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From Small THz Arrays to Large Antenna Apertures for THz Beams Propagating to Large Distances: The THz Flashlight

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Abstract

For THz communication and radar, one may wish to maintain a tight antenna beam out to significant distances, still in the near field. While THz arrays may be quite small, one can expand the beam out to larger diameters by appropriate reflectors (or lenses) so as to keep the beam collimated to large distances.

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1. Introduction

Recent papers [1, 2] have discussed how to increase the energy radiated in a THz pulse by use of switched oscillators driving zig-zag (or meander or serpentine) planar antennas with conducting surfaces $\leq \lambda / 4$ (in the dielectric) behind the antenna. Besides a single-ended system, the concept applies to differential and quad geometries driven by a single switch driven by a femptosecond (*fs*) laser. These in turn can be combined into arrays as discussed in [2].

With an array in the centimeter size, the beam will diverge after

$$\ell \simeq 2\frac{D^2}{\lambda} = 2\frac{(0.01)^2}{6\times10^{-4}} = \frac{1}{3}\,m \tag{1.1}$$

for an assumed

$$\begin{aligned} D &= 1\,\text{cm} \\ f &= 500\ \text{GHz} \\ \lambda &= \frac{c}{f} = 0.6\ \text{mm} \\ \ell &\simeq 2\frac{D^2}{\lambda} = \frac{2(0.01)^2}{6\times10^{-4}} = 0.33\ \text{m} \end{aligned} \tag{1.2}$$

For propagating to larger distances we need larger array diameters, or some other way to expand the beam near the source. For example a 10 cm diameter array would give

$$\ell \simeq 2\frac{D^2}{\lambda} = \frac{2(0.1)^2}{6\times10^{-4}} \simeq 33\ \text{m} \tag{1.3}$$

2. Using Telescope Techniques

A commonly used telescope design (optical and radio telescopes) is known as a Cassegrain antenna. As shown in Fig. 2.1, this might take the simple commonly used form. Now a (relatively) small source array propagates an approximate plane wave toward a secondary reflector which converts the wave into a spherical form to be reconverted into a large-diameter plane wave. Now we can start to think big with

Looking at Fig. 2.1, this starts to look like a flashlight. So we might call this a THz flashlight. (The British might prefer THz torch.)

Table 2.1. Beam distance vs. antenna aperture.

D	ℓ
0.1 m	33 m
0.2 m	133 m
0.5 m	0.833 km

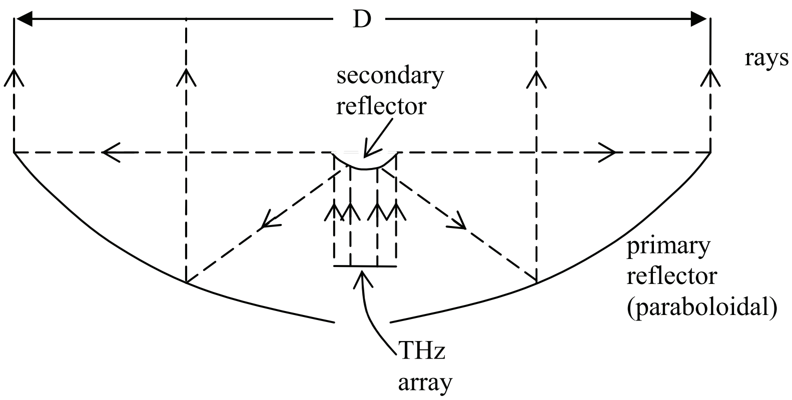

Fig. 2.1 Cassegrain THz Antenna

3. Receiving System

Now, this beam of diameter D (out to a distance ℓ) needs to be detected by one's intended receiver. The first step is to concentrate this beam. By the reciprocity theorem, good transmitting antennas make good receiving antennas. So take the Cassegrain antenna in Fig. 2.1 and run it in reception.

The difference between transmission and reception lies in the design of the receiving/discriminating/downconverting system near the focus. While the antennas may be of the same type, there is no switched oscillator. Some matching device, such as a quarter-wave transformer, can change the impedance presented to the detection device (rectifier, etc.). That is, however, another subject.

4. Concluding Remarks

As we can see, using optical and microwave techniques, such as used in telescopes, can be quite appropriate in the THz regime. Beams can be propagated, before divergence, to significant distances without being overly large.

References

1. M. E. Shaik, C. E. Baum, and C. Christodoulou, "Integrated Switched Oscillator and Zig-Zag Antenna with Photoconductive Semiconductor Switch as a Terahertz (THz) Pulse Transmitter", Sensor and Simulation Note 541, July 2009.

2. C. E. Baum, P. Kumar, and S. Altunc, "Arrays of Zig-Zag Antennas Driven by Switched Oscillators", Sensor and Simulation Note 542, August 2009.