Science is young, science is a positive but nostalgic adventure among the ruins of the old worlds

Romantic motivation for some European scientists at the beginning of the nineteenth century

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Any investigation about what romanticism meant for science in its historical development has to start with some common place oppositions. They can best be summarised by two words in *ism*: positivism versus romanticism. There is the opposition between bourgeois virtues of development and progress scientists were supposed to sustain, and the aversion to bourgeoisie most romanticists have expressed. There is the opposition between a look towards future science was offering, and a look towards the past, writers of the romantic school all nostalgically recalled. There is the opposition between the subjective world of man's fancy, and the objective world scientists were describing. But as was shown with some sarcastic pleasure seventy years ago by Henri Gouhier, Comte's most gifted biographer[1], there is too the opposition within positivism itself, between the life of the father of positivism as a romance, and his philosophic system in the form of a treatise.

A romantic life for the creator of the non romantic positivism

Auguste Comte began his life far outside Paris in the south of France in 1798, and in a family of the very low bourgeoisie. After arriving in Paris, aged 18 and for political reasons Auguste was sacked from the Ecole polytechnique, which was supposed to secure him social success as due to his talent in the sciences. To replace nobility, selection of the elite had been instituted by the French revolution, and this selective system had reluctantly been maintained by the Bourbons when back to the throne in 1815, once Napoleon's eccentric and romantic second government had failed in Waterloo's plains. Comte then had to quit his mentor, Claude Henri de Rouvroy, count de Saint-Simon, who envisioned a grandiloquent government managed by scientists, economists and engineers. Comte went momentarily mad, had to attend Doctor Esquirol's well fashioned house for alienated, married a prostitute he wanted to save from her fate but had eventually to live separately. Nevertheless, he required everybody who counted in the intellectual and scientific world in Paris to attend his *Cours de philosophie positive* in 1830. In the romantic kind of intellectual prophecy, he was sure to provide the new philosophy for the new century, encompassing all human activities in a *science de l'homme*, which then became sociology. Within two short years, Comte developed an adoration to Clotilde de Vaux and, on her sudden death, turned this adoration into a religion. In a fantastic and gloomy scene which Hoffmann could have imagined in 1817 in one of his *Nachtstücke*., Comte spent a whole night close to the corpse, forbidding everybody and even the family to enter the room.

1 Henri Gouhier, La jeunesse d'Aug. Comte et la formation du positivisme, Paris, 3 tomes, 1936-1941.

This is for Comte's life. In his *Cours de philosophie positive* however, there is no fiction and no romance. The positivist account for the development of the human mind according to three successive ages or *états* (theological age, metaphysical age, and positivist age) so largely organised the rhythm still used nowadays by historians of ideas, that this classification prevented historians of science to evoke anything close to romantic science. Except when describing the romantic lives of the new heroes, those who were regularly celebrated in the positivist calendar. That man alone from his own genius and Napoléon serving as a representation, was responsible for intellectual or material conquests in favour of all, became a *topos* for romanticism: "my life is a romance" was told in Saint Helen island, by the prisoner still so apt to detect new trends[2]. And the mood was well represented in scientists' biographies, as they were told for the edification of a large public by François Arago, after 1830 when he became perpetual secretary of the French *Académie des Sciences* in Paris. The genre became fashionable all over Europe, along with travel diaries and perhaps far more appreciated in general than the authors of the literary movement then called romanticism. Whether Arago described Joseph Fourier, Alessandro Volta, Thomas Young or James Watt, all scientists who had recently died, he claimed science was an adventure. It was the true adventure to gain glory in a new world under construction, or better said in the modern world. So Arago quoted with some pleasure an epitaph written by Lord Brougham in honour of Watt who had died in 1829, just regretting Watt had not been made a peer, like in France Laplace recently was.

> *James Watt who directing the force of an original genius early exercised in philosophical research to the improvement of the Steam Engine, enlarged the resources of his country, increased the power of man, and rose to an eminent place among the most illustrious followers of science and the real benefactors of the world*[3].

There is little doubt that this presentation of an intellectual– Watt is not named as a scientist or as an engineer, but as a man philosophing for free– got his moral colour from a revolutionary and romantic mood: benefactor of mankind (*bienfaiteur de l'humanité*) was the expression Lavoisier had used in July 1793 in order to justify the maintenance of an Academy of science in the newly founded Republic[4]. Lavoisier then spoke the revolutionary rhetoric, by which a universal development was considered to be the natural fruit of a national one, as soon as a nation was a republic[5]. Watt's epitaph organised the same logic, just the political aspect being forgotten. It was with the same logic, then opposed to any national bias, that Comte justified placing in his calendar scientist's names instead of saints.

The role of History in scientific activities

Watt's epitaph might have provided motivation for a scientist to work. This last word was a new but important word in the revolutionary vocabulary concerning the elite, with the disappearance of whatotium. classically meant for an intellectual, and even the kind of active curiosity the 18th century developed. Even to be a benefactor, work had to be done by a scientist as

2 Las Casas, Le Mémorial de Sainte Hélène, Paris, 1823.
3 François Arago, James Watt, a biography read at the Institut, December 8th, 1834, in Œuvres complètes de François Arago, J.-A.Barral (ed.), t. 1, Paris, Gide et J. Baudry, 1854, p. 477.
4 See, Lavoisier, Œuvres, t. , 1793,
5 Jean Dhombres, Quelle fut la part du "natioanl" dans le bilan postrévolutionaire des Lumières en Europe ? Annales Hist. Rév. Fr, 2000, 2, pp. 197-211.

a worker. Therefore, we cannot place abstract and unhistorical reason or logical development for the content of science only, and leave romance for scientist' lives, as just actors who happened to live during the period of romanticism. So for anybody interested by the cognitive enterprise of science in a historical perspective, the interesting question is to understand whether the romantic qualification of a world's benefactor or just nation' benefactor as a new representation for the scientist's role in society, helped or directed scientists doing science. Has it brought motivation for their works? Could we detect, during the period of romanticism, a new scientist's ethos and a new form of *libido sciendi* ? These are the question I will address here.

