



Anthropogenic Electromagnetic Waves Observed by the Van Allen Probes

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While the majority of extra low frequency/very low frequency (ELF/VLF) electromagnetic waves observed in the inner magnetosphere are of a natural origin, some of these waves are due to an anthropogenic activity on the ground. We use high-resolution multicomponent electromagnetic wave measurements obtained by the EMFISIS instrument onboard the Van Allen Probes spacecraft to analyze the occurrence and propagation of these man-made emissions. First, we focus on so-called power line harmonic radiation (PLHR), i.e., electromagnetic radiation from electric power systems on the ground at frequencies corresponding to the harmonics of the base power system frequency. We demonstrate that PLHR is at times observed at considerable radial distances. A detailed wave analysis reveals that these waves typically propagate unducted, with an evidence for their bouncing between the hemispheres. Second, we analyze narrowband pulse emissions at a frequency of about 11.9 kHz coming from the Alpha navigation transmitters. This frequency is low enough that they there are readily detectable and their detailed wave analysis can be performed, allowing us to determine whether they propagate ducted or unducted. We show that the unducted propagating waves are detected more often, indicative of their larger spatial extent. However, the ducted propagating waves tend to have larger Poynting fluxes. Consequently, the transmitter signal powers propagating in the ducted and unducted modes are found to be roughly equal.