THEMATIC SKETCH[1]

by Alexander Grothendieck

1. FUNCTIONAL ANALYSIS

My works in functional analysis (from 1949 to 1953) have been, essentially, about the theory of topological vector spaces. Among the numerous notions introduced (topological tensor products and nuclear applications [G1], Fredholm applications [G5], integral applications and its different variants ([G1], [G4]), applications of summable p^{th} power, nuclear spaces, (DF)-spaces [G3]), the notion of nuclear space had the best fate and it has been the object of numerous seminars and publications. In particular, a volume of the treatise of I. Gelfand about the "Generalized Functions" [GV] is consecrated to nuclear spaces. One of the reasons of this success derives, without doubt, from probability theory, since, among all the topological vector spaces, in the nuclear spaces measure theory assumes its simplest form (Minlos theorem).

The results of [G4], the deepest, seem not having been assimilated by the further developments, but they seem a source of inspiration in some very recent and delicate works about the inequalities related to Banach spaces theory, such as the works of Pelczynsky.

We remember the very fine results of [G4] and [G6] about the properties of decreasing of the suites of proper values of certain operators in Hilbert spaces and in general Banach spaces.

2. HOMOLOGICAL ALGEBRA ([G7], [G8], [G9], [G13])

After 1955, in the role of the "usager" and not in the role of the specialist, I have been conducted to continually enlarge and improve the language of homological algebra, because of the needs of algebraic geometry (duality theory, theories of Riemann-Roch type, ℓ-adic cohomology, cohomology of De Rham type, crystalline cohomology).

We had two principal directions for these reflections:

a) ***the development of a non-commutative homological algebra*** (systematized in the thesis of Jean Giraud [Gi2]);

b) ***theory of derived categories***, developed systematically by J.-L. Verdier [V], and exposed by R. Hartshorne [RD], L. Illusie [I] and in [SGA 4, Exp. XVIII].

These two currents of reflections are far from being completed and, without doubt, they are called to be unified to homotopical algebra (cf. the work of Quillen [Q] for a preliminary sketch), and to the theory of n-categories, particularly useful in the geometric interpretation of cohomological invariants ([Gi2] and [R]).

3. ALGEBRAIC GEOMETRY

In this topic my influence has been the most direct and deep, because, since 1959, the mostly part of my works are about this subject.

a) ***Foundational works.*** The problem was to find a frame enough great to have a common fundament for algebraic geometry (developed by A. Weil, O. Zariski, C. Chevalley and J. - P. Serre over a general base field) and arithmetic. This is realized in EGA I, II, and some parts of EGA III and IV, with the introduction and the study of the notion of "scheme". Some generalizations have been developed: the formal schemes (EGA I, par. 10); the theory of algebraic spaces of Michael Artin [K]; the "algebraic stacks" or "algebraic multiplicities" of Deligne and Mumford [DM]; the "relative schemes" [H] (expecting the "formal multiplicities" and the "relative algebraic varieties" over general ringed topos etc.). These generalizations show us the conceptual importance, in the language of scheme, of the notion of localization, i.e. the notion "topos" (cf. par. 7). The foundations developed in [EGA] and [SGA] are, today, the "pain quotidien" of the mostly part of algebraic geometers and their importance has been stressed by many mathematicians: O. Zariski, J.-P. Serre, D. Mumford, Y. Manin, H. Hironaka, F. Chafarevich.

b) ***Local theory of schemes and morphisms of schemes***. In this context we have the developments of commutative algebra (cf. par. 4) and the detailed study of notions as "lisse" morphisms, étale morphisms, net[2] morphisms, plat morphisms etc. The four volumes of [EGA, Chapter IV] are consecrated to these developments, which inspired analogue developments in the theory of analytic spaces and rigid-analytic spaces.