As soon as I have stated questions, I must assume a reflexive attitude about the reasons I chose such questions. I could easily have focused on scientist's lives, not only to explore the oppositions fiction/science I began with, but also to understand a scientist's work from his life[6]. But exploring scientist's lives would require first to rehabilitate the one century old question about the scientist's psychology, which was at the beginning of scientific and positive psychology. It was systematically refused by most historians of science, even those like Gaston Bachelard who were so interested by a psychoanalysis of invention. Thus, because of positivism, I will not be looking at romanticism as a posture for scientists in their lives, in spite of many of them showing a spleen[7], which is some new form of the old melancholia Aristotle attributed to genius.

> *For which reasons are they obviously melancholic all those who have been men of exception, for philosophy, city life (πολιτικην), poetry and arts (τεχνας)[8].*

I remain within this positivist-born domain, history of science, so that I will just look for the relations between science and history. But it has to be in a rather unusual direction. To make precise the question of a scientist's work, and its result, science, I will check how a position about what history meant, might have influenced the scientist's production at the beginning of the nineteenth century.

Once again I have to analyse my choice. I in fact cannot put aside the effect of the new century, as it was so often celebrated by Stendhal, Musset, Goethe or Coleridge, all being associated with romanticism in general. Not only in France, the new century was necessarily the non too happy heir of the Revolution, as Goya's painting or drawings are good testimonies. Jean Starobinski, for his book on *1789 and the emblems of Reason*, had a remark on Goya, which provides to romanticism some preparatory steps, and gives to the research of an origin by the Spanish painter, or what I called research for an history, a force far different from the more usual return to Antiquity.

> *L'origine pour Goya (comme pour Diderot, et bientôt pour les romantiques) n'est pas un principe idéal, mais une énergie vitale[9].*

Look at the terrifying illustration of Saturn, that is Chronos or History, devouring his son.

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6 This is what I did earlier when writing a rather long biography of Joseph Fourier, Jean Dhombres, Jean-Bernard Robert, Fourier, créateur de la physique mathématique, Belin, 2000.
7 See the Lagrange's melancholia the historian George Sarton described, or Cauchy's discouragement at the age 24, see Jean et Nicole Dhombres, Naissance d'un pouvoir. Sciences et savants en France (1793-1824), Payot, Paris, 1989.
8 See Jackie Pigeaud, Aristote. L'homme de génie et la mélancolie, Greek text, and French translation of Aristotle's problem XXX, 1, Paris, Rivages, 1988.
9 Jean Starobinski, 1789. Les emblèmes de la raison, Paris, 1979, Flammarion, p. 132.

Illustration 1: Goya, Saturn devouring one of his son, 17, Prado

In some inspired pages, the historian of art, Elie Faure, commented that Goya had explored all intellectual experiences of the past, and could be a Watteau, a Dante, a Rembrandt, a Callot or an Hokusai, thus recovering all histories.

> *Il est Goya, un paysan d'Espagne, farceur et sentencieux, un gamin féroce, un philosophe courroucé, uin visionnaire impossible à arrêter dans une forme, quelque chose de gai, de mauvais, de lubrique, et de noble en même temps tour à tour*[10].

How was science in the same period devouring its past ? Even if cultural or stylistic definitions for the adjective "romantic" or for the scholar substantive "romanticism" are still debated for the various arts and among the various countries, but so reluctantly used in epistemological terminology, both words are indeed linked to history. There is, as already seen, the history of a particular genius, his life being intrinsically woven to intellectual progress and thus celebrated, but there is also the history of a period of time reacting to a shattered past in order to define modernity, which like science was less seen as a construction to come, than as a world always in construction. So that a large part of the success of positivism among the triumphant bourgeoisie, a class which members of the romanticism school affected to despise, is indeed the way it scientifically explained progress as a man-made and however necessary history. Thus creating a science, the science of progress, served by history viewed as the education of man to his future. Positivism explained intellectual history was a conquest, requiring the vital energy Starobinski spoke about Goya, to undertake some crucial steps, and so demolishing others. In order to view science in action, or to understand the science production during the era of romanticism, guided in part by Gusdorf's remarkable analysis[11], I characterise romanticism by its interpretation of the human past as a move, located between but not necessarily after Antiquity, Christianity, Renaissance, Enlightenment, and the Revolution, certainly not in exile from Antique Egypt which was just recaptured for mind's imagination thanks to a group of young scientists turned into archeologists and in a way into a new profession. Romanticism recreated history of the human thought, and inventions were landmarks of this history the modern world inherited only in part, as some might have been lost by time running and empires disintegrating. Here lies the main opposition to positivism, for which oblivion of some of the past is the rule for progress

As the question is to know whether the romantic attitude towards History, and even their own history, helped or motivated scientists in their creative task, a first positive trace lies in the contradictions this historical and subjective localisation created for the universal values of objectivity attributed to scientific knowledge since Aristotle, and capitalised as progress by positivism. Such contradictions may in fact account for collective melancholia, which is the other face of the taste for ruins and shattered fate in Europe at the beginning of nineteenth century. Romanticism discovered that human reason, however coherent as it might be in the long and positive run, has had its epochs, each now ruined, but still having its beauties for to-day, and its truths. Could this feeling be prevented to those doing history of science?

10 Elie Faure, Histoire de l'art, II, J.J. Pauvert, Paris, 1961, p. 140.
11 Georges Gusdorf, Les sciences humaines et la pensée occidentale, Fondements du savoir romantique, vol. 9, Du néant à Dieu dans le savoir romantique, vol. 10, Payot, Paris, 1984.

When, for Easter 1802 and for the official signature of the Concordat between Bonaparte and Pie VII, Chateaubriand published *Le Génie du Christianisme*, a large part of his success was to present Christianity as a history. Its cult exhibited the beauty of past things, Christianity having taken the best humane values from the Greek and Roman worlds, even is those were past and destroyed worlds. Simultaneously, Chateaubriand could celebrate the new century, coming after the critical period of Enlightenment thus making possible to taste the Christian past in such an esthetical way, and as a lost innocence. Most scientists of the period, while well aware of the difficult development of science, Galileo's problems not being forgotten, were too looking for an innocence of the mind.

Because it was an invention of scientists who had benefited form the turmoil of the Revolution, Chateaubriand condemned counting in decimals. He saw this system was destroying the memory of the past, when there were still pounds, ounces and miles, and not the litany of kilo, hecto or deca with new names for abstract units. The decimal system characterised a trend towards universality to reduce the world to quantities, and the mental algebra decimal required, instead of usual and antique proportions, was so fit for pure computing that it reduced a nation using it to merchant activities. By their precision even, decimals were for accountant's books and so deprived human adventure of any mystery. The climbing of a mountain was reduced to the computation of a height, and a scientific endeavour in Australia to a cost. Without a part of mystery, there was no human action possible, even for scientists. Friedrich von Hardenberg, better known as Novalis, sang it in the way which will fashion Naturphilosophie.

