THE WOLF AND THE STREET: NARRATIVE ENCOUNTERS WITH MATHEMATICS

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1. Introduction

I was invited to this conference to present the results of an old experiment, a twenty year old exploration of narrative and mathematics, in the form of a collection of fairytales.

I began writing the stories of *Racconti per il lupo* (Tales for the Wolf) in 1986, when I was a sixteen year old student of the *Liceo Classico*, more occupied with ancient Greek texts and philosophy than with mathematics. I finished the collection when I was about to graduate in Theoretical Physics, at the University of Milano, in 1993.

Those few years spanned enormous transformations, at the personal level, going through the passage from late adolescence to adulthood, and from being a student of classical languages to a professional physicist, as well as on the larger scale of society and the world: those were the years that marked "the end of the short century", with all the upheaval, excitement and anxiety that came with it. In their minuscule cameo scale, the mathematical stories I was putting together, act as a small fragmented mirror of larger events.

The stories, written in Italian, and illustrated by a series of collages I prepared in the style of Max Ernst, are now available online at the publisher Lulu.com, along with some of my more recent writings.

In this presentation, I will try to describe the main ideas behind that old attempt at conveying in a narrative form some mathematical concepts, and I will contrast the spirit of that early encounter with mathematics, with the very different spirit in which I came to see the mathematical profession nowadays, after twenty years of experience. The latter is best represented in some of my more recent writings, especially the lyric prose collection *Street Science*, composed in 2013, illustrated by mathematical street art graffiti, also available online from the same publisher.

2. Tales for the Wolf

I will describe briefly the structure of the stories in *Racconti per il Lupo* and some of the main narrative themes. The work consists of eighteen short stories, collected under the title *Matematica e altre fantasie* (Mathematics and other fantasies).

The titles of the individual stories are: *The breath of the Aegean*, *Two-voice invention*, *Desert rose*, *Klein's Easter*, *Transcendental love*, *Little Red Hood*, *Sergels torg*, *Venetian shadows*, *The projective oval office*, *The Vodnik in the Ljubljanica*, *Stockholm fish*, *Ghost*, *The cold night of Helge von Koch*, *The ice cream seller*, *The hyperbolic fashion designer*, *The crazy puzzle of the Republics*, *The monkey of randomness*, *Möbius band*.

2.1. **Mathematical themes.** Each story is followed by a couple of pages of discussion, where the main mathematical idea contained in the story if briefly recalled and explained. These are, respectively, Gödel's incompleteness theorem, underlying the story "The breath of the Aegean", the Banach–Tarski paradox in "Two-voice invention", Penrose's aperiodic tilings in "Desert rose", non-orientable surfaces in "Klein's Easter" and "Möbius band", Cauchy sequences and the construction of real numbers in "Transcendental love", Banach–Caccioppoli's fixed point theorem in "Little Red Hood", Banach and Hilbert spaces in "Sergels torg" and "Stockholm fish", fractal dimensions in "Venetian shadows" and "The cold night of Helge von Koch", the classification of conics in "The projective oval office", the optimal stopping problem of probability theory in "The Vodnik in the Ljubljanica", the group of Lorentz transformations in "Ghost", the geometry of quadrics in "The ice cream seller", hyperbolic geometry in "The hyperbolic fashion designer", the chromatic number and coloring problems in "The crazy puzzle of the Republics", random sequences and Kolmogorov complexity in "The monkey of randomness".

As one can easily see, the range of topics includes more elementary mathematics, such as the classification of two-dimensional surfaces, topics from students standard curriculum, like Dedekind's construction of real numbers, or the notions of Hilbert and Banach norms, of conics and quadrics. There are also topics that are more frequently seen in mathematical popularization, like fractals. There is hardly any mention of more sophisticated mathematics, except for Gödel's theorem, another favorite of mathematical popularization. The choice of topics was not planned. I just wrote about any mathematical topic I came across as a student in those early days that captured my curiosity. I turned them into stories, and used the stories as a way of communicating the mathematical ideas to a larger public (back then consisting mostly of a circle of close friends).

