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Proof: Let $\{U_i\}$ be a family of Stein open subsets of X which covers V(f) and such that for each index i we have $U_i \cap V(f) \neq \emptyset$.

We consider the exact sequence of sheaves on X

$$0 \to \mathcal{O}_X \xrightarrow{t} \mathcal{O}_X \to \mathcal{O}_Z \to 0 \tag{1}$$

where t is the multiplication by f. It is exact because f is a non zero-divisor in $\mathcal{O}_{X,x}$ for each $x \in X$. We take $h \in O(Z)$. From theorem B of Cartan-Serre it follows that for every i the restriction of h to $V(f) \cap U_i$ can be extended to a holomorphic function $f \in O(U_i)$. If we have $U_i \cap U_j \neq \emptyset$, from the restriction of the exact sequence (1) to $U_i \cap U_j$, we obtain that $f_i - f_j = g_{ij} f$, where $g_{ij} \in O(U_i \cap U_j)$ is uniquely determined because f is not a zero-divisor of $O(U_i \cap U_j)$.

We take the covering of X given by $X \setminus V(f)$ and $\{U_i\}$. As data for the 1-Cousin problem in X we take the costant 1 on $X \setminus V(f)$ and the meromorphic function f_i/f on X. Again f_i/f is a meromorphic function on U_i , because f is not a zero-divisor on $\mathcal{O}_{X,x}$ for each $x \in U_i$.

We obtain a meromorphic function g on X which satisfies the thesis of the 1-Cousin problem. The function gf is holomorphic on X and gives an extension of h to X.

G. Berg in [2] lemma, gave a proof more or less of the lemma above, if V(f) is a Stein space. He uses a strong theorem of Siu about the existence of a Stein open neighborhood of any Stein analytic subspace in any complex space. Our proof is similar, but does not use this strong theorem and is therefore more elementary.

THEOREM 1. Let X be a complex n-dimensional space, such that O(X) gives local coordinates (in particular it is holomorphically spreadable). Suppose that X and every closed analytic subspace have the 1-Cousin property. Suppose that X is either reduced or Cohen-Macaulay. Then X is a Stein space.

Proof: The proof is by induction on $n = \dim X$. If we have $n \le 1$, then X is a Stein space because it does not contain any positive dimensional analytic compact subspace. Suppose $n \ge 2$.

We put as in [6] $S_d = \{x \in X : \operatorname{prof}_x (\mathcal{O}_{X, x}) \leq d\}$. By [6] theorem 1.11, S_d is an analytic closed subspace of X with dim $S_d \leq d$. For each $f \in O(X)$, we have dim $(V(f) \cap S_{k+1}) \leq k$ for each integer k if and only if f_x is a non zero-divisor in $\mathcal{O}_{X, x}$ for each $x \in X$ by [6], Corollary 1.18.

We may assume that X has no isolated point. Therefore, both under the hypotheses that X is reduced or that X is Cohen-Macauley, we obtain $S_o = \emptyset$.

By a simple application of Baire's cathegory theorem, we obtain $f \in O(X)$ such that h has two different values on each irreducible component of dimension k of S_k .

First we want to prove that X is holomorphically separated. We fix two distinct points $x, y \in X$. If we have $f(x) \neq f(y)$, the result is trivially true. Suppose f(x) = f(y). By considering instead of f the function f - f(x), we may suppose that f vanishes at x. Therefore we suppose x, $y \in V(f)$ and we put $Z := (V(f), \mathcal{O}_Z)$ with

$$\mathcal{O}_Z := \mathcal{O}_X / f \mathcal{O}_{X|V(f)}.$$

a) If X is reduced, V(f) with the reduced structure is by the inductive hypothesis a Stein space. But a complex space Y is a Stein space if and only if Y_{red} is a Stein space. Therefore Z is a Stein space, too.

b) If X is Cohen-Macaulay, then also Z is Cohen-Macauley. In fact for each $x \in X$ with f(x) = 0, we have

$$\operatorname{prof}\left(\mathcal{O}_{X,x}/f \mathcal{O}_{X,x}\right) = \operatorname{prof}\left(\mathcal{O}_{X,x}\right) - 1$$

by [6], lemma 1.2, and

$$\dim \left(\mathcal{O}_{X, x} / f \mathcal{O}_{X, x} \right) = \dim \mathcal{O}_{X, x} - 1 .$$

From the inductive hypothesis it follows that Z is a Stein space.