Wenn nicht mehr Zahlen und Figuren
Sind Schlüssel aller Kreaturen,
Wenn die, so singen oder küssen,
Mehr als die Tiefgelehrten wissen,
Wenn sich die Welt ins freie Leben
Und die Welt wird zurückbegeben[12]

When eventually numbers and figures would no longer be the key to all creatures, when those who sing or kiss will know more than scholars, when the world will be left to his free life and to himself.

So by reaffirming Adam's original sin - to have tasted the forbidden fruits of the tree of knowledge- Chateaubriand wished to prove that Christianity had always well oriented man's scientific curiosity. It was a damnation that this curiosity was so enlarged during the Enlightenment, due to mathematics and its analytical powers, that it then appeared possible to erase any mystery in the world. Chateaubriand was in a paradoxical way too proud of the new century, and this is the unmistakable romantic part, to just evoke serious difficulties for scientists. In his *Songs of experience*, William Blake's terrifying representation in 1795 of a punished Adam, is adequate to express this contradiction, and a question to history, man being deprived of his true origin. Adam,

12 Novalis, Wenn nicht mehr Zahlen und Figuren,

so old looking with his hairs which fall very low on his young and energetic naked body, is still advancing towards God as his origin; he refuses the other direction of his future, a direction however shown by the running horse who carries God governing a cosmos in flames.

Illustration 2: God judging Adam, by William Blake, 1795, The Tate Gallery, London

Coleridge chose to begin his poem on the ancient mariner by the satanic inspired destruction of the bird of good luck, which was at the origin of his story.

And I had done an hellish thing,

And it would work 'em woe:

For all averred, I had killed the bird

That made the breeze to blow 13.

How was the opposition between what is old and what is young, so fundamental to romanticism interpreted or player into science?

Young and old: the romantic interpretation of the generation gap.

Mainly due to science as morality had been tarnished by the revolution, progress dissipated any mystery for the benefit of all, and certainty being achieved from human proofs, scientists then began to be considered as prophets. They were viewed as preparing a new society, some deep nostalgia notwithstanding about the worlds of the various pasts, when everywhere mystery was the essence of knowledge, and even was a push towards more knowledge. Science was becoming a function, a paternal and religious function for mankind, so a scientist had to be an old man, and his knowledge was to come from a past world. This view was contradicted by what could be seen of young scientists. The romantic contrast between old and young a poet like Musset wil use, was reduced to youth only in a portrait of Joseph Fourier. He is represented teaching mathematics in early 1798 at the same Ecole polytechnique where Lagrange was behaving as a Nestor of science. Almost the same age as general Bonaparte, Fourier exhibits the same youth, the same enthusiasm for diffusing scientific knowledge, thus preparing a new world Bonaparte was also preparing. Two pictures are eloquent.

Illustration 3: A portrait of Fourier, due to Dutertre in 1798.

Illustration 4: Bonaparte at Arcole by Gros

If Bonaparte is represented with the energy of Cesar, it is really the first portrait we have of a scientist, and a professor (not a university professor), looking so young and having such a vital energy: Boilly later will represent a bourgeois and rather quiet Fourier, then perpetual secretary of the Academy of sciences, and having attained his glory through the difficult recognition of his book on *Analytic Theory of Heat*.

Illustration 5: Fourier in his glorious posture as an Academician

13 Samuel Taylor Coleridge, The Rime of the Ancient Mariner,

When Fourier's book appeared in 1822, some lines were written in an extraordinarily style, to claim the newly established theory was to last for ever. This romantic ambition precisely was the effect of Adam's sin according to Chateaubriand, and a denial of the unavoidable decaying effects of time.

> *Les théories nouvelles expliquées dans notre ouvrage sont réunies pour toujours aux sciences mathématiques et reposent comme elles sur des foncements invariables ; elles conserveront tous les éléments qu'elles possèdent aujourd'hui, et elles acquerront continuellement plus d'étendue 14*

Fourier's theory was so presented as a success story because it had in fact a romantic story Fourier wanted to recall. As noticed with enthusiasm by Comte in 1830, Fourier worked on phenomena only to build his heat theory, and the fundamental mathematics he discovered, Fourier series and Fourier integrals, were not accidental. It was the language of Nature herself to produce phenomena, and this is not a version of *Naturphilosophie*, but a philosophy of nature. Fourier preserved this idea by calling *natural* or *proper modes* the simplest solutions of the partial differential equation, heat equation, he had discovered, from which all functions could be deduced. Nature was only complicated (an arbitrary function to represent a repartition of temperature) because natural phenomena had to be analysed in order to be produced.

Illustration 6: some lines of Fourier's manuscript in 1807, showing the Heat equation

Both Lagrange and Laplace refused to acknowledge Fourier's discovery in 1808, without refusing him to have obtained the true equation. The rather old generation, so proud of analyticity and computations, thought impossible a physical phenomena like heat propagation was so reduced, without any approximation. Fourier was too much their heir for them to recognise his achievement. It required for Fourier to enter the Academy, and more to become perpetual secretary to obtain a publication of his 1807 manuscript, to which he changed almost nothing. As his thoughts had been natural, so he claimed, even if there were technically shorter ways to obtain his results, his manner was the correct man or even God manner, at least the manner for ever to understand heat propagation. The way the oppositions between 18th and 19th century were solved by Fourier, are those given by a poem Alessandro Manzoni wrote on Napoléon's death in 1821, just a year before Fourier's book. Such verses were immediately translated by Goethe and celebrated by Lamartine:

Ei si nomò : due secoli
L'un contro l'altro armato
Sommessi a lui si volsero,
Come aspettando il fato;
Ei fe' silenzio, ed arbitro
S'assise in mezzo a lor.

14 Joseph Fourier, Théorie analytique de la chaleur, Paris, 1822, p. xxj.

He gave his name, and two centuries in arms one against the other, looked in turn to him in an obedient way waiting to their fate. He went silencious, and the judge sat between them.