The stories are accompanied by illustrations, which I made as collages, in the style of Max Ernst. They are simpler illustrations than the more elaborate collages that constitute the second part of the book, the visual narrative "Wolf in the Fold", about which I'll say a few words below, and they are meant only to capture the spirit of the story, not to provide a story in themselves. The reason for this choice of style is explained briefly in the introduction, where I wrote: "The images are a hommage to Max Ernst, for no other reason than in memory of that *Surrealism in the service of Revolution*, or perhaps only because Surrealism and Mathematics always make for a happy combination".

2.1.1. *Little Red Hood and the quest for identity.* Besides the mathematical themes mentioned above, the stories are full of references to the geopolitical events of the time (late '80s and early '90s) when they were written.

The story that gives the title to the collection is a retelling of the fable of Little Red Hood, with some twists in the story, which ends with the little girl and the mathematician wolf eloping and living happily ever after. The "Tales for the Wolf" are, supposedly, the stories with which Little Red Hood will entertain her lover wolf, during their happy days in the depths of the forest. The same story contains a parallel political theme, on the effective dissolution of the traditional Italian political Left in 1991 and the vacuum that it left behind, and the difficult quest for identity of its survivors.

The latest days of the Cold War and its aftermaths also make an appearance in the stories "The projective oval office" and "The crazy puzzle of the Republics".
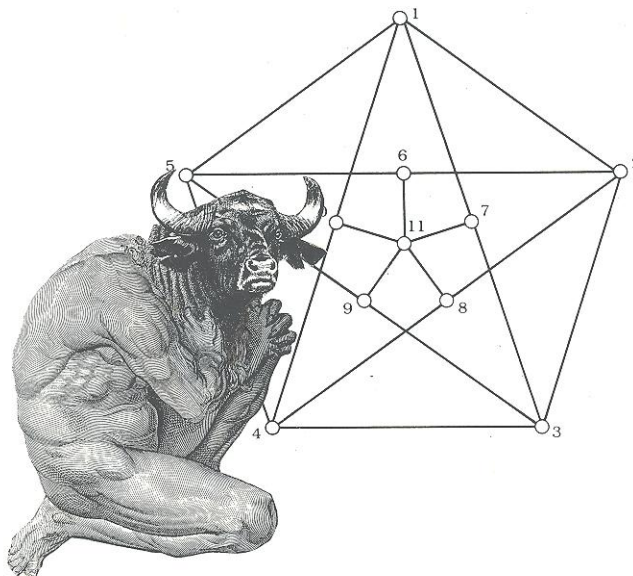
FIGURE 1. Illustration from "The breath of the Aegean"

2.1.2. *Theseus, Oedipus, Pindar and the ancients.* Another theme crisscrossing through the stories of *Racconti per il Lupo* is Greek mythology and references to ancient Greek culture. This is inevitable, since I underwent the typical Italian intellectual upbringing, with a good scholarly education in the Classics, Latin and ancient Greek. I had a serious interest in the Greek language and culture, to the point that I seriously entertained the idea of Philology of ancient languages as an alternative career choice to Physics and Mathematics. (Well, there's still time.)

So the story about Gödel's incompleteness theorem is set inside the framework of the Greek myth of Theseus, with a few hidden references to writings of Károly Kerényi and Bruno Snell. Similarly, "The monkey of randomness" has an ancient Greek setting, including Greek citations from Sophocles "Oedipus Rex" and Pindar's first Pythian.

2.1.3. *Cities of the Eastern nights.* Another kind of mythology permeates the stories, a mythology of cities: Stockholm, Budapest, Ljubljana. Northern and Eastern European cities, Mitteleuropa, as I had experienced it, in a flurry of train traveling outside of our national boundaries, in that brief period of time in between when frontiers became suddenly permeable and when wars began to ravage the Balkans. A brief, almost magical, encounter which is embodied in a dance of cities and water: fountains in Stockholm, the Danube passing between Buda and Pest, and rivers in Prague and Ljubljana inhabited by magical Vodniks.

