Hence, there are enough local symmetries to ensure only physical states in the spectrum. Regarding these aspects, the Lagrangian for a massless ($M_0 = 0$) particle with spin $N/2$ is given by [19].

$$L = \frac{1}{2}E^{-1}\eta_{\mu\nu}\dot{x}^{\mu}\dot{x}^{\mu} - \frac{i}{2}\eta_{\mu\nu}\psi_k^{\mu}\dot{\psi}_k^{\nu} - \frac{i}{2}E^{-1}\eta_{\mu\nu}\lambda_k\psi_k^{\mu}\dot{x}^{\nu}$$
$$- \frac{1}{8}E^{-1}\eta_{\mu\nu}(\lambda_k\psi_k^{\mu})(\lambda_k\psi_k^{\nu}) + i\eta_{\mu\nu}\psi_k^{\mu}\psi_l^{\nu}V_{kl}, \tag{2.1}$$

where repeated Latin indices indicate sums. The action related to the Lagrangian above is invariant under reparameterization of the parameter $\tau \to \tau + s(\tau)$, under supersymmetry and local $O(N)$ transformation [18, 19] as shown in the table below

Variables	Reparametrization	Supersymmetry	Local O(N)
δx^{μ}	$s\dot{x}^{\mu}$	$i\alpha_k\dot{\psi}_k^{\mu}$	0
$\delta\psi_k^{\mu}$	$s\dot{\psi}_k^{\mu}$	$\alpha_k\left[E^{-1}\dot{x}^{\mu} - \frac{i}{2}E^{-1}\lambda_l\psi_l^{\mu}\right]$	0
δE	$s\dot{E} + \dot{s}E$	$i\alpha_k\lambda_k$	0
$\delta\lambda_k$	$s\dot{\lambda}_k + \dot{s}\lambda_k$	$2\dot{\alpha}_k + 4\alpha_l V_{kl}$	t_{kl}
δV_{kl}	$s\dot{V}_{kl} + \dot{s}V_{kl}$	0	$\frac{1}{2}\dot{t}_{kl} + t_{kn}V_{nl} - t_{ln}V_{nk}$

Table 1. Symmetry transformations of the spinning particle model [19].

where α_k is an odd element of a Grassmann algebra which is an arbitrary function of τ, and t_{kl} are the generators of the group $O(N)$. The Euler-Lagrange equations obtained by varying the action related to the Lagrangian, equation (2.1), give us the equations of motion

$$p_{\mu} = E^{-1}\left(\eta_{\mu\nu}\dot{x}^{\nu} - \frac{i}{2}\lambda_k\eta_{\mu\nu}\psi_k^{\nu}\right) \tag{2.2}$$

$$\dot{p}_{\mu} = 0 \tag{2.3}$$

$$\dot{\psi}_k^{\mu} = \frac{\lambda_k}{2}p^{\mu} + 2\psi_l^{\mu}V_{kl}, \tag{2.4}$$

and the constrains of first kind

$$\eta_{\mu\nu}p^{\mu}p^{\nu} \approx 0 \tag{2.5}$$

$$\eta_{\mu\nu}\psi_k^{\mu}p^{\nu} \approx 0 \tag{2.6}$$

$$\eta_{\mu\nu}\psi_k^{\mu}\psi_l^{\nu} \approx 0 \tag{2.7}$$

$$\pi_k^{\mu} - \frac{i}{2}\psi_k^{\mu} \approx 0, \tag{2.8}$$

where $\pi_k^{\mu} = \frac{\partial L}{\partial\dot{\psi}_k^{\mu}}$. These equations describe the motion of a free massless spinning particle with spin $N/2$ after quantization.

For a massive spinning particle, it was proposed in [18] the introduction of an additional (Minkowsky scalar) Grassmann variable ψ^5 which goes over to γ^5 in the quantization procedure, and this field could carry a mass in the constraint. We further introduced a