Non-spherically-decaying radiation from an oscillating superluminal polarization current: possible low-power, deep-space communication applications in the MHz and THz bands

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The emission of electromagnetic radiation from a superluminal (faster-than-light in vacuo) charged particle was first studied by Sommerfeld in 1904. However, the Special Theory of Relativity was published a few months later; prevailing scientific opinion then effectively curtailed the research field until Ginzburg and coworkers pointed out in the 1980s that no physical principle forbids emission by extended, massless superluminal sources. A polarization current density (d**P**/d*t*; see Maxwell's fourth equation) can provide such a source; the individual charged particles creating the polarization do not move faster than *c*, the speed of light, and yet it is relatively trivial to make the envelope of the polarization current density to do so.

Based on these principles, we have constructed a practical realization of an accelerated, oscillating superluminal source [1,2]. This provides precise control of the source speed over the range *c* to 2*c* and emits radiation chiefly at frequencies ~0.6 THz [1,2]. As described in theoretical [3,4] and experimental [1,2] papers that explore the physics of the practical machine, the emitted radiation has many unusual characteristics, including: (i) the intensity of some components decays as the inverse of the distance from the source, rather than as $1/(\text{distance})^2$ (i.e. these components are *non-spherically-decaying*); (ii) the emission is tightly beamed, the exact direction of the beam depending on the source speed; and (iii) the emission contains very high frequencies not present in the synthesis of the source. Note that the non-spherically-decaying components of the radiation do not violate energy conservation. They result from the reception, during a short time period, of radiation emitted over a considerably longer period of (retarded) source time; their strong electromagnetic fields are compensated by weak fields elsewhere [1].

In this presentation, we shall describe recent calculations and measurements that explore the geometry of the non-spherically-decaying radiation. We show that the emission occupies a very small polar angular width of order 0.8 degrees in the far field. Based on these findings, we suggest that a superluminal source could act as a highly directional transmitter of MHz or THz signals over very long distances. Such a machine would have very low power requirements compared to a conventional transmitter, making it suitable for communication to and from deep space probes.

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