Behaving as an historian in his *Vorlesungen über die Entwicckung der Mathematik im 19 Jahrhundert*, in a book published after the first world war, the then old Göttingen mathematician Felix Klein insisted on the new spirit launched into science by the school where Fourier taught. Klein characterised it by youth and enthusiasm for the analytical power of the mind, linked with a new rigor supposedly valid for ever, and not forgetting the also very romantic theme of a personal contact with creators.

Since the foremost mathematicians were hired as teachers in this amazing workshop, it is not surprising that the achievements of the school soon rose to an extraordinary height. This was due, in part to the zeal of the young people, who, in classroom, art rooms and laboratories, were exposed to the personal influence of stimulating and important teachers[15].

There was an intellectual training, which Stendhal, aged 16, was discovering in Grenoble. A group portrait, drawn in 1798, shows many young faces, and among them Beyle, alias Stendhal, all from the city's Ecole centrale, all having to learn hard mathematics as Stendhal will recall in his *Vie de Henry Brulard*, in order to collectively prepare Ecole polytechnique and so to achieve social progress towards notoriety and power through science.

Illustration 7: portraits of students at the Ecole centrale in Grenoble, 1798

And there was some difficulty for Stendhal to recognise that a collective apprenticeship to algebra was necessary, as it was a modern kind of knowledge, and so a philosophical one not already digested in textbooks, but already explained at the Ecole polytechnique, and transmitted to professors in Ecole centrale. Stendhal was also astonished that a personal judgement on school abilities remained necessary, and even that scientific activities were serving as a selection criteria. On the manuscript of his for long unpublished autobiography, Stendhal has drawn the way he happily suffered, while confronted to the examiner in mathematics, but also his grand-father, a notable of the city and a man of the Enlightenment, in front of the blackboard (in fact *a toile cirée*) then drawn as a guillotine.

Illustration 8: A drawing by Stendhal of his unsuccessful attempt at a public mathematical proof at the Ecole centrale in Grenoble in 1798

To confirm the new position of scientists in society, a painting, presented by Louis-Leopold Boilly to the Salon of 1802 in Paris, fits with new tastes and opinions the year Chateaubriand published his book, sometimes presented as a launching for romanticism in France. Boilly's painting shows the skilled Jean-Antoine Houdon, working on a bust in front of a seated scientist, which tradition claims to be Laplace. Houdon's famous sculpture of Voltaire, now in the Comédie française, is well visible behind. To the writer's public glory of the eighteenth century, after the

15 Felix Klein, Development of Mathematics in the 19th Century, transl. M. Ackerman, Math. Sc. Press, Massachussetts, 1979, p. 61.

revolution it seemed fit add the glory of a sovereign of ideas and computations. No specification however makes science to be recognised in this painting, and the hero looks like a philosopher, with the same qualification as attributed in Watt's epitaph.

Illustration 9: Houdon sculpting, by Leopold Boilly in 1802, Musée Carnavalet, Paris

The glorified scientist, shown in the process of being glorified, has an appearance more like Gaspard Monge, Napoléon's favourite geometer. But is quite certainly Lagrange, the melancholic and mathematical genius born in Turin in 1736. Boilly was twenty years younger than Houdon, the creative artist wearing his working gown, and Houdon had nearly the same age as Lagrange[16]. The scientist is clad in the way of the old regime, and so bears an air of being out of the present world, and he belonged to a distinguished past, not to the point of some dumbness as some historian was recently judging[17]. His attitude is much closer to Voltaire's "hideous smile", which Alfred de Musset so ambiguously described as modern smile[18]. The poet played with what appears young and what appears old; 18th century was too innocent for geniuses, but the new century could then achieve their works, still as an old, compulsory and sas thing done by the young ones in the 19th century.

Dors-tu content Voltaire, et ton hideux sourire

Voltige-t-il encor sur tes os décharnés ?Ton siècle était, dit-on, trop jeune pour te lire;

Le nôtre doit te plaire, et tes hommes sont nés[19].

Are you happy sleeping, Voltaire, and is your hideous smile still flying over your disincarnated bones. Your century, so it is said, was too young to read your text, so our century does please you, and your men are born.

To have a look at Houdons's sculpture more closely than in Boilly's scene won't help us too much; it is always difficult to historically interpret a smile.

Illustration 10: In a senator's toga, a smiling Voltaires seated, but ready to raise, by Houdon in 1778. The marble version is in the Foyer de la Comédie française in Paris; here is a terra-cotta, preserved in Montpellier, and it was done form the plaster version made by Houdon and revised also by him

Smiling is not a romantic attitude, and with Voltaire's smile as expressed by Houdon we see nowadays the Roman smile attributed to old and prosperous age. Romantic look of the second generation was different. So Pope Clement XIII's head as sculpted by Canova around 1789, was a better representation of old age for romantic artists, as there is no sign of any happy future.

Illustration 11: Clement XIII'head, by Canova, 1789, Musée des beaux-arts de Nantes

The three standing women represented in Boilly's painting – they are Houdon's daughters and the seated lady is Houdon's wife – are bored by the scene they have to attend. With the surge of

16 Houdon was born in 1741, then only five years younger than Lagrange.
17 See
18 The recent interest by historians to attitudes, like smiling or laughing, has avoided romanticism as such.
19 Alfred de Musset, Rolla, IV, 1833,

bourgeoisie, and the institution of meritocratic system, science was no longer an intellectual activity fit to their sex. Science was not adapted to their youth. A deep contrast with the portrait Louis David made of the chemist Lavoisier, a man in his young maturity, working in his laboratory with his wife close to him, less a muse than an assistant.

Illustration 12: David's representation of Lavoisier and his wife in 17

Why not quote here the very romantic story about the mathematician Sophie Germain, who aged 22, was obliged to use the disguise of a boy's name in order to send her solutions to mathematical problems raised by the old Lagrange, when he was still professor of Analysis at the Ecole polytechnique, just before 1800.

Illustration 13: Lagrange's portrait by

One case-study: invention, imagination, and new school practice in the sciences for imaginary numbers

Algebra, Stendhal explained us later, was just a way of giving up all qualities of things to only think of their role as quantity; precisely what Chateaubriand was reproaching to algebra. It was thus an abstraction, for which formal and logical thinking was necessary, and so thought Lagrange who refused to draw figures in his famous *Mechanique analitique*, first published in 1788, and nowadays viewed as having prepared the way to the second geometrization of mechanics (fiber spaces, etc.). Contemporaries just saw the analytic aspect. Because it has been a sort of common apprenticeship for the formative period of romanticism, it is significant here to explain the mathematical invention, which is summarised by the qualification of the geometric representation of complex numbers. This invention came from the school practice Stendhal was experiencing, and decidedly symbolised a difference with the eighteenth century, with the role of image for what earlier was abstract imagination.

