Angular Momentum Radio Techniques

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Present-day state-of-the-art radio science and wireless radio communication techniques are almost exclusively based on the simple physical mechanism by which radiation is generated and detected by a one-dimensional (scalar) oscillating current modulated with information. This approach has the unavoidable fundamental physical limitation that it only utilizes the translational degrees of freedom of the EM field. The physical observables that describe these translational degrees of freedom are the mechanical linear momentum of the charged particles (also known as the charge degree of freedom), $\mathbf{p}^{\text{mech}}$, and the associated EM linear momentum (the volume integrated Poynting vector), $\mathbf{p}^{\text{field}}$. The inherently single-state vectorial observable $\mathbf{p}^{\text{field}}$ can propagate in free space to a remotely located receiving antenna where the reverse linear momentum exchange process takes place, allowing the information encoded onto $\mathbf{p}^{\text{field}}$ to be extracted from the induced mechanical momentum of the charges, *i.e.* the receiving antenna current.

However, as is well known, to completely specify the dynamics of any physical system, including an electromechanical system comprising particles and the pertinent EM field such as a radio antenna in action, it is not enough to account only for the translational dynamics, *i.e.* the *linear* momenta, of this system. To make full use of the information-carrying capacity of the EM field, one must also take into account the two- and three-dimensional rotational degrees of freedom, *i.e.* the mechanical and EM *angular* momenta of the system. These pseudovectorial observables describe the system's rotational dynamics that can neither be generated nor detected by linear dipoles or similar linear-momentum antennas but require actuators and transducers that are based on two- or three-dimensional (vectorial) currents.

We describe laboratory and real-world radio experiments in which beams encoded with orbital angular momentum (OAM) were used to transfer information. In particular, we present results from the use of PSK protocols and multiple-input-multiple-output (MIMO) multipath reflective techniques.