Therefore under both assumptions we have proved that Z is a Stein space. In particular there exists a $g \in O(Z)$ such that $g(x) \neq g(y)$. From lemma 1 it follows that there exists $G \in O(X)$ which extends g. In particular we have $G(x) \neq G(y)$, proving that X is holomorphically separated.

Let χ be a character of O(X); χ is a multiplicative functional from O(X) to C. By [5], Corollary pag. 222, or [4], pag. 182, to prove that X is a Stein space it is sufficient to demonstrate that χ is a valuation in a point of X. We take $h \in O(X)$ as before, i.e. such that h has two different values on each irreducible component of dimension k of S_k . We put $f = h - \chi(h)$. We put H: = ker (χ). H is a maximal ideal of O(X). The function f is in H. We define Z as above. Z is again a Stein space by the inductive hypothesis. From lemma 1 and the exact sequence (1) in lemma 1, we obtain an exact sequence

$$0 \to f \ O(X) \to O(X) \to O(Z) \to 0$$
(2)

Since $f \in \text{ker}(\chi)$, χ induces a character χ' on O(Z). Since Z is a Stein space, χ' is induced by the valuation in a point $x \in Z \subset X$. If $\{g_i\} \in O(Z)$ generate ker (χ')

and $p(f_i) = g_i$, the functions f_i and f generate $H = \text{ker}(\chi)$. Therefore, for every $m \in H$ we have m(x) = 0. Since M is a maximal ideal, χ is the valuation at the point x.

If dim X = 2, then it is sufficient to assume the 1-Cousin property for X. In fact its 1-dimensional subspace Z in the proof above is a Stein space because it has no compact, analytic subspace of positive dimension. If X is Cohen-Macaulay, it follows from lemma 1 that it is sufficient to assume that X and every closed analytic subspace Z of X given by global equations $f_1, ..., f_k$ and with

$$\mathcal{O}_{\mathbf{Z}}:=\mathcal{O}_{\mathbf{X}}/(f_1,...,f_k)\mathcal{O}_{\mathbf{X}|\mathbf{Z}}$$

are Cousin-I space.

If in the theorem above we omit the condition that X has local coordinates given by global functions, we obtain only that every character is given by a valuation at a point of X. An easy inductive argument shows also that for every character χ of O(X), ker (χ) is finitely generated. Therefore we obtain the following

PROPOSITION 1. Let X be a holomorphically spreadable complex space such that every closed analytic subspace has the 1-Cousin property. Suppose that X is reduced or Cohen-Macaulay. Then

- a) X is holomorphically separated,
- b) every character χ of O(X) is a valuation at a point of X and ker (χ) is finitely generated.

THEOREM 2. Let X be a complex reduced space which is a relatively compact open subset of a holomorphically separated, reduced complex space Y. Then X is a Stein space if and only if any closed analytic subspace, with its reduced structure, has the 1-Cousin property.

Proof: The "only if" part is well-known. We have dim $X = n < +\infty$ and we use induction on n. For $n \leq 1$ the result is well-known. Now suppose $n \geq 2$. Let $\{x_n\}$ be a sequence in X without accumulation points in X. We may suppose, eventually extracting a subsequence, that $\{x_n\}$ converges to a point $y \in \mathcal{O}(X)$. If we take into account the proof of [3], theorem 1.3, it remains only to prove that there exist

$$f_1, ..., f_k \in O(Y)$$

with only y as a common zero and such that there exist

 $g_1, ..., g_k \in O(X)$