It too has a romantic story as was found independently and in different forms by a Oslo born mathematician Caspar Wessel, aged 54, a French emigrant to London Buée who used the pages of the *Philosophical Transactions* in 1806, and a citizen of Geneva born in 1768 like Fourier, in an almost unread book also published in 1806. The book was sold at the expenses of its author, a bookkeeper in Paris named Argand, having fled Geneva because he was too much of a Jacobin. In spite of the publication in 1799 of the Wessel's paper by the Royal Academy in Copenhagen, it also had no success. But Jean-Robert Argand was rediscovered in 1813 by Gergonne, editor of the first journal entirely devoted to professors of mathematics.

Professors were indeed discussing the content of complementary courses of mathematics they now had to teach to all boys (boys only) who were registered in the Lycées, replacing the old colleges after their collapse during the revolution. Mathematics had always been an optional choice for students in colleges before 1789, but from 1802 on, boys and so future members of the school of romanticism in France, all had a good training in mathematics. Not generally up to differential and integral calculus, but certainly algebra was a strong basis. This was acknowledged by Stendhal. Due to the use of analytical tools, a new kind of geometry was then created, buy people of the old school, like Carnot born in 17 or Legendre born earlier in 17. This geometry was immediately called *elementary geometry*. It was different form Euclid's geometry. For example, proportion theory was replaced by fractions and algebra, centres of gravity entered into the picture, and what amounted to pre vector calculus, and so on. All this had to be defined by the new math professors,

and this explains the word elementary put before geometry. However, the first decade of the nineteenth century is the last and short period when classical authors of the Antiquity in the sciences were read for what they could bring once more to scientific thought and scientific construction, as if there remained some mystery in their works from which the new world could benefit. Soon afterwards, in the thirties, such old authors were left to scholars, forgotten by the inventors, or better said, were instituted as myths. Legendre presented his Geometry in year II (1794) as a revival of Euclid ; he meant that he was forgetting the changes made to geometry during the second part of the seventeenth century, and during the Enlightenment.

Argand, at the end of his book in 1806, by precisely locating his innovations (in particular the two algebraic operations - vectors operations - on directed lines, addition and multiplication), used the word ”induction” which was not a common one in mathematics, and will be developed in by Whewhell in his *History of the inductive sciences.* IN 1846, Comte will write his *Treatise on Elementary Analytic Geometry*, to show the main ideas launched by Descartes had to be put to a better understanding. This was another form of induction, not on mathematical objects, but on mathematical thoughts. Argand's book was also called an Essay, a rare title then for such mathematics, as if the book had something too personal and which could only later be confirmed as useful. It certainly was not the dogmatic way of a Euclidean synthesis; Legendre as well, in spite of a Euclidean revival, had to constantly rewrote the proof he provided to the fifth postulate. Let us read Argand.

> *Les méthodes dont on vient d'exposer l'essai reposent sur deux principes de construction, l'un pour la multiplication, l'autre pour l'addition des lignes dirigées ; et il a été observé que, ces principes résultant d'inductions qui ne possèdent pas un degré suffisant d'évidence, ils ne pouvaient, quant à présent, être admis que comme des hypothèses, que leurs conséquences ou des raisonnements plus rigoureux pourront faire admettre ou rejeter*[20].

The methods, which were just explained in the present Essay, use two construction principles, one

If this shy presentation used the rhetoric of a beginner in mathematics, it also expressed new young force, not yet tamed by academic circles. Legendre is the only academician named by Argand, and no approval from him is stated. We know that Legendre never presented Argand's book to the first Class of the Institut. This shows the gap generation, a romantic theme, to be present in the sciences.

Let us explain on Argand's case, as it is not exactly the same case as Fourier's difficulty with the old generation. Some years after the publication of his unread book, in the *Annales de mathématiques pures et appliqués*, and at Gergonne's request, Argand resumed what he now called a theory. But he first adopted the academic point of view, that is the largely dominant 18th century point of view, by explaining the use of signs as operations. Condillac had then reduced invention in mathematics, so that algebra was seen as the required type of rigor for creation in mathematics. Ironically leaving aside the question of truth– a very surprising sentence –, Argand then adopted a judgement from consequences or the fruits of the theory. He eventually considered school uses as a

20 R. Argand, Essai sur une manière de représenter les quanittés imaginaires dans les constructions géométriques, nouveau tirage de la 2e édition de 1874, Paris, Blanchard, Paris, p. 60.

probing *fact*. This was really a revolutionary attitude: young people, school boys even, were to decide what was the best for the future of mathematics, which the bright inventors during the 18th century had too restricted to an analytic future. In this context, a very young Evariste Galois was not an exception while publishing in the *Annales de mathématiques* in 18 . Many of his schoolmates were so required from their professors, in the school issued form the revolution, to exert on new themes, and not be bounded by the ways mathematics of the Enlightenment had.

> *La théorie dont nous venons de donner un aperçu peut être considérée sous un point de vue propre à écarter ce qu'elle peut présenter d'obscur, et qui semble en être le but principal, savoir, d'établir des notions nouvelles sur les quantités imaginaires. En effet, mettant de côté la question si ces notions sont vraies ou fausses, on peut se borner à regarder cette théorie comme un moyen de recherches, n'adopter les lignes en direction que comme signes des quantités réelles ou imaginaires, et ne voir, dans l'usage que nous en avons fait, que le simple emploi d'une notation particulière. Il suffit pour cela, de commencer par démontrer, au moyen des premiers théorèmes de la Trigonométrie, les règles de multiplication et d'addition données plus haut ; les applications iront de suite, et il ne restera plus à examiner que la question didactique: "si l'emploi de cette notation peut être avantageurx ; s'il peut ouvrir des chemins plus courts et plus faciles pour démontrer certaines vérités". C'est ce que le fait seul peut décider*[21].

What was the fact really about ? There had been no *fact* in mathematics, just readable proofs – and the fact, a word to which Comte will give some importance in epistemology, was here what we call now the plane, seen as a two-dimensional topological space. Argand's plane is still acknowledged in book's presentations for topology, but generally not in algebra. Youth was in Analysis at the very beginning of the 19th century; it came to be algebra thirty years later. But Argand and Galois were not easily recognised, even Galois's papers being lost by Cauchy, forgotten by Fourier, or the other way round. This situation led later to the idea of an avant-garde, having the task of disturbing status quo.

