$$L(x) := \sum_{n=1}^{\infty} \frac{f_n(x)}{2^n c_n}$$

is a smooth function having the required properties. In particular, as for any $n \geq 1$ the differential $df_n$ vanishes on $A_n \cup A_n^*$, the differential of $L$ vanishes on $R$. □

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*(Reçu le 14 mars 2003)*

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