

Personal Notes of *Part I: Scalar Fields of Quantum Field Theory* by Srednicki

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1 Attempts at relativistic quantum mechanics

$$i\hbar \frac{\partial}{\partial t} |\psi, t\rangle = H |\psi, t\rangle . \quad (1.1)$$

$$H = \frac{1}{2m} \mathbf{P}^2 . \quad (1.2)$$

$$i\hbar\frac{\partial}{\partial t}\psi(\mathbf{x},t)=-\frac{\hbar^2}{2m}\nabla^2\psi(\mathbf{x},t). \quad (1.3)$$

$$H=+\sqrt{\mathbf{P}^2c^2+m^2c^4}. \quad (1.4)$$

$$H=mc^2+\frac{1}{2m}\mathbf{P}^2+\cdots. \quad (1.5)$$

$$i\hbar\frac{\partial}{\partial t}\psi(\mathbf{x},t)=+\sqrt{-\hbar^2c^2\nabla^2+m^2c^4}\,\psi(\mathbf{x},t). \quad (1.6)$$

$$-\hbar^2\frac{\partial^2}{\partial t^2}\psi(\mathbf{x},t)=\left(-\hbar^2c^2\nabla^2+m^2c^4\right)\psi(\mathbf{x},t). \quad (1.7)$$

$$g_{\mu\nu}=\begin{pmatrix}-1&&&\\&1&&\\&&1&\\&&&1\end{pmatrix}. \quad (1.8)$$

$$g^{\mu\nu}=\begin{pmatrix}-1&&&\\&1&&\\&&1&\\&&&1\end{pmatrix}. \quad (1.9)$$

$$\bar{x}^\mu=\Lambda^\mu{}_\nu x^\nu+a^\mu. \quad (1.10)$$

$$g_{\mu\nu}\Lambda^\mu{}_\rho\Lambda^\nu{}_\sigma=g_{\rho\sigma}. \quad (1.11)$$

$$\begin{aligned}
(x - x')^2 &\equiv g_{\mu\nu}(x - x')^\mu(x - x')^\nu \\
&= (\mathbf{x} - \mathbf{x}')^2 - c^2(t - t')^2.
\end{aligned} \tag{1.12}$$

$$\begin{aligned}
(\bar{x} - \bar{x}')^2 &= g_{\mu\nu}(\bar{x} - \bar{x}')^\mu(\bar{x} - \bar{x}')^\nu \\
&= g_{\mu\nu}\Lambda^\mu{}_\rho\Lambda^\nu{}_\sigma(x - x')^\rho(x - x')^\sigma \\
&= g_{\rho\sigma}(x - x')^\rho(x - x')^\sigma \\
&= (x - x')^2.
\end{aligned} \tag{1.13}$$

$$\partial_\mu \equiv \frac{\partial}{\partial x^\mu} = \left(+\frac{1}{c} \frac{\partial}{\partial t}, \nabla \right), \tag{1.14}$$

$$\partial^\mu \equiv \frac{\partial}{\partial x_\mu} = \left(-\frac{1}{c} \frac{\partial}{\partial t}, \nabla \right). \tag{1.15}$$

$$\partial^\mu x^\nu = g^{\mu\nu}. \tag{1.16}$$

$$\bar{\partial}^\mu = \Lambda^\mu{}_\nu \partial^\nu. \tag{1.17}$$

$$\bar{\partial}^\rho \bar{x}^\sigma = (\Lambda^\rho{}_\mu \partial^\mu)(\Lambda^\sigma{}_\nu x^\nu + a^\sigma) = \Lambda^\rho{}_\mu \Lambda^\sigma{}_\nu (\partial^\mu x^\nu) = \Lambda^\rho{}_\mu \Lambda_{\sigma\nu} g^{\mu\nu} = g^{\rho\sigma}. \tag{1.18}$$