2.1.4. *Flowers from Baghdad.* The story "Desert rose" was written in 1991, in the wake of the staring of the first Gulf War. It contrasts the Baghdad of the historical Islamic Renaissance, the center of culture, science, and art, with the modern war ravaged, bombed city. Sadly, twenty years later, this is the only story that has not lost its relevance in terms of immediate reference to contemporary political events.

The Möbius-band-shaped poem that forms the last story is another hommage to a middle eastern setting, a touch of Orientalism perhaps, to which our country of rich Arabic heritage is easily susceptible (just think of Pasolini's majestic filmic rendering of "The Arabian Nights"). In fact, the form of that last poem is more directly inspired by a song by the Italian singer songwriter

FIGURE 2. Illustration from "Desert rose"

Francesco Guccini, set in a similar desert setting, which in turn elaborates on the biblical verse, "Watchman, how much is left of the night?".

2.2. **Wolf in the Fold.** The second half of the book *Racconti per il Lupo* consists of a visual collage, titled *Wolf in the Fold*, conceived as a hommage to Max Ernst's famous visual "collage-novel" *Une Semaine de Bonté*. It consists of nineteen collages, each accompanied by a short poem. The poems are themelves collages, made of titles of paintings by the main artists of Surrealism.

The "story" narrated in "Wolf in the Fold", in as much as it makes sense to speak of storyline in Surrealist collage-novels, is the rest of the story of Little Red Hood and the Wolf, after their happy first encounter narrated in one of the short stories in the first half of the book. It is a story of love and mathematics, of happy moments of collaboration and moments of deep suffering and despair. All in all, it is an open-ended cautionary tale about the delicate balance between infatuation, especially in relation to those people we perceive as role models in the early days of our mathematical apprenticeship (and sometime in the later stages of our life as well) and the potential disillusionment that always lurks in the act of projection, in the Jungian sense, of our aspirations onto others.

It is, in a way, nothing more than the standard story of the inevitable voyage from love to disillusionment, set in the framework of a mathematician's life. While the stories of the first half of the book are about mathematical concepts, embodied in a framework of narrative, the visual collage *Wolf in the Fold* is already something else, more akin to what my later writings will become, not a story of mathematics but one of mathematicians, not a cheerful story of ideas, but a darker story of individuals.

It is a tragic mistake, which is easy to make over and over again during a lifetime of scientific enquiry, to measure one's value, interests, aspirations and achievements upon a meter set by somebody else, someone we admire, perhaps, and would like to invest of the power of life and death over a path which is ultimately solely our own to plot and govern. While it may seem at first rewarding to receive confirmation and encouragement from a trusted source, ultimately in science nothing good can possibly come from any form of authority principle. Science is anarchist by its very nature.

FIGURE 3. From the Surrealist Collage-Novel "Wolf in the Fold"

In retrospect, the disillusionment repeatedly caused by a sequence of failed attempt at searching for a "magical other", with whom to share the intellectual adventure of exploration of the boundaries of the mathematical unknown, are perhaps one of the main factors in the progressive darkening of my perception of the profession. Far from being the collective, shared, progressive enterprise I had imagined it to be at around the time when I was writing the stories of *Racconti per il Lupo*, mathematics as a profession revealed itself to be largely a callous and vicious environment, where enthusiasm is systematically snuffed out, where trust in other human beings is nearly always misplaced, and no real sense of common purpose exists. There is no "other", there is no "sharing". As I wrote elsewhere (in my theater play *The Somber Science*): "It would be so easy to create an illusion of meaning in our lives: it's enough to have an ideal to fight for, a desire to change the world, a community to belong to. It is so tempting to get validation, support and a sense of purpose, through these outlets: Party, Commune, Collective. Science is a harsher meter to confront oneself with: there is no easy way to reassure oneself, no red banners to wave in the wind. We are all alone in front of the terrifying silence of the universe. Those rare moments when one can share the experience of understanding with another fellow traveler are precious, unique."