---

[2] Grothendieck, since the end of 60s, began to use the term "net" as synonymous of "unramified".

c) *Construction of schemes.* Among the techniques developed and by some unpublished seminars [FGA], we developed a descente theory [SGA 1, Exp. V and VI], a theory of quotient schemes, Hilbert schemes and Picard schemes, and a theory of formal moduli. We obtained an existence theorem of sheaves of algebraic moduli associated to formal moduli [EGA III, par. 5]. The new point of view is, essentially, the construction of a scheme starting by a functor that represents it. In this approach, I didn't reach a flexible characterization of representable functors by a relative scheme (locally of finite type over a Noetherian scheme). Michael Artin resolved definitely this problem, substituting the notion of scheme with the more general and more stable notion of "algebraic space" [K]. Among other researches in this direction, inspired by my papers, we have the work of J. Murre about Picard Schemes over a field [Mu] , the work of D. Mumford and M. Raynaud about Picard schemes over general bases [Ra], and finally the work of Mumford and Seshadri about the passage to quotient.

d) *Fundamental Group.* ([SGA 1], [SGA 2], [SGA 7, Exp 1 e 2], [FGA, n. 182], [G17]). From an algebraic-geometric point of view, after the definition of fundamental group of a general variety, everything had to be done: from descent theorems (including some formal theorems à la Van Kampen) until the calculus of fundamental group in the first not-trivial case (an algebraic curve without some points). We add the theorem of degeneration and finite presentation of fundamental group of an algebraic variety over a algebraically closed field. These results are in [SGA 1], obtained using some classical results over the complex field (obtained through transcendent methods) and a panoply of tools created for our aims (descente theory, étale morphisms, existence theorems for coherent sheaves). Other more special results are: theorems of Lefschetz type [SGA 2]; action of local monodromy groups over the fundamental group of a fiber [SGA 7, Exp. I]; calculus of some local fundamental groups [G17], via the fundamental groups of some formal schemes. These results have been used in many works and were the inspiration for the thesis of M. me Raynaud [R].

e) *Local and global Lefschetz theorems* for the Picard groups, for the fundamental group, for the coherent and étale cohomology. We have obtained a comparison between the invariants (cohomological and homotopical) of an algebraic variety and of a hyperplane section. The starting ideas are in [SGA 2]; the definitive theorems (in terms of necessary and sufficient conditions) are in the thesis of M.me Raynaud [R].

f) *Intersection theory and Riemann-Roch theorem (for general schemes).* The principal new idea is that there is almost an identity between the Chow group of classes of cycles over a variety X and a certain group of "classes of coherent sheaves" (modulo torsion), that is K(X). In a modest context this is exposed in [G10] and [G11]. In a more ambitious context it is exposed in [SGA 6]. In the same spirit cf. [SC]. Since then, the idea of reformulating a theorem of a variety (due to F. Hirzebruch) in a more general theorem about a morphism between varieties had a great success and not only in algebraic geometry but also in algebraic topology and differential topology (starting from the "Riemann-Roch differential formula" developed by M. F. Atiyah and F. Hirzebruch [AH], under the inspiration of my relative formulation of Riemann-Roch theorem [G10]).

g) ***Abelian schemes.*** In classical terms, these are the families of abelian varieties, parametrized by some scheme. The most important theorems are the "theorem of semi-stable reduction" [SGA 7, exp. IX] and its consequences and variants; the theorem of existence of morphisms of abelian schemes in [G12] and its variants (generalized by Deligne in a theorem about the cohomology of Hodge-De Rham relative of a family of non-singular complex projective varieties); and a theory of infinitesimal deformations of abelian schemes (unpublished over a general base) in terms of deformation of a Hodge filtration over the cohomology group H^1 relative of De Rham (seen as a crystalline cohomology).

h) ***Monodromy groups.*** My principal contributions are contained in the first volume of [SGA 7] about the fundamental properties of the action of local monodromy group over the cohomology, as over the fundamental group of a fiber. The principal application is the semi-stable reduction theorem of abelian schemes.

4. ALGEBRA ([EGA], [SGA][CS])

As said about homological algebra, algebra has been for me a tool to develop and not an aim. My contributions to algebra consist in a purely algebraic part (which, once extended in a theory of higher K groups, will become part of homological and homotopical algebra).

Also, some of my results in algebraic geometry can be specialized in some results of pure algebra, such as the isomorphism between K(A[t]) and K(A), where A is a ring.

