# Changes to Chapter 5 of SFQFT

**Section 5.5.1**

In (5-57), next to the ½, insert a factor of $\zeta_r$.

**Section 5.5.2**

at the end, after "here", insert "except that we get a minus sign for scalar polarized photons"

in sidebar note: change "like" to "parallels"

**Section 5.6**

Inside the box for (5-59), insert "$r$ = 1,2,3"

After (5-59), insert the following paragraph.

"It turns out that for $r = 0$, $a_0(\mathbf{k})$ destroys a scalar photon and $a_0^\dagger(\mathbf{k})$ creates one, but the derivation, due to the minus sign in (5-56), is not so straightforward, is quite complicated, and leads to results we would consider strange. As but a partial example, one would find that $\langle 0|0\rangle = 1, \langle 1_{\mathbf{k}0}|1_{\mathbf{k}0}\rangle = -1, \langle 2_{\mathbf{k}0}|2_{\mathbf{k}0}\rangle = 1, \langle 3_{\mathbf{k}0}|3_{\mathbf{k}0}\rangle = -1, \ldots$ , i.e., the sign of the norms oscillates as one increases the number of scalar photons in a state. This is known as a non-positive definite norm. There are concomitant seemingly strange signs arising in the scalar photon equivalent of (5-59). There are ways around all this[1], but we will not delve into them here, since real scalar photons are not observed in our physical world, and as we will soon discuss, they essentially drop out of our theory."

**Section 5.8.3**

In the paragraph after (5-81), change "is negative, but it is always … value of" to "and the longitudinal energy expectation value have opposite signs and"

Middle of pg. 153, above the sub-section titled "Comments on Scalar and Longitudinal Waves" insert the following sub-section.

"The Two Big Benefits of the Weak Lorenz Condition

So, the two things the Gupta-Bleuler condition give us are

1. The commutator $\left[\partial_\mu A^\mu(x), A^\nu(y)\right]$ not = 0 is no longer a problem because we don't assume $\partial_\mu A^\mu = 0$.
2. Scalar and longitudinal photons drop out of the theory, and thus theory matches experiment."

[1] See for example, S.N. Gupta, *Quantum Electrodynamics*, Gordon and Beach, NY (1977); G. Källén, *Quantum Electrodynamics*, Springer, NY (1972); J.M. Jauch and F. Rohrlich, *The Theory of Photons and Electrons*, 2nd ed. Springer, NY (1976), Sect. 6.3; and R. Klauber, references in footnote on pg. 50 of this text.