2nd URSI AT-RASC, Gran Canaria, 28 May – 1 June 2018

# Precise localization of multiple non-cooperative objects in a disordered cavity by wavefront shaping

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Wave propagation in a disordered cavity is known to yield a completely scrambled, speckle-like wave field. Typical indoor environments constitute (low quality factor) disordered cavities for microwaves due to the presence of many reflecting and scattering objects. Therefore, probing an indoor scene to localize objects with waves in combination with traditional ray-tracing tools is (almost) unfeasible. Nonetheless, it is well known that information about the object position is encoded in the Green's function. This enabled uniquely identifying the location of a source in a disordered cavity after a dictionary of the Green's functions for different source locations had been established [1]. The process of correlating the measured Green's function with the dictionary entries may be interpreted as a simulated Time Reversal experiment.

Here, we start off by tackling the case of passive (i.e. non-emitting) objects inside a cavity. Indeed, the scattering contribution of such passive objects to the Green's function between two arbitrary points in the cavity also uniquely encodes the object position. Borrowing the assumptions of DRAWS (Diffusive Reverberant Acoustic Wave Spectroscopy [2]), we can decompose the spectrum of the transmission between two arbitrary antennas into the static cavity contribution and the contribution from each object. We demonstrate in the microwave domain that the object contributions are unique, as illustrated in Fig. 1(b). The ability to unravel this interplay permits us to localize *multiple passive* objects in a disordered cavity.

Next, we replace the temporal degrees of freedom (DoF) of the broadband transmission measurement with spatial DoF obtained by Wavefront Shaping [3,4]. Using simple electronically reconfigurable reflectarrays partially covering the cavity walls, as depicted in Fig. 1(a), we measure the single-frequency transmission between two arbitrary points for a series of random configurations of the cavity boundaries. We show that this, too, yields unique signatures, as displayed in Fig. 1(c). We demonstrate the localization of *multiple passive* objects with *single-frequency* measurements by wavefront shaping.

Finally, we discuss the minimum number of DoF needed to successfully localize multiple objects.

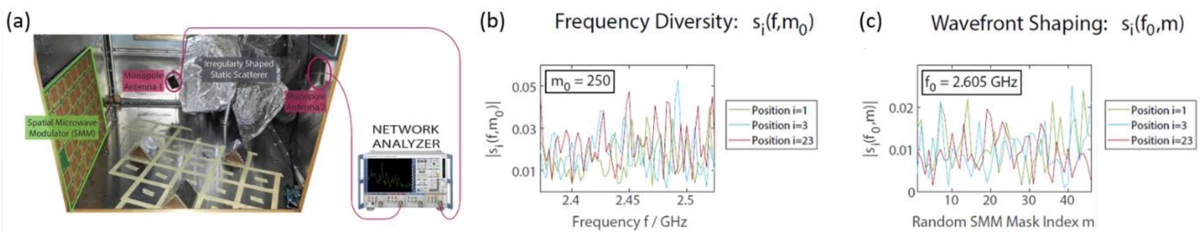


**Figure 1.** (a) Setup. Sample dictionary entries $\boldsymbol{s_i}$ of the scattering contribution of a passive object at position $\boldsymbol{i}$, (b) from the broadband approach; (c) from the wavefront shaping technique.

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