I indicate some of my contributions.

a) ***Categorical algebra.*** Since 1953 I felt myself obliged, for my needs (in algebraic geometry), to develop a categorical panoply ever insufficient. The mostly part of my results are developed in [EGA] and [SGA] (especially in the first two tomes of [SGA4]). We can't describe these results, now entered in the current use. We remember only the use of the concept of the "universes" (in order to surpass some logical difficulties present in the intensive use of categories) and the concept of "descente" (developed systematically by Giraud [Gi1]).

b) ***Commutative algebra.*** In the language of schemes, commutative algebra can be considered essentially the local study of schemes. Chapter IV of [EGA]contains numerous new results of commutative algebra, especially the notion of "excellent ring" and its properties of permanence (whose absence was the most evident lacuna in the work of M. Nagata on local rings).

5. GROUP THEORY

a) *Algebraic Groups* ([SGA 3], [SC]) This subject is a mix of algebraic geometry and group theory. [SGA 3] deals with general schemes and the algebraic geometry part is considerably larger of group theory. However, through scheme theory, we have obtained some new results, even in the case of groups defined over a base field, the most interesting being contained in [SGA 3, Exp. XIV]. My principal contribution, developing the works of Borel and Chevalley in the context of classical algebraic geometry, has been the systematic application of scheme theory to algebraic groups and to group-schemes

b) *Lie Algebras.* As sub-product of my researches about the algebraic groups in characteristic p > 0, I have found some delicate results about sub-algebras of Borel and Cartan of some Lie algebras, especially on imperfect base-fields [SGA 6, Exp. XIII and Exp. XIV]

c) *Brauer Group.* My contributions derive, essentially, by application of étale cohomology to the theory of Brauer groups.[CS, *Le Groupe de Brauer I-II-III*]

d) *Discrete Groups*. In [CS, Exp VIII], I developed a purely algebraic theory of Chern classes of representations of a discrete group over a general base field (or even a base ring), with some applications of arithmetic nature about the order of Chern classes of complex representations. This theory can be considered as a particular case of a theory of Chern classes of linear representations of general group-schemes, and more generally of a theory of ℓ-adic Chern classes of vector fibred over a general ringed topos. In [G14] I have established, up some things, that for a discrete group G, the theory of linear representations of G (over a general base ring) depends only by the profinite completion of G.

e) *Formal Groups* ([SGA 7], [G12], [G15], [G16])**.** This topic is a mix of group theory, Lie groups, algebraic geometry, arithmetic and (in a form very similar to Barsotti – Tate groups) local systems theory. Scheme theory gives a great simplification in this area, as we find in the classic exposition of Manin of Dieudonné theory [M1]. My principal contribution, together with this conceptual simplification, has been the development of a Dieudonné theory for Barsotti – Tate groups over general base schemes with residual characteristic p > 0, in terms of "Dieudonné crystals" associated to such groups. A sketch of this theory has been exposed at the ICM of Nice [G15] and in Montreal during the summer of 1970 [G16], and during my courses at the College de France in 1970/71 and 1971/72. A part of these ideas have been developed in the thesis of Messing [Me], and the technical needs of this theory have been the origin of the development of the theory of deformation of commutative group-schemes of Illusie [I], where he proved some conjectures suggested by the "crystalline Dieudonné theory". The relations between abelian schemes and Barsotti –Tate groups have been explored in [SGA 7, exp IX] and [G12].

6. ANALYTIC GEOMETRY ([SHC], [G18], [G19])

My influence in analytic geometry is due not so much to new results ([SHC], [G18], [G19]), but, rather, to the points of view inspired by algebraic geometry that I introduced, and to numerous

suggestions I have given. One of the oldest is the finiteness theorem of Hans Grauert for the proper morphisms of analytic spaces bringing to his recent generalization in a theorem that can be enounced in terms of derived categories (I have insisted for much time about this formulation proved independently by R. Kiehl [K] and by O.Forster and K.Knorr [FK]).

Other finiteness theorems (Frish and Siu) for the higher direct images of a coherent sheaf for an open immersion, using the depth of the sheaf in the points of the complement set, inspired by analogue theorems in algebraic geometry [SGA 2].