2.3. **Night Songs.** The introduction to *Racconti per il Lupo* consists of two pieces, respectively called *Canzone di Notte, N.1* and *Canzone di Notte, N.2* (Night Songs, N.1 and N.2). The titles are a direct reference to a series of songs by the same name, by the Italian singer songwriter Francesco Guccini. These introductions were later additions, written in 2011, when I came across the old manuscript of *Racconti per il Lupo* and decided to publish it. They attempt to summarize the cultural context in which those stories were written, the leftist Italian *intelligentsia*, which was going through a period of crisis and restructuring in the late '80s and early '90s. Pasolini had variously referred to that cultural milieu as *"il paese nel paese"* (the country within the country), a very tightly wound community, encompassing the vast majority of Italian intellectuals (writers, artists,

FIGURE 4. Illustration from "Street Science"

musicians, scientists, philosophers) over several decades of postwar history. That environment, which I grew up in and belonged to, effectively ceased to exist, with the transition of the early '90s that ushered twenty years of populist governments pandering to the extreme right, and no longer held in check by a strong, well organized and intellectually capable Left. I was no longer living in Italy by then, and I was thankfully spared the experience. My "Night Songs" are songs of remembrance, which are meant to set the larger stage on which the otherwise very light and humorous short stories are taking place.

3. STREET SCIENCE

Let me now fast forward ahead twenty years, from 1993, when the last of the stories of *Racconti per il Lupo* was written, to 2013, when I wrote the collection of lyric prose *Street Science*.

The protagonist of *Street Science* is no longer mathematics, but the experience of mathematics as a profession, articulated as a journey in twelve episodes, from student to full professor, through graduate school at the University of Chicago, a postdoctoral experience at MIT, a few years at a Max Planck research institute, finally landing with my present job at Caltech.

Mathematics itself is present in *Street Science* in the illustrations that accompany the lyrics. Unlike the illustrations of *Racconti per il Lupo*, these do not try to give a pictorial symbolic image that evokes the atmosphere of a story, and where mathematics is incorporated as a symbol, but they deal directly with mathematical formulae, without context or metaphor. Advanced mathematics written as urban graffiti: the metaphor here is in viewing the mathematical community through the eyes of the asphalt jungle.

3.1. **Street Art and Street Signs.** The title of the collection is clearly meant to bring to mind two associations. The first is with *Street Art*, which is the general term referring to urban graffiti artists, a form of art that is associated to political protest, to the marginalized inner city youth, cut out from mainstream society. The term *Street Science* positions the author as an outsider to the scientific establishment, even though formally a part of it by official curriculum and affiliation. Street Art is primarily a form of protest and revolutionary fight, achieved through the means of art. I similarly perceive my scientific activity nowadays as being a war, fought one small lemma at a time, with each paper the analog of a so called "street art bomb", in the urban jargon, or even just a "tag". The other reference is to the term *Street Signs*, meant as marks of directions, pointers of the way, for those who, in the middle course of life, may have found themselves in a dark forest.

The illustrations that accompany the collection of lyrics are meant precisely as signposts, drawings in the style of street art graffiti, superimposed on a blueprint of the New York subway wagons, representing mathematical formulae taken from various results I worked on, at different times in my mathematical career. They are placed in the text to mark the periods of time the corresponding

lyrics refer to with the appropriate mathematical content. So there is gauge theory and noncommutative geometry and motives and quantum field theory, slowly moving towards the singularity of the present moment, where all of these paths seem to have come to abrupt endpoints.

3.1.1. *In the Alley of Dark Workshops.* *Street Science* takes off exactly where *Racconti per il Lupo* ends, with a first piece set in 1993, the year when I graduated in Physics and started off on a journey that would cause me to change country, switch from Physics to Mathematics (or at least physically inspired mathematics) and gradually climb up all the ladder of the professional scientific community. The first episode, called *Midnight in the Alley of Dark Workshops* [1] describes exactly the same scene that is portrayed in the two "Night Songs" in the Introduction to *Racconti per il Lupo*.

