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SUPERGRAVITY BEFORE 1976*

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ABSTRACT

A story on how an attempt to realize W. Heisenberg's idea that the neutrino might be a Goldstone particle had led in its development to the discovery of a supergravity action.

1. INTRODUCTION

There are two kinds of fields which are directly related to continuous symmetries. These are the Goldstone and Yang–Mills fields.

The Goldstone fields are a manifestation of spontaneously broken symmetries. The Yang–Mills fields appear when a symmetry is localized.

Both kinds of fields were predicted theoretically, and at the moment of their invention seemed to have no relation to reality.

However, as revealed by Higgs and others, their mutual interplay, exhibiting itself as the Higgs effect, has thoroughly changed the situation. And nowadays the concept of the

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gauge fields and of the spontaneously broken symmetries is the backbone of theories unifying all known interactions:

Internal symmetry group G	→	spontaneous breakdown	→	Goldstone particles, $s = 0$	→	Goldstone particles Gauge fields Higgs effect
	→	localization	→	Y–M gauge fields $l = 1$		

The modern idea of the unification involves not only internal symmetries but also a new type of symmetry discovered at the beginning of the 1970's, namely, supersymmetry, which is intrinsically intertwined with the former.

Main features of the supersymmetry have been discussed in the talks by P. Dimopoulos and S. Fayet [1]. So, I shall remind the audience only that supersymmetry was independently discovered by three groups of authors:

Yu. Gol'fand & E. Lichtman (1971)
D. Volkov & V. Akulov (1972)
J. Wess & B. Zumino (1974)

The motivation and starting points used by these groups were quite different.

The motivation of Gol'fand and Lichtman [2] was to introduce a parity violation in the quantum field theory. The starting point of the paper by Akulov and myself [3, 4] was the question of whether Goldstone particles with spin one half might exist. Wess and Zumino [5] performed the generalization of the supergroup which first appeared in the Neveu–Schwarz–Ramond dual model [6, 7].

The approach of the Volkov–Akulov papers is the most appropriate for gauging the super-Poincaré group, which was done a little bit later in the papers by Soroka and myself [8, 9]. The last-mentioned papers are the natural continuation of the Volkov–Akulov papers since the transformation laws for gauge fields are determined by the same group structure as that used for the description of the Goldstone fields.

As it has already been mentioned, our approach was caused by the question about the possible existence of the spin 1/2 Goldstone particles.

The second question closely related to the first one is: what is the group whose breakdown yields Goldstone fields with the required properties? In some respect this is the reverse of the usual consideration of Goldstone and gauge fields when an internal symmetry group is given and the properties of the fields are derived from the known symmetry group properties:

Can the Goldstone fermion with $s = 1/2$ exist?	⇒	Super-Poincaré group, Supergravity	←	A group of which kind?

Answering these questions led us to the discovery of the super-Poincaré group.

It is convenient to consider the internal symmetry groups and the super-Poincaré group in parallel since it gives the possibility of learning which features of the two cases are common and which are different:

Goldstone fields Gauge fields Higgs effect	⇔	Internal symmetries
	⇔	Super-Poincaré

As we shall see below the analogy between the two cases gives rather rich intuitive insight which helps one to trivialize the procedure of gauging the super-Poincaré group and getting the supergravity action.