I gave analogues remarks for the theorems about cohomology with compact support of coherent algebraic sheaves, completed through a theorem of existence, and their interpretation in terms of theorems of Lefschetz type for "coherent cohomology" (the algebraic version is a part of the thesis of Michèle Raynaud [R], while the analytic version is due to Trautman [T]).

Speaking about the great research themes rather than particular technical results, I think that the themes nominated and following have been directly inspired or influenced by the ideas I developed in algebraic geometry:

a) *Construction techniques of analytic spaces* finishing even to some "global modular" spaces, as the modular spaces of Picard, for some compact analytic spaces as in [SHC] (the general case has not yet treated), which have some "local" modular spaces of deformation of a given complex analytic structure, or to the model of formal geometry ("theorem of existence of formal modules) [FGA, n. 195]. In some cases, the claims obtained in algebraic geometry are directly applicable (cf. [H]); in other cases new difficulties come out, not all overcame at this time. (cf. the definitive work of Douady [D]);

b) *Theorems of local and global duality* for the coherent sheaves developed by J.L. Verdier, J.P. Ramis, G.Ruget (([RR], [RRV]), inspired by the same theory I developed for schemes [RD].

c) *Formulations of theorems of Riemann-Roch type* for compact analytic varieties or for proper morphisms of such varieties [SGA 6, Exp. 0]. The essential problems remain open.

d) *Complex-analytic De Rham theorems* ([G19]) and complex crystalline cohomology. Some results and some ideas, developed about this subject by myself, have been developed in many theoretical developments, such as the generalization of Hodge theory by P. Deligne. [Dl].

e) *Rigid analytic spaces.* Taking inspiration by the example of "Tate elliptic curve" and by the needs of formal geometry over a complete ring of discrete valuation, I arrived to the partial formulation of notion of "rigid-analytic variety" over a field of complete valuation, which played its role in the first systematic study of this topic by J. Tate. The "crystals" introduced on algebraic varieties defined over a field of characteristic $p > 0$ can be interpreted in some cases in terms of vector fibred with integrable connection over some types of rigid analytic spaces over a field of characteristic 0. This seems to indicate the existence of deep relations between crystalline cohomology in characteristic $p > 0$ and cohomology of local systems over rigid analytic varieties in characteristic 0.

7. TOPOLOGY ([SGA4], [G8])

Until now, it is, above all, the K-invariants of topological spaces that I introduced during my researches about the Riemann-Roch theorem in algebraic geometry, that has known the most brilliant success; the K- invariants have been the starting point of many researches in homotopical topology and differential topology.

The numerous constructions that I have introduced in my algebraic proof of Riemann-Roch (such as the operations λ_i and their links with the operations of symmetric group) have become current practice – not only in algebraic geometry and algebra, but also in topology and number theory (cf. the works of M. Atiyah, H. Bass, D. Quillen, J. Milnor, J. Tate, M. Karoubi, Shi, etc…).

Even more fundamental is the enlargement of general topology, in the spirit of sheaf theory (developed initially by Jean Leray) contained in the point of view of topos theory [SGA4]. I have introduced the topos since 1958, guided by the need to define a ℓ-adic cohomology of algebraic varieties (and more generally of schemes), which is the tool for the cohomological interpretation of the celebrated Weil conjectures.

Effectively, the traditional notion of topological space is insufficient to treat the case of algebraic varieties over fields different by the complex field. The topology proposed by Zariski doesn't give us reasonable "discrete" cohomological invariants. Today the point of view of topos and the corresponding notion of "localization" are part of the daily practice of algebraic geometers and begins to enter in the theory of categories and mathematical logic (with the proof of B. Lawvere [L] of the theorem of Cohen about the independence of the continuum axiom, using a suitable adaptation of notion of topos).

It doesn't happen the same in topology and differential and analytic geometry, though some first steps in this direction (such as the attempt of the proof by Sullivan of of the Adams conjecture in K-theory, by reduction to a property of Frobenius operation over algebraic varieties in characteristic $p > 0$).