The intellectual change with Argand's plane is that reality, and not formal reasoning, obliged to consider rotations and similarities (homothéties) be the organisers of the two-coordinates plane. Those two operations could as well be represented by two numbers, a modulus and an angle. Modulus is a word coined by Argand, and still in use nowadays. As if it had been invented with complex numbers during the seventeenth century. In the romantic mood, indeed just a year later after his first public paper in Gergonne's *Annales*, Argand felt obliged to make use of history. Because he wanted to show what his innovation was. Argand interpreted trigonometric formulae, a triumph of what was then called algebraic analysis, which had been analytically worked by Euler from the equation $e^{x\sqrt{-1}} \quad \cos x \quad \sqrt{-1}\sin x$. And so trigonometry was dependent of the use of functions, and more specifically of the use of infinite power series from which sine and cosine functions were computed in tables. Where was a definition? The application to geometry, and this is

21 R. Argand, "Essai sur une manière de représenter les quantités imaginaires dans les constructions géométriques", Annales de mathématiques pures et appliquées, t. IV, p. 147; reproduced in R. Argand, Essai sur une manière ..., Paris, Blanchard, Paris, pp. 90-91.

how one could now view Euler's representation of complex numbers, rested on an induction, or an affirmation of adequacy, but certainly not on a proof[22].

Using the two dimensions of the geometric plane, Argand thus gave the a short convincing and rigorous proof of what was called the fundamental theorem of algebra. There were lengthy and unconvincing works from Euler, and Lagrange on this theorem. These proofs had been largely criticised by the young Gauss in 1799. The genius had understood that algebraic analysis, the Enlightenment form for Calculus, was not only ill founded, but inefficient as well towards new results. Gauss, whose life is certainly the less romantic life for a scientist, still had the romantic approach to the past, by declaring it ruined, and asking for a new approach to ontology in mathematics, which led to topology.

Illustrations 14, 15, 16, and 17: Portraits of mathematicians of the romanticism era

Far less advanced that Gauss, Argand's proof did not rest upon algebraic thinking, and was a critique as well of previous algebraic proofs, if only by being extremely short. Argand knew he had created a powerful tool, not destroying the algebraic or formal and sophisticated techniques used by Euler and Lagrange, but putting those into oblivion. At least for the purpose of analysis, that is when one wished to work on functions and variables, as has been stated by Euler as early as 1747 in his *Introducio in analysin infinitorum*. Argand was going back to the origin. A part of the recent past had to be forgotten. The situation is not precisely the one described by Thomas Kuhn as a revolution in science. Because there was no accidental disturbance, and what was to be destroyed was a historical development from the hard kernel of the theory, and the solution was to come back to this kernel, i.e. to earlier state of Eulerian mathematics. Argand deliberately used a possessive denomination for what was to become a universal and objective point of view about the complex field, and also analysis on the complex numbers. It is noticeable how the realistic origin later helped the use of complex numbers in physics, in optics, electricity, etc.

> *Je réclamerai, à l'égard de ma méthode, un examen plus particulier. J'observe qu'elle est nouvelle, et que les opérations mentales qu'elle exige, quoique fort simples, peuvent bien demander quelque habitude pour être exécutées avec la célérité que donne la pratique dans les opérations ordinaires de l'Algèbre*[23].

> *I would require towards my method some more precise examination. I observe it is a new method, and mental operations which the method requires , though simple, may well require some use in order to be executed with the swiftness as provided by practice in the ordinary operations of Algebra*

Argand's romantic play with history, or better said his sense of positionning a method in the history of mathematics, was somewhat theorised by a poet like Alfred Musset, "l'enfant du siècle"[24], who had learned mathematics as every one of his age– he was born in Paris in 1810. He explained with pride but also a certain kind of unhappiness, *schadensfreude* could have written

22 R. Argand, Réflexions sur la nouvelle théorie des imaginaires, suivies d'une application à la démonstration d'un théorème d'Analyse, Annales de mathématiques, t. V, p. 198; reproduced in R. Argand, Essai sur une manière ..., Paris, Blanchard, Paris, pp. 112-113.
23 Idem, p. 115.
24 Musset's autobiography, La confession d'un enfant du siècle appeared in 1836.

Sigmund Freud, that while knowing the past was for ever destroyed, his generation was advancing towards a better future, a sort of America, but among ruins. Through storms, this Eldorado could be reached with some white sail using the splendid ships built according to the prescriptive rule of the *Scientia navalis* due to mathematicians like Jean Bernoulli, Leonhard Euler and Pierre Bouguer in the 18th century, or using some heavy and bad-looking steamers.

> *Le siècle présent, en un mot, qui sépare le passé de l'avenir, qui n'est ni l'un ni l'autre et qui ressemble à tous deux à la fois, et où l'on ne sait, à chaque pas qu'on fait, si l'on marche sur une semence ou sur un débris*[25].

> *The present century, which divides past from future, without belonging to any one and resembling to both, where with every step made, one does not know whether one is walking over some seeds or some wrecked fragments.*

An illustration here could be that by Turner, showing a sailing ship being brought to its final stop by a steamer. But I prefer showing two different images. One is a plane lines of a ship in the last quarter of the 18th century: it shows a ship as a mathematical table, and as a splendid object on the ocean. The other image is unbelievable during the 18th century, even if this century liked ruins. It represents a ship transformed into a prison: this was a usual way during the century, but painters could not dare showing such a decay, and a bad-looking ship. It became a rather usual way of painter like Cooke, and even sea-side landscapes played with decay.

Illustrations 18, 19 and 20: ships

It requires just some mathematical habits to show that Argand had provided the basic technicalities of 19th century analysis, with the use of inequalities and of dividing ε. It required two steps, corresponding to the two dimensions on the complex field, or to the double work one has to do on lengths and angles, i.e. what we, in an insufficient way, call the geometric representation of complex numbers.

Ilustration 21: The short page where, in 1806 but recopied in 1874, Argand ended his book, by proving the fundamental theorem of algebra, without using algebra

Illustration 21: The trace of the sending of Argand's book to Gergonne. In a romantic way, there exists no longer a book from the first Argand's edition in 1806.

