Macrocausality Conditions from Analyticity Properties of Scattering Kernels in Field Theory

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Abstract. From the analyticity properties of the scattering kernels in axiomatic field theory we derive macrocausality conditions for the scattering amplitudes in the sense of Iagolnitzer-Stapp. By applying the generalized Laplace transform theorem of Bros-Iagolnitzer, we show the equivalence of such conditions with the exact size and shape of the analyticity domains.

1. Introduction

In the last ten years, several authors have looked for a direct space-time interpretation of the analyticity properties of scattering amplitudes of elementary particles. As a matter of fact one can adopt two different attitudes concerning investigations of this type:

i) One believes that analyticity should be derived from "physically-admissible" space-time properties of the collision amplitudes; the latter properties should in particular express the short-range character of interactions together with a certain form of causality. This point of view was supported for the first time by Omnès in [1], where a derivation of the analyticity of two-body amplitudes in t-ellipses, was proposed on the basis of a certain short-range hypothesis. An analogous derivation was given in a more rigorous form in [2]. The same point of view had also been adopted by the tenants of axiomatic S-matrix theory [3]. In this context, a set of general "macrocausality conditions" was defined by Iagolnitzer and Stapp in [4], which was proved to be equivalent to local analyticity properties of the n-body collision amplitudes. These macrocausality conditions express in an appropriate mathematical language the fact that in collision processes, all energy-momentum transfers which are not carried by stable elementary particles give rise to short range phenomena in space-time.

We note that in the above formalism (as well as in [1] and [2]), the short range properties are always assumed to hold in the sense of *exponential* decrease, the latter being essential to yield analyticity.

ii) Starting from the analyticity properties of the scattering kernels which have been proved in axiomatic field theory, one tries to derive equivalent space-time properties of transition amplitudes. This is the point of view which we adopt in the present work. To the same field theoretical context belong the works by