8. COHOMOLOGICAL THEORIES

a) **COHERENT COHOMOLOGY.** We obtained finiteness theorems; comparison theorems with the formal cohomology [EGA III], duality theorems and theorems about residues [RD].

b) **ℓ-ADIC COHOMOLOGY.** In [SGA4] we defined the étale cohomology, obtaining comparison theorems, finiteness theorems, theorems about the cohomological dimension, the weak Lefschetz theorem. In [SGA5] we obtained duality theorems, the Lefschetz formulas, the formulas of Euler-Poincare, and application of étale cohomology to L-functions [SGA 5].

c) **DE RHAM COHOMOLOGY** ([G19], [G20])

d) **CRYSTALLINE COHOMOLOGY.** Some ideas are exposed in [CS, *Crystals and the De Rham Cohomology of Schemes*], then reprised and systematized in the thesis of Pierre Berthelot [B], and in the work of Luc Illusie and Pierre Berthelot about the crystalline Chern classes [BI].

9. ARITHMETIC ([SGA 5, EXP. XVI], [CS, EXP. III])

My principal contribution has been (with the collaboration of Michael Artin) the proof of rationality of L-functions associated to general ℓ-adic sheaves over the algebraic varieties over finite fields – the particular case being the L-functions associated to the characters of finite groups acting over these varieties.

Starting from Weil conjectures we arrived to express the L-functions in terms o alternate products of characteristic polynomials of Frobenius acting on the "cohomology with proper support" of the variety.

Much more than of a simple question of rationality, these results open the way to a systematic cohomological approach of subtle arithmetical invariants as the functions Z and L of varieties, and the interpretation in arithmetical terms of duality theorems (now proved) and of Lefschetz theorems for the hyperplanes sections (yet not proved in characteristic p > 0). This is an immense topic of study, which for the nature of the things should be centered, sooner or later, on the notion of "motive" (common denominator of different types of cohomology that we attach to an algebraic variety), but that, probably, will never explored until the end – the hour of this type of investigations being already passed (even if the people aware of this are rare).

10. MOTIVIC DIVAGATIONS ([M2], [De])

Here we enter in a mathematical dream, trying to image what "could be", being insensately optimistic using the partial knowledge we have about the arithmetic properties of cohomology of algebraic varieties.

The notion of "motive" can be defined rigorously with the "moyen du bord" ([M2] and [De]), but if we want to go further and define some "natural" properties we have to face some conjectures today unproved [G21], such as Weil and Tate conjectures and others that the notion of motive suggests irresistibly.

These properties have been the object of numerous (private and public) conversations, but they were never published, because it is not in use in mathematics (contrarily to physics) publishing a coherent dream, and follow it till the end in its different elements.

It is evident, for everyone expert of cohomology of algebraic varieties, that "there is something", that "the motives exist".

I had the idea of writing, contrarily to use, an entirely conjectural book about motives – a sort of "mathematical science-fiction".

I was occupied by tasks more urgent than the tasks of mathematician and I strongly doubt that such a book will be written, and that we will arrive (even conjecturally) to have a global idea, precise and vast, of the formalism of motives.

Before it will happen, under the weight of the events, people will understand that speculative science can't save humanity and that there are more urgent tasks that "mettre sur pied" the most beautiful theory of world – conjectural or not.

REFERENCES

[G1] ***Produits Tensoriels Topologiques et Espaces Nucléaires***, Mem. of AMS **16** (1955)

[G2] ***Résumé de la Théorie Métrique des Produits Tensoriels Topologiques et Espaces Nucléaires***, Annales de l'Institut Fourier **4** (1952), 73 – 112

[G3] ***Sur les espaces (F) et (DF)***, Summa Math. Brasil. **3** (1954), 57 – 123

[G4] ***Résumé de la Théorie Métrique des Produits Tensoriels Topologiques,*** Bull. Sao Paulo **8** (1954), 1 – 79

[G5] ***La Théorie de Fredholm***, Bull SMF **84** (1956), 319 – 384

[G6] ***The Trace of Certain Operators***, Studia Mathematica **20** (1961), 141 –143

[G7] ***A General Theory of Fiber Spaces with Structure Sheaf***, Preprint (1955)

