Theory of axo-axonic inhibition

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The axon initial segment (AIS) of cortical pyramidal cells receives GABAergic synapses from Chandelier cells. These synapses are particularly important as they can block the neuron's output. Here I will show how resistive coupling theory explains the electrical impact of this axo-axonic inhibition. Resistive coupling theory is a branch of cable theory that addresses the specific electrical situation of the AIS, which sits on a thin axon next to a large somatodendritic compartment. In that situation, sodium current entering the AIS at spike initiation flows mostly resistively to the soma, which acts as a current sink. This produces an ohmic voltage gradient between soma and AIS, proportional to distance. Similarly, a hyperpolarizing current at the AIS produces a negative voltage gradient, which raises the somatic spike threshold. This is one important factor of the inhibitory effect of axo-axonic synapses, which is distance-dependent. The second factor is synaptic conductance, which raises the axonal spike threshold. Finally, I will show how displacements of the AIS can change the strength of inhibition.