Zeitschrift: L'Enseignement Mathématique
Herausgeber: Commission Internationale de l'Enseignement Mathématique
Band: 14 (1968)
Heft: 1: L'ENSEIGNEMENT MATHÉMATIQUE

Artikel: FLATNESS AND PRIVILEGE
Autor: Douady, A.
Kapitel: §2. Analytic pull-back
DOI: https://doi.org/10.5169/seals-42343

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Definition 3 : Let X', X be analytic spaces, Y a closed analytic subspace of X defined by J, and $f = (f_0, f^1) : X' \to X$ a morphism.

The inverse image of Y by f, $f^{-1}(Y)$, is the analytic subspace Y' of X' defined by the ideal $J' = f^1(J)\,\mathcal{O}_{X'}$.

The inverse image of a simple point x in X is called the f-fiber over x, and is denoted by $f^{-1}(x)$ or $X'(x)$.

Proposition 1 : If $f = (f_0, f^1) : X' \to X$ is a morphism of analytic spaces, and Y is a subspace of X, then $f^{-1}(Y) \simeq Y \underset{X}{\times} X'$.

Proof : Let T be any analytic space, and $g : T \to X'$ a morphism. Then g can be considered as a morphism from T to $f^{-1}(Y)$ if and only if $f \circ g$ can be considered as a morphism from T to Y. Thus $f^{-1}(Y)$ and $X' \underset{X}{\times} X$ are solutions of the same universal problem.

§ 2. *Analytic pull-back*

In the following we want to generalize the notion of inverse image of a subspace.

We shall first recall the basic properties of the tensor product $E \underset{A}{\otimes} F$, where A is a commutative ring and E, F are two A-modules.

(1°) $E \otimes A^n = E^n \ (n \in N)$

(2°) If the sequence of A-modules $F' \to F \to F'' \to 0$ is exact, then also the sequence $E \otimes F' \to E \otimes F \to E \otimes F'' \to 0$ is exact. (Right exactness of the tensor product)

(3°) If $(F_i)_{i \in I}$; $f_{ij} : F_j \to F_i$ is an inductive system, then

$$E \otimes \varinjlim F_i = \varinjlim (E \otimes F_i).$$

On the other hand these properties characterize completely the functor $\otimes$.

Definition 1 : Let $f = (f_0\ f^1) : X' \to X$ be a morphism of analytic spaces, and $\mathcal{E}$ an $\mathcal{O}_X$-module. Then $f_0^* \mathcal{E}$ is an $f_0^* \mathcal{O}_X$-module and $\mathcal{O}_{X'}$ is also an $f_0^* \mathcal{O}_X$-module (by $f^1 : f_0^* \mathcal{O}_X \to \mathcal{O}_{X'}$).

The analytic pull-back $f^* \mathcal{E}$ of $\mathcal{E}$ by f is defined by scalar extension:

$$f^* \mathcal{E} = f_0^* \mathcal{E} \underset{f_0^* \mathcal{O}_X}{\otimes} \mathcal{O}_{X'}$$

Remark : The inverse image is a particular case of the analytic pull-back.

In fact, if Y is a closed analytic subspace of X and $f : X' \to X$ is a morphism:

$$f^* \mathcal{O}_Y = f_0^*(\mathcal{O}_X/J_Y) \underset{f_0^* \mathcal{O}_X}{\otimes} \mathcal{O}_{X'} \simeq f_0^* \mathcal{O}_X/f_0^* J_Y \underset{f_0^* \mathcal{O}_X}{\otimes} \mathcal{O}_{X'}$$

$$\simeq \mathcal{O}_{X'}/f^1(J_Y).\, \mathcal{O}_{X'} \simeq \mathcal{O}_{f^{-1}(Y)}$$

(The third isomorphism follows from the fact, that $A/I \underset{A}{\otimes} E \simeq E/IE$).

Elementary properties of the analytic pull-back :

(*a*) $(f^* \mathcal{E})_{x'} = (f_0^* \mathcal{E})_{x'} \otimes_{(f_0^* \mathcal{O}_X)_{x'}} \mathcal{O}_{X',x'} \simeq \mathcal{E}_x \otimes_{\mathcal{O}_{X,x}} \mathcal{O}_{X',x'}$ where $x = f_0(x')$ (since $\otimes$ commutes with inductive limits).

(*b*) $f^*(\mathcal{E} \underset{\mathcal{O}_X}{\otimes} \mathcal{F}) = f^* \mathcal{E} \underset{\mathcal{O}_{X'}}{\otimes} f^* \mathcal{F}$, where $\mathcal{E}$ and $\mathcal{F}$ are $\mathcal{O}_X$-modules.

(*c*) If $\mathcal{E}$ is a coherent $\mathcal{O}_X$-module, then $f^* \mathcal{E}$ is a coherent $\mathcal{O}_{X'}$-module.

In fact, $\mathcal{E}$ has a locally finite presentation:
$\mathcal{O}_X^q \to \mathcal{O}_X^p \to \mathcal{E} \to 0$, and f^* is compatible with cokernels, $f^*(\mathcal{O}_X^r) = \mathcal{O}_X^r$.

Special case : The pull-back of vector bundle. Let (E, π) be an analytic vector bundle over the analytic space X, and $f: X' \to X$ a morphism of analytic spaces. The fiber product carries a unique structure of vector bundle over X', such that $\bar{f}$ is a bundle morphism. We call this bundle E'.

$$\begin{tikzcd} E \times_X X' \arrow[r, "\bar{f}"] \arrow[d, "\pi'"] & E \arrow[d, "\pi"] \\ X' \arrow[r, "f"] & X \end{tikzcd}$$

Proposition 1 : Let $\mathcal{E}$ (Resp. $\mathcal{E}'$) be the sheaf of analytic sections of E (Resp. E'). Then $\mathcal{E}' = f^* \mathcal{E}$.

Proof (Sketch) : We have a $f_0^* \mathcal{O}_X$ linear morphism $f_0^* \mathcal{E} \to \mathcal{E}'$, which extends to a morphism $f^* \mathcal{E} \to \mathcal{E}'$. We can prove that this is an isomorphism. Since the question is local with respect to X', we can suppose that E is a trivial bundle over X with fiber $\mathbf{C}^r$, then $\mathcal{E} = \mathcal{O}_X^r$. Also $\mathcal{O}_{X'}^r = f^* \mathcal{O}_X^r$. Therefore $f^* \mathcal{E} = \mathcal{E}'$.

§ 3. *Introduction to flatness by examples*

Let S be an analytic space. By analytic space over s we mean an analytic space X provided with a morphism $\pi : X \to S$. Let S be a simple point in S, and consider $X(s) = f^{-1}(s)$.