[G8] ***Théorèmes de Finitude pour la Cohomologie des Faisceaux***, Bull. SMF **84** (1956), 1 – 7

[G9] ***Sur Quelques Points d'Algèbre Homologique***, Tôhoku Math. Journal **9** (1957), 119 – 221

[G10] A. BOREL – J.P. SERRE, ***Le Théorème de Riemann-Roch (d'après Grothendieck)***, Bull. SMF **88** (1958), 97 – 136

[G11] ***La Théorie des Classes de Chern***, Bull SMF **88** (1958), 137 – 154

[G12] ***Un théorème sur les Homomorphismes des Schémas Abéliens***, Inv. Math **2** (1966), 59 – 78

[G13] ***Catégories Cofibrées Additives et Complexe Cotangent Relatif,*** Springer LNM **79** (1968)

[G14] ***Représentations Linéaires et Compactification Profinie des Groupes Discrets***, Manuscripta Math. **2** (1970), 375 – 396

[G15] ***Groupes de Barsotti-Tate et Cristaux***, Actes of ICM Nice (1970), Tome **1**, 431 – 436

[G16] ***Groupes de Barsotti-Tate et Cristaux de Dieudonné***, Les Presses de l'Université de Montréal (1974)

[G17] (WITH J. MURRE), ***The Tame Fundamental Group…,*** Springer LNM **208** (1971)

[G18] ***Sur la Classification des Fibres Holomorphes sur la Sphère de Riemann,*** Amer. J. Math. **79** (1957), 121 – 138

[G19] ***On the De Rham Cohomology of Algebraic Varieties***, Publ. Math. IHES **29** (1966), 95 – 103

[G20] ***Hodge's General Conjecture is False for Trivial Reasons***, Topology **8** (1968), 299 – 303

[G21] ***Standard Conjectures on Algebraic Cycles***, Bombay Colloquium (1968)

[SC] ***Seminar Chevalley 1958***, Exp. 4 and Exp. 5.

[SHC] ***Seminar Henri Cartan 13*** (1960/61), from Exp. 7 to Exp. 17.

[FGA] A. GROTHENDIECK, ***Fondements de la Géométrie Algébrique***, Secrétariat Mathématique Institut Henri Poincaré[3].

[EGA] A. GROTHENDIECK – J. DIEUDONNÉ, ***Eléments de Géométrie Algébrique***, Publ. Math. de l'IHES (1960 – 1967)

[SGA] A. GROTHENDIECK AND COLLABORATORS, ***Séminaires de Géométrie Algébrique du Bois-Marie*** (1960 – 1969)

SGA 1 – ***Revêtements Etales et Groupe Fondamental*** (1960/61), Springer-Verlag (1970)

SGA 2 – ***Cohomologie locale et Théorèmes de Lefschetz Locaux et Globaux*** (1962), North-Holland (1968)

SGA 3 – ***Schémas en Groupes*** (1962/64), Springer-Verlag (1970)

SGA 4 – ***Théorie des Topos et Cohomologie Etale des Schémas*** (1963/64), Springer-Verlag (1972/73)

SGA 5 – ***Cohomologie ℓ-adique et Fonctions L*** (1965/66), Springer-Verlag (1977)

SGA 6 – ***Théorie des Intersections et Théorème de Riemann-Roch*** (1966/67), Springer-Verlag (1971)

SGA 7 – ***Groupes de Monodromie en Géométrie Algébrique*** (1967/69), Springer-Verlag (1972/73)

[CS] ***Dix Exposes sur la Cohomologie des Schémas***, North-Holland (1968)

---

[3] This text contains Grothendieck' s expositions at the Bourbaki Seminar from1957 to 1962, with some "commentaires".

WORKS INSPIRED BY GROTHENDIECK

[AH] M. ATIYAH − F. HIRZERBRUCH, *Riemann-Roch Theorem for Differentiable Manifolds*, Bull. AMS **65** (1959), 276 − 281

[B] P. BERTHELOT, *Cohomologie Cristalline des Schémas de Caractéristique p > 0,* Springer LNM **407** (1974)

[BI] P. BERTHELOT − L.ILLUSIE, *Classes de Chern en Cohomologie Cristalline*, C.R. Acad. Sci. Paris **270,** 1695 − 1697 ; 1750 − 1752.

