Super-resolution property in near and far field based on time reversal

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Compact antenna arrays are appealing due to sub-wavelength inter-element spacing and independent channels. For building multi-independent channels in the limited space of a mobile station, it is of great significance to study the time reversal (TR) technique, which was shown to achieve super-resolution focusing property to be applied for the design of compact antenna arrays (G. Lerosey *et al., Science*, **315**, 2007, pp. 1120-1122).

The TR bandwidth adopted has an important role in determining the super-resolution performance. It was concluded that TR at a single frequency resulted in lack of focusing property in the far field (P. Romain *et al., Physics Review A*, **87**, 2013, 041801) while phase-conjugation of a monochromatic wave equivalent to single-frequency time reversal exhibited the property of $\lambda/7$ resolution (λ as wavelength) focusing in the near field (O. Malyuskin *et al*, *IEEE Transactions Antennas and Propagation*, **58**, 2010, pp. 2884-2893). Besides, current investigations about TR super-resolution focusing are based on wide-band signal excitations, yet single-frequency models are far less frequent. Thus it is desired to present quantifiable results about the super-resolution performance of single-frequency TR in near and far field.

A sub-wavelength antenna array with inter-element interval of 1/35 wavelength is considered herein. To summarize, it consists of three coaxial probes around which is uniformly arranged a number of metal wires (random displacements of these wires from this uniform distribution are considered as well and corresponding results will be proposed at the symposium). Three ultra-wideband bowtie antennas are placed at some distance in order to be used as time-reversal mirror (TRM), receiving forward electromagnetic waves and radiating, as usual in this matter, time-reversed waves.

The distance between the antenna array and the TRM and the inter-element spacing of the metal wires have been in particular parametrically investigated via a number of numerical simulations (using CST MicroWave Studio®) so as to investigate their impact on the super-resolution characteristics. The focusing performances in the frequency domain with this TR technique are compared to those observed without TR. Then, a method of approach is proposed from this comparison. It is based on the analysis of frequency spectra of the wideband TR and enables to determine the frequencies such that the targeted antenna element exhibits the single-frequency super-resolution property in both near and far fields.

At the present stage of the analysis, the main hurdle is that the computations (here with CST MWS, but the same is expected from other brute-force 3-D codes possibly available) are very demanding since one has to model both array and TRM in a very accurate way, which impairs a systematic study. So a complementary investigation has been started on an ideal 2-D model of the whole system to allow more progress on the theoretical aspects at less computational cost. Results of this investigation will be discussed at the symposium as well.