning point in my own research. It convinced me (although not without some sad feelings) to stop working on hadronic string theory and to switch my attention to QCD, clearly appearing to be a much more promising approach. This shift of interest also coincided with my moving to a full-time position at CERN. There, in the years 1977-1978, I worked with Daniele Amati and Roberto Petronzio on the factorization theorem (of soft and collinear divergences) and with Ken Konishi and Akira Ukawa on perturbative jet evolution (the so-called jet calculus). Then, in 1979, Daniele and I wrote a paper on what we dubbed "pre-confinement" in perturbative QCD [6]. Pino and Marcello were coming quite often to CERN as visitors. I thus had the opportunity of telling them about what I had been doing in QCD and they showed a lot of interest. I like to think (even if perhaps it's not true) that I rescued both of them from S-matrix and Reggeon Field Theory in soft hadronic physics to perturbative QCD. We published a paper [7] together (involving also Daniele and Antonio Bassetto) on infrared sensitive processes and one (together with Luca Trentadue) on jet evolution and color screening [8] very much related to [6]. But Pino and Marcello managed to go much further with other important results on small-x physics and colour coherence effects (see e.g. [9]), topic on which they also collaborated with Al Mueller (co-discoverer of this effect together with Boris Ermolaev and Victor Fadin), Yuri Dokshitzer, and Valery Khoze.

Then comes my own story about the birth of HERWIG. My recollection is slightly different from Bryan Webber's and I can be of course biased, but here it is: one day around 1982 I was having coffee with Daniele in the CERN Cafeteria while discussing the possibility of writing a computer code to implement the pre-confinement idea for the evolution of realistic jets. We both felt helpless for tackling such a challenge and were wondering about who could be more suitable than us at the task.

Just at that point, as far as I remember, Bryan happened to pass by and asked if he could join us for coffee. Given what he had been working on recently, we immediately realized that he could be the right guy for the job and started talking him into it. We may have also mentioned that Pino would have been the right person for helping him out on the more analytic part of the project. He immediately sounded very interested. In February 1983 the first Marchesini-Webber paper [10] appeared with the crucial role of colour interference effects mentioned in the title. The pre-confinement idea appears in the abstract and Daniele and I were copiously thanked for "many long and fruitful discussions".

3 Gravitational Scattering and pre-collapse

Pino was a rare example of a theorist who could master both the most subtle theoretical ideas and the details of a computer code that could produce actual numbers out of them. The construction of the HERWIG code is the clearest example. A qualitatively similar (although not as important) episode came up many years later, in 2007. Daniele, Marcello and myself –exactly twenty years after we had started the so-called ACV approach to transplanckian energy gravitational scattering– had come up with a simplified model [11] that could possibly describe both the scattering regime at large impact parameters and the collapse regime which is classically expected to occur above some critical value of $\rho \equiv G_N s/J$. Could our simplified approach reproduce quantitatively classical expectations for $\rho_{crit.}$? The technical problem was to find real-regular classical solutions to a rather complicated non-linear two-dimensional field theory and check whether there was a value of ρ above which this was no longer possible. We could solve this problem analytically by inventing an unphysical situation in which the problem would reduce to solving ODE's, something that even I can do with Mathematica. But the full (modulo the above-mentioned simplifications) problem led to PDE's.

We mentioned the problem to Pino who immediately grasped it (although we had not followed much the ACV approach) and established the crucial bridge between the three of us and a real computer practitioner, Enrico Onofri. In a short time this led [12] to a precise evaluation of $\rho_{crit.}$, consistent with –and close to– classical expectations (which can only provide an upper limit).

4 Last but not least

These were just a couple of "imprese" that Pino successfully tackled and carried through. I cannot refrain, however, from mentioning a most remarkable science-policy "impresa" to which Pino gave an absolutely essential contribution: the creation of the Galileo Galilei Institute at Arcetri, Florence. Such a structure, envied world-wide, would not be there without Pino's vision and dedication. We all owe him this wonderful gift.

References

[1] G. Veneziano, "Origin and intercept of the Pomeranchuk singularity," Phys. Lett. B **43**, 413-416 (1973).

[2] G. Marchesini and G. Veneziano,"Nonvanishing of the Bare Triple-Pomeron Coupling from s-Channel Unitarity," Phys. Lett. B **56**, 271-274 (1975).

[3] D. Amati, G. Marchesini, M. Ciafaloni and G. Parisi, "Expanding Disk as a Dynamical Vacuum Instability in Reggeon Field Theory," Nucl. Phys. B **114**, 483 (1976).

[4] M. Ciafaloni, G. Marchesini and G. Veneziano, "A Topological Expansion for High-Energy Hadronic Collisions. 1. General Properties and Connection with the Reggeon Calculus," Nucl. Phys. B **98**, 472-492 (1975).

[5] M. Ciafaloni, G. Marchesini and G. Veneziano, "A Topological Expansion for High-Energy Hadronic Collisions. 2. s-Channel Discontinuities and Multiparticle Content," Nucl. Phys. B **98**, 493-520 (1975).

[6] D. Amati and G. Veneziano, "Preconfinement as a Property of Perturbative QCD," Phys. Lett. B **83**, 87-92 (1979).

[7] D. Amati, A. Bassetto, M. Ciafaloni, G. Marchesini and G. Veneziano, "A Treatment of Hard Processes Sensitive to the Infrared Structure of QCD," Nucl. Phys. B **173**, 429-455 (1980).

[8] G. Marchesini, L. Trentadue and G. Veneziano, "Space-time Description of Color Screening via Jet Calculus Techniques," Nucl. Phys. B **181**, 335-346 (1981).

[9] A. Bassetto, M. Ciafaloni and G. Marchesini, "Jet Structure and Infrared Sensitive Quantities in Perturbative QCD," Phys. Rept. **100**, 201-272 (1983)

[10] G. Marchesini and B. R. Webber, "Simulation of QCD Jets Including Soft Gluon Interference," Nucl. Phys. B **238**, 1-29 (1984).

[11] D. Amati, M. Ciafaloni and G. Veneziano, "Towards an S-matrix description of gravitational collapse," JHEP **02**, 049 (2008).

[12] G. Marchesini and E. Onofri, "High energy gravitational scattering: A Numerical study," JHEP **06**, 104 (2008).