The Physics of Angular Momentum Radio

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Wireless communications, radio astronomy and other radio science applications of today are predominantly implemented with techniques built on top of the electromagnetic linear momentum (Poynting vector) physical layer. As a supplement and/or alternative to this conventional approach, techniques rooted in the electromagnetic angular momentum (moment of momentum) physical layer have been advocated, and promising results from proof-of-concept laboratory as well as real-world radio communication experiments using angular momentum were recently reported.

A sparingly exploited physical observable, the angular momentum describes the rotational (spinning and orbiting) physical properties of the electromagnetic fields and the rotational dynamics of the pertinent charge and current densities. In order to encourage and facilitate the exploitation of angular momentum techniques in real-world implementations, we present a theoretical review of the fundamental physical properties of electromagnetic angular momentum observable.

Starting from an overview that puts electromagnetic angular momentum into its physical context among the other Poincaré invariants of the Maxwell theory, we describe the multi-mode quantized character and other physical properties that sets electromagnetic angular momentum apart from the electromagnetic linear momentum. In particular, we show that the electromagnetic angular momentum density radiated from any arbitrary distribution of of charges and current densities, located in a volume of finite extent, invariably falls off asymptotically in space as the distance squared from this volume. These properties allow, among other things, a more flexible and efficient utilization of the radio frequency spectrum.

Implementation aspects are discussed and illustrated by examples based on analytic and numerical solutions and references are made to pertinent experiments.