Angular Self-adaptive Doppler Cloak Based on Space-time Modulated Metasurface

Xinyu Fang, Minghui Chen, Mengmeng Li, and Dazhi Ding
School of Microelectronics (School of Integrated Circuits)
Nanjing University of Science and Technology, China

Abstract — Doppler cloaks are engineered electromagnetic covers, based on (space-)time modulated metamaterials and metasurfaces, able to compensate the Doppler effect induced by the motion of a scattered, making it appears as if it were at rest to a detecting radar system. Perfect Doppler compensation can be theoretically always achieved for any relative velocity and motion direction of the cloaked scatterer with respect to the detecting system. However, the motion can be still detected from the cross-section variation of the Doppler cloaked scatterer, especially under oblique incidence illumination. The challenge is therefore to have a proper Doppler compensation and maintain the amount of scattered energy toward the detection system as much constant as possible with respect to the illumination angle. In this abstract, we propose the design of Angular self-adaptive planar Doppler cloak composed by a pair of space-time modulated metasurfaces: the first metasurface focuses the incident field in a specific location on the second metasurface, that is designed for enabling retro-reflection and Doppler frequency shift compensation. Here, the operative scenario is shown in Fig. 1(a), the self-adaptive Doppler cloak is applied to a metallic planar reflector, moving towards its normal direction, and illuminated by an oblique plane wave. We demonstrate that the proposed Doppler cloak can perform frequency conversion and simultaneously maintain the radar cross-section (RCS) of the reflector as much stable as possible within an angular range of about 60° centered at the normal direction, the Monostatic RCS comparison between a reference metallic plate and the Doppler cloaked is shown in Fig. 1(b). The self-adaptive Doppler cloak may enhance the undetectability of cloaked moving objects.

Figure 1: (a) Illustration of the operative scenario of angular self-adaptive Doppler cloak. The incident plane wave impinges obliquely on the Doppler cloaked metallic reflector that is moving towards the positive z-direction. The wave is reflected back toward the detecting antenna and at the same frequency of the incident one, despite the system is moving with a velocity $v$. (b) Monostatic Radar Cross Section of a reference metallic plate illuminated at the incident frequency $f_0$ and the Doppler cloaked metallic plate at the frequency shifted reflected frequency $f_0 + f_m$ within the operative angular range [0°–30°].