The Physics and the Mathematics for MIMO

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The objective of this presentation is to illustrate that the principle of superposition of power is not always valid in electrical engineering and hence not applicable to analysis of multi antenna systems where multi-streams are affected by mutual interference. In electrical engineering, it is the voltage and the current that always can be superposed and that is why another name of it is field theory, as the voltages and the currents are the results of the fields. Examples are presented to illustrate how the Maxwellian physics can be introduced to improve the system performance of multi antenna systems. This group also includes MIMO systems. The first objective of this presentation is to define the appropriate metric for comparison of performance between various multiantenna systems. In addition, when comparing the performance between systems, the input power needs to be the same for all the systems, as it is not clear how one excites an antenna in theory using a priori power, as antennas are excited with voltage sources just like in circuit theory. It becomes clear that the use of the Hartley definition of channel capacity is more appropriate to use for a multiantenna system rather than the Shannon Channel capacity which uses the superposition of power as Shannon did not develop the theory for wireless systems where the presence of self-interference is the limiting factor in the performance of a system rather than background thermal noise. From a physics perspective, it is illustrated that a 1×1 SISO system may perform better than a 2×2 MIMO system under specific circumstances. However, as the concept of channel capacity is developed on purely mathematical grounds based on entropy, it is difficult to relate the physics to the mathematics as the capacity is defined with respect to background thermal noise whereas no receiver can accept a signal weaker than 100 μV/m in the absence of interference, which is far above the background noise. One of the goals is also to illustrate that an $N\times N$ MIMO system does not necessarily have better performance than N separate SISO systems, using the same total input power. In addition, a zero-forcing scheme is presented where decoupling receivers in a MIMO broadcast scenario allows the direct use of the Hartley definition of capacity. Numerical examples are presented to illustrate this scenario and a comparison in performance with conventional systems is made illustrating that this system can perform equally well.