Resource Letter: $2(2S+1)$- Component Model and Its Connection with Other Field Theories.

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This Resource Letter has been presented at the IF-UNAM SEMINAR (12-11-1993). In the Joos-Weinberg $2(2S+1)$- component approach [1] to description of particles of spin $S=1$ the wave function (WF) of vector boson is written as six component column. It satisfies the following motion equation:

$$\left[\gamma_{\mu\nu}p_\mu p_\nu + M^2\right]\Psi^{(S=1)} = 0, \tag{1}$$

where $\gamma_{\mu\nu}$'s are covariantly defined $6\otimes 6$- matrices, $\mu,\nu = 1,...4$.

The main results are [2]:

– the scalar Lagrangian of Weinberg's theory (the case of massless $S=1$ particles and a lá Majorana interpretation of Weinberg's WF)

$$\mathcal{L}^W = \partial_\mu\bar{\Psi}\gamma_{\mu\nu}\partial_\nu\Psi \tag{2}$$

is shown to be equivalent to the Lagrangian of free massless skew-symmetric field $\mathcal{L}^H = F_k F_k/8$ ($F_k = i\epsilon_{kjmn}F_{jm,n}$), presented by Hayashi (1973), ref. [3]. It describes massless particles with the longitudinal physical components only. The transversal components are removed by means of the new "gauge" transformation;

– the vector Lagrangian, proposed in [2a], gives the dynamical invariants which are equivalent to the ones found by Lipkin (1964) and Sudbery (1986), ref. [4]. The energy-momentum conservation is associated not with translational invariance but with invariance under duality rotations;

– since the result of the item (1) is in contradiction with Weinberg's theorem about connection between (A,B)- representation of the Lorentz group and helicity of particle ($B-A=\lambda$) and, moreover, the Weinberg's massless equations [1] admit the acausal ($E\neq\pm p$) solutions [5], the new interpretation of the Weinberg's $S=1$ spinor has been proposed. It is based on use of a pseudovector potential $\tilde{A}_k$, $\Psi = col(\tilde{A}_k +\ iA_k \quad \tilde{A}_k -\ iA_k)$;

– the interaction Hamiltonian (two $S=1/2$ particles and one massless $S=1$ particle) , proposed by Marinov (1968), appears to lead to the equations which are analogous to the equations for the Dirac oscillator [7, 8]:

$$\begin{cases} (E^2-m^2)\xi = \left[\vec{p}^{\,2} + m^2\omega^2 r^2 + 2iEm\omega(\vec{\sigma}\vec{r}) + 3m\omega + 4m\omega\vec{S}[\vec{r}\times\vec{p}]\right]\xi, \\ (E^2-m^2)\eta = \left[\vec{p}^{\,2} + m^2\omega^2 r^2 + 2iEm\omega(\vec{\sigma}\vec{r}) - 3m\omega - 4m\omega\vec{S}[\vec{r}\times\vec{p}]\right]\eta. \end{cases} \tag{3}$$

Similarly to [8] these equations include the term $(\vec{\sigma}\vec{r})$ and are not invariant under parity. To keep parity conservetion it is necessary to assume that ω, the frequency, is a pseudoscalar quantity, what means complicated dispersion law. However, "irregular" invariants (where upper and down components of bispinors have been mixed) for interaction between such types of fields were pointed out in ref [6] to be possible. Since vector and pseudovector WF's could be expressed by using some combination of two bispinors, this fact gives the opportunity to construct other invariant which leads to the Dirac oscillator equations, proposed in ref. [7].

The presented formalism has been used for calculation of the scattering amplitude for two gluon interaction. The remarkable fact is that the amplitude coincides with the amplitude in Lobachevsky space ($p_0^2 - \vec{p}^{\,2} = M^2$) for interaction of two spinor particles except for obvious substitutions. Moreover, the relativistic partial-wave equations have been obtained for the singlet gluonium state, the triplet one and the 5-plet gluonium state in relativistic configurational representation, which is just generalization of x-representation. Shapiro plane-wave functions are used instead of Fourier transformation.

The relativistic analogue of the Shay-Good Hamiltonian has been also obtained in the Lobachevsky space. The new magnetic momentum vector has been defined [2f].

The conclusions are:

– searches of alternative formulations of vector boson theory do have definite reasons because of some shortcomings (in my opinion) of usual QFT (the problem of indefinite metrics, the nonrenormalizability of vector boson field theories with the presence of mass term in the Lagrangian, e.t.c.);

– the Weinberg's $2(2S+1)$- formalism, which is used in the presented work, is very similar to the standard Dirac's approach to spinor particles and, therefore, seems to be convenient for practical calculations;

– interpretation of WF of massless $S = 1$ particle, which has been given by Weinberg [1b], is not sufficiently satisfactory;

– we have, in fact, a bivector form of interaction between spinor particle and Weinberg's vector boson instead of a minimal form of interaction in the case of the new interpretation of the Weinberg's WF;

- the estimations of the possible influence of the above-mentioned model on the experimental results deserve further elaboration.

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