

## Background Lecture: Grothendieck Existence Theorem for coherent sheaves.

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The topic of this lecture is the Grothendieck Existence theorem (EGA, Chapter III, Theorem 5.1.4). The statement there is rather technical so I propose that in your presentation you try to keep it as down to earth as possible. To this end, I suggest presenting the above theorem without using formal schemes, and assuming that  $f : X \rightarrow Y$  is proper and that  $A$  is complete local. The statement then becomes the following.

Let  $\mathfrak{m} \subset A$  be the maximal ideal and for an integer  $n$  let  $A_n$  denote  $A/\mathfrak{m}^{n+1}$ , and let  $X_n$  denote  $X \times_{\mathrm{Spec}(A)} \mathrm{Spec}(A_n)$ . Let  $\varprojlim \mathrm{Coh}(X_n)$  denote the category of data  $(F_n, \iota_n)_{n \geq 0}$ , where  $F_n$  is a coherent sheaf on  $X_n$  and  $\iota_n : F_{n+1}|_{X_n} \rightarrow F_n$  is an isomorphism of coherent sheaves on  $X_n$ .

The most commonly used version of the Grothendieck Existence Theorem is then the following:

**Theorem 1.** *The reduction functor*

$$(\text{coherent sheaves on } X) \rightarrow \varprojlim \mathrm{Coh}(X_n)$$

*is an equivalence of categories.*

In the context of the workshop, an important consequence of this theorem is the following (please try to fit this in if possible):

**Theorem 2.** *Let  $A$ ,  $A_n$ , etc. be as above. Suppose given for every  $n$  a closed subscheme  $Z_n \subset \mathbb{P}_{A_n}^r$  (for some fixed  $r$ ) flat over  $\mathrm{Spec}(A_n)$  such that  $Z_{n+1} \times_{\mathrm{Spec}(A_{n+1})} \mathrm{Spec}(A_n) \subset \mathbb{P}_{A_n}^r$  is equal to  $Z_n$  for all  $n \geq 0$ . Then there exists a unique closed subscheme  $Z \subset \mathbb{P}_A^r$  inducing the  $Z_n$ .*

This theorem is obtained by applying the preceding theorem to the ideal sheaves defining the  $Z_n$ .

# Grauert's Theorem On Direct Images Of Coherent Sheaves

**Marco Cascella**



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