Appendix D develops an approximate expression for the spatial autocovariance function of envelope based on shape factors [Dur99a]. The approximation is given by

$$\rho(r, \theta) \approx \exp\left[-23\Lambda^2(1 + \gamma\cos[2(\theta - \theta_{\max})])\left(\frac{r}{\lambda}\right)^2\right] \tag{5.115}$$

Equation (5.115) allows us to estimate the envelope correlation between two points in space separated by a distance r along an azimuthal direction θ. The behavior of Equation (5.115) is benchmarked in Section 5.8.5 against several known analytical solutions presented in [Jak74].

5.8.3.3 Coherence Distance

Coherence distance, D_c, is the separation distance in space over which a fading channel appears to be unchanged. As shown in Chapter 7, coherence distance is important in the design of wireless receivers that employ spatial diversity to combat spatial selectivity. For mobile receivers, a similar parameter called *coherence time*, T_c, is the elapsed time over which a fading channel appears to be constant (see Equation (5.40.b)). For the case of a static channel, the coherence time of a mobile receiver may be calculated from the coherence distance ($T_c = D_c/v$, where v is the speed of the mobile).

Definitions for coherence distance may be based on the envelope autocovariance function. A convenient definition for the coherence distance, D_c, is the value that satisfies the equation $\rho(D_c) = 0.5$ [Ste94]. The classical value for coherence distance in an omnidirectional Rayleigh channel is given by

$$D_c \approx \frac{9\lambda}{16\pi} \tag{5.116}$$

Using the generalized autocovariance function of Equation (5.115) and evaluating $\rho(r, \theta)|_{r = D_c} = 0.5$ leads to a new definition of coherence distance:

$$D_c \approx \frac{\lambda\sqrt{\ln 2}}{\Lambda\sqrt{23(1 - \gamma\cos[2(\theta - \theta_{\max})])}} \tag{5.117}$$

For omnidirectional propagation, Equation (5.117) differs from Equation (5.116) by only –3.0%. Furthermore, Equation (5.117) captures the behavior of non-omnidirectional multipath. As angular spread, Λ, decreases, the coherence distance in a local area increases. As the angular constriction, γ, increases, the coherence distance develops a strong dependence on orientation, θ.

5.8.4 Applying Shape Factors to Wideband Channels

The theory presented in Section 5.8 was originally developed for a flat fading small scale assumption. By realizing that wideband channels may be modeled as discrete, resolvable multipath components in time delay, one can readily see how the theory may be applied to *each* resolvable time delay bin, as shown in Figure 5.4. The shape factor theory allows the fading statistics of individual multipath to be studied [Pat99].