NATURE | NEWS

Adding a twist to radio technology

Spiralling radio waves could revolutionize telecommunications.

Edwin Cartlidge

02 March 2012

The research on which this story is based has now been published in the New Journal of Physics. Nature's coverage, published on 22 February, 2011 and presented again below, is based on the version of the paper submitted to ArXiv[1].

Marcus Mok/Corbis

Twisted radio waves could free up more bandwidth for mobile phones and computers.

The bandwidth available to mobile phones, digital television and other communication technologies could be expanded enormously by exploiting the twistedness as well as wavelength of radio waves. That is the claim being made by a group of scientists in Italy and Sweden, who have shown how a radio beam can be twisted, and the resulting vortex detected with distant antennas.

The simplest kind of electromagnetic beam has a plane wavefront, which means that the peaks or troughs of the beam can be connected by an imaginary plane at right angles to the beam's direction of travel. But if a beam is twisted, then the wavefront rotates around the beam's direction of propagation in a spiral, creating a vortex and leaving the beam with zero intensity at its centre.

Physicists have been able to create twisted beams of visible light for about 20 years, having initially noticed that such beams were being produced inside some laser cavities. These twisted beams of light are useful in nanotechnology, as optical 'tweezers' or 'spanners' to manipulate tiny particles. To date, however, no-one has attempted to do the same thing at the radio wavelengths used in telecommunication.

Spiral waves

Now, a group led by Bo Thidé of the Swedish Institute of Space Physics in Uppsala and Fabrizio Tamburini of the University of Padua, Italy, has succeeded in twisting the waves emitted by the type of antenna used by standard wireless routers to transmit data over long distances[1]. The team did this by reflecting the waves off an eight-stepped, spiral-staircase-like structure positioned a couple of metres from the antenna, the axis of which lined up with the beam. The idea was that different sections of the wavefront would bounce off different steps, introducing a delay between the reflection of neighbouring sections and so causing the wavefront to become twisted and take on the shape of the reflector.

To prove that they really had twisted the beam, Thidé and his colleagues measured the beam's intensity with a pair of antennas seven metres away. They found that the combined intensity from the two antennas varied as they kept one fixed and moved the other around in a plane at right angles to the beam. This, they point out, is what would be expected if different portions of the wavefront traverse the plane at different times. The signals registered by the two antennas would be in-phase (that is, two peaks or two troughs), out of phase or somewhere in between depending on their relative orientation. The intensity pattern more or less matched that predicted by a computer simulation of the propagating twisted beam.

Thidé, Tamburini and others recently showed how this detection scheme, carried out using radio telescopes, could identify the tell-tale twisted radiation from spinning black holes[2] (see 'How to spot a spinning black hole'). But Tamburini thinks it could also have "revolutionary" implications for radio communications. He envisages that just as waves of different frequencies can propagate together without interference — thereby multiplying the number of signals that can be sent between an emitter and a receiver — so too could bandwidth be expanded by simultaneously transmitting waves with the same frequency but different degrees of twistedness.

The next important milestone will be the demonstration of twisted radio transmission in noisy, real-world conditions — so far the experiments have been done in an electromagnetically and acoustically insulated room at the University of Uppsala. The researchers hope to start testing a partially spiralled satellite dish within the next few days, then to use a similar device to transmit a twisted radio beam several hundred metres across the lagoon in Venice three months from now.

Tamburini thinks that the bandwidth available to mobile phones and laptop computers could be increased by a factor of nine almost immediately, and at relatively little extra cost, by carefully positioning four antennas inside the devices. He estimates that this technology could enter the market within the next two to five years. Technological improvements could make even more bandwith available.

Taco Visser, an electrical engineer at Delft University of Technology in the Netherlands, thinks that twisted radio beams would "certainly increase capacity" in telecommunication channels. But he cautions that atmospheric turbulence, which causes fluctuations in the amplitude and phase of a signal, would probably limit the extent to which beams could be twisted and therefore restrict the number of available channels. He also says it is not clear how portable devices such as mobile phones could emit such twisted beams, because each channel would require its own spiral reflector.

However, Tamburini says that he has devised a scheme in which individual spiral reflectors are not needed. He has shown in a simulation that this scheme works and is now looking to build a prototype system and patent it, adding that the most complicated aspect is how to send and recieve twisted beams from a device when it is moving about.

Visser says that the work could also have other useful applications. For example, he says, radio waves could be used to make a scaled-up version of an optical spanner. So rather than manipulating objects just a few millionths of a metre across, twisted radio waves could be used to manoeuvre objects several millimetres long. Conceivably, he says, this could allow small toxic or radioactive objects to be handled remotely.

Nature | doi:10.1038/nature.2012.10160

References

1. Thidé, B., Tamburini, F., Mari, E., Romanato, F. & Barbieri, C. *Preprint at* http://arxiv.org/abs/1101.6015 (2011).
2. Tamburini, F., Thidé, B., Molina-Terriza, G. & Anzolin, G. *Nature Phys. advance online publication* doi:10.1038/nphys1907 (2011).