

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

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## **1 Attempts at relativistic quantum mechanics**

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$-\hbar^2 c^2 \partial_0^2 \psi(x) = (-\hbar^2 c^2 \nabla^2 + m^2 c^4) \psi(x). \tag{1.19}$$

$$(-\partial^2 + m^2 c^2 / \hbar^2) \psi(x) = 0. \tag{1.20}$$

$$(-\bar{\partial}^2 + m^2 c^2 / \hbar^2) \bar{\psi}(\bar{x}) = 0. \quad (1.21)$$

$$\bar{\partial}^2 = g_{\mu\nu} \bar{\partial}^\mu \bar{\partial}^\nu = g_{\mu\nu} \Lambda^\mu{}_\rho \Lambda^\nu{}_\sigma \partial^\rho \partial^\sigma = \partial^2. \quad (1.22)$$

$$\langle \psi, t | \psi, t \rangle = \int \mathbf{d}^3 x \langle \psi, t | \mathbf{x} \rangle \langle \mathbf{x} | \psi, t \rangle = \int \mathbf{d}^3 x \psi^*(x) \psi(x). \quad (1.23)$$

$$i\hbar \frac{\partial}{\partial t} \psi_a(x) = (-i\hbar c (\alpha^j)_{ab} \partial_j + mc^2 (\beta)_{ab}) \psi_b(x). \quad (1.24)$$

$$H_{ab} = cP_j (\alpha^j)_{ab} + mc^2 (\beta)_{ab}. \quad (1.25)$$