This technique of analysis Argand created in 1806 will be present by Gauss in a paper on the hypergeometric function in 1814, and will be formalised and so publicised in a textbook by Cauchy in 1821. It became described as the weierstrassian rigor, as it required uniform properties to be understood, which was not the case of Cauchy and his contemporaries. Therefore, Cauchy's textbook, about which the positivist Comte is silent, was young indeed, and still represented a young move of the thought, contradicting Michel Serres's recent presentation of the effect of textbooks in mathematics to be that of tombs, abolishing imagination

25 A. de Musset, in La confession d'un enfant du siècle, M. Allem, Paul-Courant (ed.), Œuvres complètes en prose, La Pléiade Paris, 1960, p. 69.

It is certainly the effect of the history of the discovery that no drawing was made for this proof by Argand in 1806, nor by Cauchy in 1821. The new conception was not derived from Euclidean geometry: the dimension property was a computation, a method, an imagination, not an image. In a romantic way towards history and what is now maintained in the expression of complex representation, has not kept the process Argand made for his discovery. Romantic poets, in Germany mainly, were a priori regretting that efforts for changes in knowledge would no longer be celebrated, and modern creators' works could no longer be celebrated. The analytic kind of philosophy of 18th century had taken too much in the domain of reputation and glory.

Illustration 22: a drawing now generally associated with the Argand's proof for the fundamental theorem of algebra

Youth, Cauchy (texts books as tombs)

It is interesting to see why Argand made at first a serious mathematical mistake in his book, or at least believed to have proved more that what he could really do. And that one had to require for the validity of the proof a technique of *reductio ad absurdo*, an indirect technique which is common by Euclid, but up to then absent from algebra.

A difficult and romantic relation to the past

To the usual generation gap, scientists of this romantic period provided the sens of a dificult heritage.

In fact the great merit of the romantic attitude in poetry, and of the transcendental method in philosophy, is that they put us back at the beginning of our experience26.

So, in 1910 and in University lectures, explained George Santayana, now rejected by historians of science. This remark brings us back to Starobinski's description of the origin and to the question of what the motivation is for a creator. Romanticism definitively closed down the one century long quarrel of the Ancients and the Moderns, once the revival of Antique thinking was over. Moderns had no longer to destroy all kinds of Ancients, even the recent Ancients from the Enlightenment. As Ancients were definitely dead27. The politically very conservative poet Victor Hugo, then aged 24 years, claimed in 1826 there was a clear cut difference with the past and he certainly played with the fact he was almost born with the century he was celebrating. It was a no origin declaration, in the same way Argand refused continuity to previous mathematicians for his invention? He knew how much he owed to Euler,as much as Hugo knew his debt to the seventeenth century literature, but refused an immediate past as an origin.

> *De notre siècle à l'autre on ne peut découvrir la transition. C'est en effet qu'il n'en existe pas. Entre Frédéric et Bonaparte, Voltaire et Byron, Vanloo et Géricault, Boucher et Charlet, il y a un abîme: la révolution28.*

26 George Santayana, Three Philosophical Poets, Lucretius, Dante, Goethe, Harvard University Press, 1910, Doubleday Anchor Books, 1953, p. 175.
27.
28 Victor Hugo's manuscript is dated 1825-1826, published in 1834, Littérature et philosophie mêlées (p. 166).

From our century to its predecessor one cannot discover any transition. As indeed there is none. Between Frederic and Bonaparte, Voltaire and Byron, Vanloo and Géricault, Boucher et Charlet, there is an abyss: the revolution.

Except Klein following Comte following the physicist Biot writing as early as 1802, historians of science have generally been reluctant to claim any influence on science of the French revolution, except a social one, with the institutionalisation of science though teaching. Better read Hugo, who wrote in 1824 a second preface to his *Odes et Ballades* of two years before, thus justifying the expression "romantique". His verses were to compose a lyrical history of the period beginning with the revolution, a period which "has not left anything unmoved in the human's heart"[29] , which is another way of glorifying the advent of a new century The new literature, *le romantisme*, was to be true in the sense it was modern, that is in direct relation or adequacy to the contemporary times

La littérature actuelle peut être en partie le résultat de la révolution, sans en être l'expression. La société, telle que l'avait faite la révolution, a eu sa littérature, hideuse et inepte comme elle. Cette littérature et cette société sont mortes ensemble et ne revivront plus. L'ordre renaît de toutes parts dans les institutions ; il renaît également dans les lettres. La religion consacre la liberté, nous avons des citoyens. La foi épure l'imagination, nous avons des poètes. La vérité revient partout, dans les mœurs, dans les lois, dans les arts. La littérature nouvelle est vraie. Et qu'importe qu'elle soit le résultat de la révolution ? La moisson est-elle moins belle parce qu'elle a mûri sur le volcan ?

To-day's literature

An adequacy to modern times required the disappearance of older ways of thought. Argand, in the slow evolution of his work, realised that for the computations on directed lines he had to forget the century long tradition of proportion theory. For the explanation he provided with geometrical images to the numbers which had been called imaginary numbers by Descartes in 1637, as they could be thought but not seen, Argand in his answer to objections, had to get rid of the kind of reasoning with ratios, so well integrated into philosophical habits from Aristotle onwards under the name of analogy.

Quant au premier point, il est et sera peut-être toujours sujet à discussion, tant qu'on cherchera à établir la signification de $\sqrt{-1}$ *par des conséquences d'analogie avec les notions reçues sur les quantités positives et négatives et sur leur proportion entre elles. On a discuté et l'on duscute encore sur les quantités néagtives ; à plus forte raison poura-t-on élever des objections contre les nouvelles notions des imaginaires.*

29 Victor Hugo, Œuvres poétiques, P. Albouy (éd.), préface (1824) to Odes et Ballades, Paris, La Pléiade, I, Gallimard, 1964, p. 273.

Mais il n'y aura plus de difficulté si, comme l'a fait M. Français (Annales, t. IV, p. 62), on établit, comme définition, ce qu'on entend par le rapport de grandeur et de position entre deux lignes[30]*.*

Argand is a mathematician; generally, he does not explain in terms other than mathematical ones. But here he is confronted with a major problem. The relation between two directed lines, or between two vectors as we could say as well, has to be a quantitative relation. Precisely the model for quantitative relations, as so much said by Aristotle, was proportion theory or theory of ratios, having a mathematical status since Euclid's book V. For directed lines a new kind of relation, had to be organised, and we are very close to the question of a function. Argand claimed he has made workable this new kind of relation, and we have seen how he proceeded. Is it still possible to use the terms proportion ? Has a mathematician the right to extend a definition, i.e. to generalise ? What is the right to create ?

