**Notes on MIMO + AN:**

**Useful references to read**

**A survey on multiple antenna techniques for physical layer security**

* P4, table with different scenarios for CSI acquisition at both end. We investigate full CSI @ legitimate RX and statistical CSI @ eavesdropper.
* AN :
  + Short distance interception: when eavesdropper close to TX 🡪 one of the AN injection motivation.
  + 93, 94: explain concept of AN injection for guaranteeing secrecy.
  + 99 : robust beamforming scheme when partial CSI @B and @E.
  + 100/101: secure MISO/MIMO when perfect CSI @B and partial @E
  + 102/103: secrecy performance analysis in SF and FF environments when multiple antennas and AN injection. 103: waterfilling power allocation strategy

SF: outage probability seems to be more appropriate

FF: ergodic SR seems to be more appropriate.

* + 104: Analysis of performance when imperfect CSI of legitimate RX due to limited feedback 🡪 derivation of power allocation technique for signal + AN when limited amount of feedback
  + 107/108: AN sent by the legitimate RX (fig 3b)
  + 109: AN sent by TX and Bob (fig 3c)

**Classifications and Applications of Physical Layer Security Techniques for Confidentiality: A Comprehensive survey**

* FD + AN:
  + 136: MIMO OFDM system + AN injection. AN cancelled out at RX in the FD domain.
* SD + AN
  + 127: multiple antennas AN when Eve CSI not known and Eve knows Hb (FDD systems). In order the scheme to perform, we need: Nt > Nb and Nt > Ne
  + 143 and 158: Orthogobal blinding achieves >0 secrecy in full MIMO systems.
  + 144: AN + spatial beamforming in MISO system in the presence of multiple eavesdropper and not wiretap CSI known
  + 146 and 159: randomized beamforming is presented: time varying multiplicative noise to prevent eavesdropping
  + 160: Artificial Fast Fading
  + 145 and 161: full duplex jamming signal sent by the legitimate RX and data sent by A.
* SD + TD + AN
  + 147/148: Spatial + temporal dimensions used to inject AN in MISO/MOM-ME OFDM scheme
* **Applications of PLS starting from p32**

**Hybrid Spatio-Temporal Artificial Noise Design for Secure MIMOME-OFDM Systems (ref 148 big survey)**

* Determination of when it is preferable to use spatial or temporal AN injection (in which scenario one of the schemes performs better)
* Under a total power constraint, advantage of the hybrid AN injection scheme over pure temporal or spatial scheme.
* Scenario: A,B,C with multiple antennas, Alice knows Bob CSI and Eve knows all CSIs (best case scenario for Eve). Eve is passive. In our future work, we will consider multiple knowledges @E depending on handshaking protocol –> enhancement on this scenario.
* Data encoded in FD but AN injected in the TD corresponding OFDM block and then in the SD.
* TD AN: thanks to multiple antennas
* SD AN: thanks to OFDM CP.
* N subcarriers over which Ns data streams are sent per subcarrier. Na TX antennas.
* Needs Na > Ns, i.e., more TX antennas than data streams to implement spatial AN. In fact, if Na = Ns, the matrix per subcar is full rank and square such that no AN can be injected in the null space.
* 2 decoding structures:
  + All subcarriers jointly: taking into account the correlation among the subcarriers due to the temporal AN
  + At each subcarrier separately. Consider each subcarrier as a MIMO channel.
* Power allocation strategy bw AN and data:
  + High SNR, large Na: equation (31). If Ne = Ns , optimal to inject 50% AN and 50% data. If Ne >> Ns, only data is preferable.
  + Low SNR, large Na: equation (34): Alice should prefer to inject only data
* Temporal vs spatial AN:
  + Alice encodes data independently at each subcarrier 🡪 Bob can perform per subcar processing. At Eve, the temporal AN is not in her null space 🡪 the different signals at each subcar are correlated 🡪 Eve needs to make joint processing on all subcarriers 🡪 temporal AN makes decoding strategy at Eve more complicated.
  + Na = Ns only temporal AN can be implemented since subcarrier matrix is a full rank square matrix 🡪 No null space can be found (from nullity-rank theorem)

**Security and Energy Harvesting for MIMO-OFDM Networks**

* Hybrid spatial and temporal AN injection
* Tradeoff between security and energy harvesting at Bob
* Passive eavesdropper
* Prob at Bob: Need relatively complex post processing to perform energy harvesting.

**🡪 Seems like no article treating on frequency + spatial AN design**