Appendix C

Identities for quark bilinears

There are four identities for the product of two quark bilinears:

$$[\bar{s}\gamma^\mu\gamma^\rho\gamma^\nu\gamma_\pm d][\bar{q}_i\gamma_\mu\gamma^\tau\gamma_\nu\gamma_\pm q_j] = 4g^{\rho\tau}[\bar{s}\gamma^\lambda\gamma_\pm d][\bar{q}_i\gamma_\lambda\gamma_\pm q_j], \tag{C.1}$$

$$[\bar{s}\gamma^\mu\gamma^\rho\gamma^\nu\gamma_\pm d][\bar{q}_i\gamma_\mu\gamma^\tau\gamma_\nu\gamma_\mp q_j] = 4[\bar{s}\gamma^\tau\gamma_\pm d][\bar{q}_i\gamma^\rho\gamma_\mp q_j], \tag{C.2}$$

$$[\bar{s}\gamma^\nu\gamma^\rho\gamma^\mu\gamma_\pm d][\bar{q}_i\gamma_\mu\gamma^\tau\gamma_\nu\gamma_\pm q_j] = 4[\bar{s}\gamma^\tau\gamma_\pm d][\bar{q}_i\gamma^\rho\gamma_\pm q_j], \tag{C.3}$$

$$[\bar{s}\gamma^\nu\gamma^\rho\gamma^\mu\gamma_\pm d][\bar{q}_i\gamma_\mu\gamma^\tau\gamma_\nu\gamma_\mp q_j] = 4g^{\rho\tau}[\bar{s}\gamma^\lambda\gamma_\pm d][\bar{q}_i\gamma_\lambda\gamma_\mp q_j]. \tag{C.4}$$

The derivation follows from the identity

$$\gamma^\mu\gamma^\lambda\gamma^\nu = g^{\mu\lambda}\gamma^\nu + g^{\lambda\nu}\gamma^\mu - g^{\mu\nu}\gamma^\lambda + i\varepsilon^{\mu\lambda\nu\rho}\gamma_\rho\gamma_5 \tag{C.5}$$

and can be found in A. Sirlin, *Nucl. Phys.* B **192**, 93 (1981).

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