DOPPLER SPREAD AND COHERENCE TIME

How fast do the taps $h_\ell[m]$ vary as a function of time m?

$$h_\ell[m] = \sum_i a_i^b(m/W)\mathrm{sinc}[\ell - \tau_i(m/W)W]$$
$$= \sum_i \underbrace{a_i(m/W)}_{1} \underbrace{e^{-j2\pi f_c \tau_i(m/W)}}_{2} \underbrace{\mathrm{sinc}[\ell - \tau_i(m/W)W]}_{3}.$$

(2 → for the baseband case)

changes due to the variation of $\tau_i(t)$ are proportional to the bandwidth

changes occur in a periods of SECONDS

changes occur at intervals of $1/(D_i 4)$

where D_i is the doppler shift for that path

Doppler spread: largest difference between Doppler shift of the paths

$$D_s := \max_{i,j} f_c |\tau_i'(t) - \tau_j'(t)|,$$

The fastest changes in filter taps occur because of the PHASE changes (2nd term)

↳ Coherence time: interval over $h_\ell[m]$ changes significantly as a function of m

$$T_c = \frac{1}{4D_s}.$$

→ due to the PHASE changes in the $h_\ell[m]$ expression

↳ ↗ D_s → ↘ T_c

Fast and Slow fading channel:

Fast fading	$T_c \ll$ delay requirement
Slow fading	$T_c \gg$ delay requirement

Fast fading channel can trasmit the CODED symbol over multiple fades of the channel

DELAY SPREAD AND COHERENCE BANDWIDTH

Delay spread: is a DIFFERENCE in propagation time between 2 paths

$$T_{\mathrm{d}} := \max_{i,j} |\tau_i(t) - \tau_j(t)|.$$

For the modulation and DETECTION what we need is the AGGREGATE value like Ds, Tc and Td. The receiver doesn't use any individual value of a paths.

Frequency coherence: how quickly channel change in frequency

↳ simple example: direct path + 1 reflected path → How channels change in frequency?

$H(f;t) = \sum_i a_i(t) \mathrm{e}^{-\mathrm{j}2\pi f \tau_i(t)}$. → FREQUENCY RESPONSE at time t

↳ The contribution due to a multipaths has a DIFFERENCIAL PHASE: $2\pi f_c (\tau_i(t) - \tau_n(t))$

causes SELECTIVE FREQUENCY: $E_r(f,t)$ changes when f changes by $1/(2T_d)$

Like in the coherence time, coherence bandwidth is: $W_{\mathrm{c}} = \frac{1}{2T_{\mathrm{d}}}$.

Flat fading	$W \ll W_{\mathrm{c}}$	→ single channel tap for represent the channel
Frequency-selective fading	$W \gg W_{\mathrm{c}}$	→ multiples taps for represent the channel

↳ is a relationship between W and Td