Supersymmetric Gauge-Invariant Interaction Revisited.

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(riccuto il 2 Dicembre 1983)

Summary. — A supersymmetric Lagrangian invariant under local \( U_1 \) gauge transformations is written in terms of a nonchiral superfield which substitutes the usual vector supermultiplet together with chiral and antichiral superfields. The Euler equations allow us to obtain the off-shell version of the usual Lagrangian for supersymmetric quantum electrodynamics (SQED).

PACS. 12.90. — Miscellaneous theoretical ideas and models.

1. — Introduction.

The superfields introduced by SALAM and STRATHDEE (1) provide an elegant and compact description of supersymmetry representation. They are defined over the eight-dimensional space whose points \( z^\mu \) are represented by \( (x^m, \theta^\alpha, \bar{\theta}^{\dot{\mu}}) \), where \( x^m \) (\( m = 0, 1, 2, 3 \)) denotes the usual space-time co-ordinates and the Weyl spinors \( \theta^\alpha, \bar{\theta}^{\dot{\mu}} \) are anticommuting Grassmann's variables with \( \mu, \dot{\mu} = 1, 2 \). We are going to use the same notations and conventions of ref. (2).

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Superfields have a general power series expansion in $\theta$ and $\bar{\theta}$ given by

\begin{align}
F(x, \theta, \bar{\theta}) &= f(x) + \theta \psi(x) + \bar{\theta} \bar{\psi}(x) + \theta \theta m(x) + \\
&\quad + \theta \theta n(x) + \theta \sigma^m \theta v_m + \theta \bar{\theta} \lambda(x) + \bar{\theta} \theta \bar{\psi}(x) + \theta \theta \bar{\theta} \bar{\psi}(x)
\end{align}

and transforms as

\begin{equation}
\delta F = (\xi \psi + \bar{\xi} \bar{\psi}) F'
\end{equation}

under a supersymmetry transformation with parameters $\xi^a$, $\bar{\xi}^\alpha$, where $Q_a$, $\bar{Q}^\alpha$ are the differential operators

\begin{align}
Q_a &= \frac{\partial}{\partial \theta^a} - i \sigma^m_{a\beta} \bar{\theta}^\beta \frac{\partial}{\partial \bar{\theta}^m}, \\
\bar{Q}^\alpha &= \frac{\partial}{\partial \bar{\theta}^\alpha} - i \theta^a \sigma^m_{a\alpha} \theta^m \frac{\partial}{\partial \theta^m}.
\end{align}

Usually some constraints are introduced on superfields and the most common ones are

\begin{align}
\bar{D}_a \varphi &= 0, \\
D_a \varphi^+ &= 0, \\
V^+ &= V,
\end{align}

where $D_a$ and $\bar{D}_a$ are the usual covariant derivatives:

\begin{align}
D_a &= \frac{\partial}{\partial \theta^a} + i \sigma^m_{a\beta} \bar{\theta}^\beta \frac{\partial}{\partial \bar{\theta}^m}, \\
\bar{D}_a &= - \frac{\partial}{\partial \bar{\theta}^a} - i \theta^m \sigma^m_{a\alpha} \theta^m \frac{\partial}{\partial \theta^a}.
\end{align}

$\varphi$, $\varphi^+$ and $V$ are called chiral, antichiral and vector superfields, respectively, and they have been used to construct supersymmetric gauge-invariant Lagrangians ($^{(2)}$).

Projection operators $P_1$, $P_2$ ($^4$) can be introduced with the following properties:

\begin{align}
P_1 \varphi^+ &= \varphi^+, \\
P_2 \varphi &= \varphi, \\
P_1 \varphi &= P_2 \varphi^+ = 0.
\end{align}
