Analytic Pulsed-beam Communication Channels

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Let $G(x_r - x_e)$ be the causal Green function for the wave equation in four space-time dimensions, representing the signal received at the space-time point x_r due to an impulse emitted at the space-time point x_e. Such emission and reception processes are highly idealized since no signal can be emitted or received at a precise point in space and at a precise time. We present a simple model for *extended* emitters and receivers by continuing G analytically to a function $\tilde{G}(z_r - z_e)$, where $z_e = x_e + iy_e$ is a complex space-time point representing a circular pulsed-beam emitting antenna dish centered at x_e and radiating in the direction of y_e and $z_r = x_r - iy_r$ is a complex space-time point representing a circular pulsed-beam receiving antenna dish centered at x_r and receiving from the direction of y_r. The analytic Green function $\tilde{G}(z_r - z_e)$ represents the *coupling amplitude* between the emission and reception dishes. The space components of y_e and y_r give the spatial orientations and radii of the dishes, while their time components determine the duration and collimation of the emission and reception processes. Causality requires that the orientation vectors y_e and y_r must belong to the future cone V_+ in space-time. The directivity D of the communication channel is a non-negative convex function on V_+, *i.e.*, $0 \leq D(y_r + y_e) \leq D(y_r) + D(y_e)$. That is, the directivity of the channel can be no better than the sum of its emission and reception components.