La seule question qui reste donc de savoir s'il est bien permis de désigner cette relation par les mots rapport ou proportion, qui ont déjà, dans l'Analyse, une acception déterminée et immuable. Or cela est effectivement permis, puisque, dans la nouvelle acception, on ne fait qu'ajouter à l'ancienne, sans d'ailleurs y rien changer. On généralise celle-ci de manière que l'acception commune est, pour ainsi dire, un cas particulier de la nouvelle. Il ne s'agit pas de chercher ici une démonstration

The main technical difficulty, which is hidden by Argand's rhetoric as it was only the problem of a change by extension, was that the generalisation did not preserve some usual and computational properties of the old definition of proportion, and particularly concerning order properties. We know that imaginary numbers compose a field, but not an ordered field, and for two complex numbers, there is nothing like z>z'. The new world was not the same as the old one, even if the new one proceeded form the old. This is by excellence the romantic problem.

Piere Leroux, then a disciple of Saint-Simon, as he defended the romantic style in 1829 on the occasion of the publication of Victor Hugo's *Orientales*, chose to discuss the role of symbols in the new poetry, with the specific work on images, in analogy with Argand who discussed the algebraic properties replaced by geometric properties. Leroux went on further with the possibility to extend an infinite variety of meanings to images. He then used a comparison with mathematics, a number being understood as a proportion.

Il faut qu'on nous accorde que toutes poésie vit de métaphore, et que le poète est un artiste qui saisit des rapports de tout genre par toutes les puissances de son âme, et qui leur substitue des rapports identiques sous forme d'images, de même que le géomètre substitue au contraire des termes purement abstraits, des lettres qui ne représentent rien de déterminé, aux nombres, aux lignes, aux surfaces, aux solides, à tous les corps de la nature, et à tous les phénomènes[31]

He added in a note

30 R. Argand, p. 112.
31 Pierre Leroux, Du style symbolique, Le Globe, 8 avril 1829, quoted by Claude Milet, in L'esthétique romantique, Paris, Agora, 1994, p. 193.

L'identité est le principe de toutes ces substitutions. En géométrie, comme en poésie, comme en tout, la comparaison est la grande route de l'esprit humain. Le poète rend l'abstrait par le sensible, le géomètre le sensible par l'abstrait ; mais tous deux ne font que substituer des rapports à d'autres rapports, ou plutôt reproduire sous des termes différents des rapports identiques. Seulement ils ne travaillent pas sur les mêmes matériaux.

It is not only the poet and the geometer who were not working on the same material, but the geometer himself by extending the meaning of what proportions were about. In a poem dated 1834, but written in 1854, Hugo was far simpler in explaining his oblivion of Aristotle.

Et sur l'Académie, aïeule et douairière
Cachant sous ses jupons les tropes effarés,
Et sur les bataillons d'alexandrins carrés,
Je fis souffler un vent révolutionnaire.
Je mis un bonnet rouge au vieux dictionnaire.
Plus de mot sénateur ! plus de mot roturier !
Je fis une tempête au fond de l'encrier,
Et je mêlai, parmi les ombres débordées,
Au peuple noir des mots, l'essaim blanc des idées
Et je dis: Pas de mot où l'Idée au vol pur
Ne puisse se poser, tou humide d'azur !
Discours affreux ! - Syllepse, hypallage, litote,
Frémirent ; je montai sur la borne Aristote,
Et déclarai les mots égaux, libres, majeurs[32].

But Aristotle was quoted by Fourier, in his first published paper in 1798, presented as the real father of mechanics: it was a rewriting of history of mechanics, when form Galileo, Aristotle had been seen as an enemy to progress, and perhaps the face of anti-science. Such trips in the far past are similar to the voyages organised in order to scientifically conquer the Earth.

A modern voyage in the far past, and the modern ways of a scientific voyage

Bonaparte's trip to Egypt in 1798, accompanied by so many young fellows from the Ecole polytechnique and a group of mature scientists feeling young enough to follow so young a general, launched many new habits in the European scientific community. First of all the habit for scientists to be close to power in order to be able to build a new world; and also engineers being considered as scientists because they had been trained in the sciences, and then able to propose, or to dream, of a new organisation for society. Egypt became a laboratory, to the point Egyptians were observed as a

32 Victo Hugo, Les Contemplations, I, 7, réponse à un acte d'accusation

zoologist decided to observe animals. The cold scientific look seemed justified as progress was to be provided, and so science could provide for its proponent an adventure, a *vita activa*, and no longer a *vita contemplativa* earlier reserved for minds having leisure. To work, for a scientist, had now a social meaning.

Almost simultaneously, there was the discovery of Antique Egypt, a possible play with fiction and history, with another world. And positivism brought the validation of such scholar studies with the idea that the study of this very old Egypt could help fashion a future for the new Egypt. An Empire leaving so large monuments had to be an Empire resting on reason and good government, a sort of an antique Egypt of the Enlightenment, when religion was a disguise for science in favour of the humblest minds. Some French scientists, by imagining Egyptian temples as scientific laboratories, found their professional vocation and they prepared the road for Archaeology, passing over the tradition of Antiquarians.

Illustration

We thus analyse a collective mood, if we also see at work a strong mental organisation, trying to cope with the power of imagination by using positive rules for establishing history and geography. Regretting to have missed the departure in Toulon to Alexandria, Alexander von Humboldt during his long trip to America, underwent the same kind of thought, which seems to have been matured during his stay in the Canary Islands: he tried to establish as positive a geography as possible (and particularly tried to check which new agriculture could be developed) and for this had to avoid forgetting the political and economical achievements of past civilisation and at the same time made a new evaluation of the Spanish colonisation bringing progress.

Conclusion

Back to positivism and romanticism, Humboldt, himself represented (images), mathematised world, history of voyages, science and nature (mountains), Pour l'honneur de l'esprit humain

Der Sänger geht auf rauhen Pfaden,

Zerreisst in Dornen sein Gewand ...

Einseam und pfadlos fliesst in Klagen

Jetz über sein ermattet Herz[33]

The singer walks to hard paths, and his garments are torn by thorns...When alone and pathless from his tired heart can flow his plaints.

33 Novalis, Der Sänger,