[D] A. DOUADY, *Le Probleme des Modules pour les Sous-Espaces Analytiques Compact d'un Espace Analytique Donné*, Ann. Inst. Fourier **16** (1966), 1 − 95

[De] M. DEMAZURE, *Motifs de Variétés Algébriques*, Sem. Bourbaki **365** (November 1969)

[Dl] P. DELIGNE, *Théorie de Hodge* **I** (Proceedings of the ICM, Nice 1970) ; **II** (Publ. Math. IHES **40** (1971), 5 − 57) ; **III** (Publ. Math. IHES **44** (1974), 5 − 77)

[DM] P. DELIGNE − D. MUMFORD, *The Irreducibility of the Space of Curves of Given Genus*, Publ. IHES **39** (1969), 75 − 109

[FK] O. FORSTER-K. KNORR, *Relativ Analytische Raume und die Kaharenz von Bildgarben,* Inv. Math **16** (1972), 113 − 160

[Gi1] J. GIRAUD, *Méthode de la Descente*, Mem. de la SMF **2** (1964), 1 − 150

[Gi2] J. GIRAUD, *Cohomologie non Abélienne,* Grundlehren Math. Wiss. **179** Springer–Verlag (1972)

[GV] I. GELFAND − N. VILENKIN, *Les Distributions (Tome 4)*, DUNOD (1968)

[H] M. HAKIM, *Topos Annelés et Schémas Relatifs*, Ergebnisse Math. Gr. **64**, Springer–Verlag (1972)

[I] L. ILLUSIE, *Complexe Cotangent et Déformations I − II,* Springer LNM **239** et **283** (1971)

[K] D. KNUTSON, *Algebraic Spaces*, Springer LNM **203** (1971)

[Ki] R. KIEHL, *Relativ Analytische Raume*, Inv, Math. **16** (1972), 40 − 112

[L] F. LAWVERE, *Toposes, Algebraic Geometry and Logic*, Springer LNM **274** (1972)

[M1] YURI MANIN, *Théorie des Groupes Formels Commutatifs sur des Corps de Caractéristique Finie*, Uspekhi Mat. Nauk **18** (1963), 3 − 90

[M2] YURI MANIN, *Correspondances, Motifs et Transformations Monoidales*, Mat. Sbornik **77** (1968), 475 − 507

[Me] W. MESSING, *Crystals Associated to Barsotti-Tate Groups (With applications to Abelian Schemes)*, Springer LNM **264** (1972)

[Mu] J. MURRE, *On Contravariant Functors from Category of Preschemes over a Field into the Category of Abelian Groups*, Publ. Math. IHES **23** (1964), 5 – 43

[Q] D. QUILLEN, *Homotopical Algebra*, Springer LNM **43** (1967)

[R] M.ME RAYNAUD, *Théorèmes de Lefschetz en Cohomologie Cohérente et en Cohomologie Etale*, Mem. de la SMF. **41** (1976)

[RR] J.-P. RAMIS – G. RUGET, *Complexe Dualisant et Théorèmes de Dualité in Géométrie Analytique Complexe*, Publ. Math. IHES **38** (1970), 77 – 91

[RRV] J.P. RAMIS – G. RUGET – J.L. VERDIER, *Dualité Relative en Géométrie Analytique Complexe*, Inv. Math. **13** (1971), 261 – 283

[Ra] M. RAYNAUD, *Spécialisation du Foncteur de Picard,* Publ. IHES **38** (1970), 27 – 76

[RD] R. HARTSHORNE, *Residues and Duality*, Springer LNM **20** (1966)

[T] G. TRAUTMAN, *Abgeschlossenheit von Corandmoduln und Fortsetzbarkeiy Koharenter Analytischer Garben*, Inv. Math. **5**, 216 – 230

[V] J.-L. VERDIER, *Des Catégories Dérivées des Catégories Abéliennes*, SMF Astérisque **239** (1996)