3.1.2. *Rites of passage.* The twelve episodes in which "Street Science" is articulated form a series of rites of passage: *Chicago* is a snapshot of my graduate school experience, and *Mother* is a lyric tribute to my mother, who died of cancer while I was in my last year of graduate school. The next passage is the one that took me from the University of Chicago to MIT, where I did my postdoc: *First stop Wonderland* recalls the early enthusiasm with which I took the new experience, quickly dissipating into more somber feelings. (Wonderland is also the first stop on one of the Boston subway lines.) The next episode, *Gauge theory* follows the growing disillusionment with the gauge theory and low dimensional topology community I nominally belonged to during my MIT years, until the final cut and my move overseas to the Max Planck Institute.

> *... I left unfinished theorems, shadows painted on a wall, a bicycle abandoned in the department hall ...*

Paradise regained recalls the difficult restarting from scratch in a new field of research that followed this first (and by no means last) debacle. The lyrics focus on a beautiful friendship that grew during the years I spent at the Max Planck Institute, which did so much to restore my sense of purpose and of identity.

> *... a Gauss measure between art gallery and poetry night, a modular form, a motive, a vision, sometimes a Latin poem. Poetry as a rhythmic articulation of feeling, math as a logical articulation of beauty, a smile to the walkways of memory, lakeshores, and midnights of changing years ...*

In the following two pieces, *Leçons de ténèbres* and *California dreaming*, a much darker side of "paradise" manifests itself. *Leçons de ténèbres*, named after the polyphonic lamentations composed for the "tenebrae" services (Gesualdo, Charpentier, Tallis, Couperin), reflects the time when a new and more traumatic turn was forced on me by the unexpected breakdown of a long collaboration I had invested in enormously for several years. (This event and the deep scars it left was discussed at length in several of my recent writings, including the theater play *The Somber Science* and the collections of essays *Screams of Metal* and *Listening to Golem*.)

California dreaming is a bitter ballad against the German "herrprofessordoktors", which explains the reasons behind my decision to relocate in California, despite the excellent working environment of the Max Planck institutes and the close friendships and deep human relations I had established there.

The following piece, *Father*, deals with the death of my father, which happened two years after I moved to California, and his uneasy human inheritance, so much echoing other woes described in the other episodes of the *Street Science* collection. The remaining three pieces, *Cipher-Punk*, *Sunset Boulevard*, and *Chaos Ashram* deal with my new life in California, with its promise, with a mixture of marvel and despair, and with all the lose ends of the past still lingering unsolved.

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[1] To catch the historical reference in this title, it is perhaps useful to mentally translate it into Italian.

3.2. **The End?** I have returned time and again to the use of narrative forms as an accompanying commentary on my experiences as a professional mathematician. The original series of short stories *Racconti per il Lupo* is by far the most cheerful and naively enthusiastic of my narrative encounters with mathematics. It was followed by two science fiction novels: *City of Sorrow*, written in 1999 and loosely based on my experiences at MIT, and *Yamaon*, written in 2002 and inspired by the atmosphere at the Max Planck Institute. In 2009, shortly after I moved to California, I wrote the theater play *The Somber Science*, as a way of expressing in written form the traumatic experiences that accompanied my relocation (the same described in *Leçons de ténèbres* and *California dreaming* in the collection *Street Science*). In 2013 I tried to give with *Street Science* a panoramic view of my experiences of the past twenty years, from the vantage point of these last few years of Californian life, as an attempt to come to terms with the profound disillusionment I have by now developed towards the mathematical community. I do not know, at this stage, whether this perspective is likely to shift in coming years; whether the beauty of science itself will continue to prevail over the human ugliness of its practitioners, offering renewed comforting vistas of beauty, capable of rekindling our enthusiasm and motivation after each new pitfall of disillusionment, or whether there is ultimately a breaking point beyond which the homeostasis ceases to restore the system functionality. What I do know is that, either way, the narrative form can be used to represent this process metaphorically and poetically, and it often offers us a unique path towards healing.

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