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Wave Packet Realization of Lightlike States*

G. DOMOKOS

Department of Physics, John Hopkins University Baltimore, Md., USA

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Abstract. We construct a new realization of lightlike particle states. The realization considered corresponds to objects which form partially localized wave packets in the space dimensions transverse to the direction of the lightlike momentum. The states of the transverse motion are classified by the representations of an algebra $SU(1, 1)$ constructed of the generators of the conformal group. It is conjectured that this realization is suitable for the formulation of the "parton"-model of hadrons.

1. Introduction

Lightlike particle states play an ever-increasing role in physics. Apart from classical objects (photons, neutrinos), the hypothesis has been recently put forward that hadrons may consist of elementary constituents and when viewed from a reference frame moving with – approximately – the velocity of light, a hadron may well be represented as a "beam" of free "partons" [1].

With these applications in mind, we studied the various realizations of lightlike states. Clearly, from the mathematical point of view, this problem reduces to the study of the linear spaces spanned by all lightlike states on which a representation of a – physically reasonable – invariance group can be realized. Within the framework of the Poincaré group, the problem has been solved in the classical paper by Wigner [2]. Intuitively one expects, however, that a lightlike state should be essentially unchanged (i.e. brought over into another lightlike state) by certain conformal transformations (uniform accelerations and dilations) as well. This turns out to be indeed the case. By studying these additional transformations one discovers a somewhat unusual and – to the present author's knowledge – hitherto unknown type of states. These have the interesting property that they are partially localized – they form "transverse wave packets" – in the two space dimensions perpendicular to the direction in which the "particle" moves with light velocity. (The "transverse space".) One may thus speculate that such a set of states is probably appropriate for the description of the "almost free" constituents of the hadrons and/or the physical hadron states themselves. The purpose of this paper is to exhibit the states just mentioned by means of an elemen-

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