



Riding the Waves



Graduate Research at the *Uoft*
Electromagnetics Group

Prof. Costas D. Sarris



Outline

- What is Electromagnetics
- Who we are; what we do
- Careers in Electromagnetics

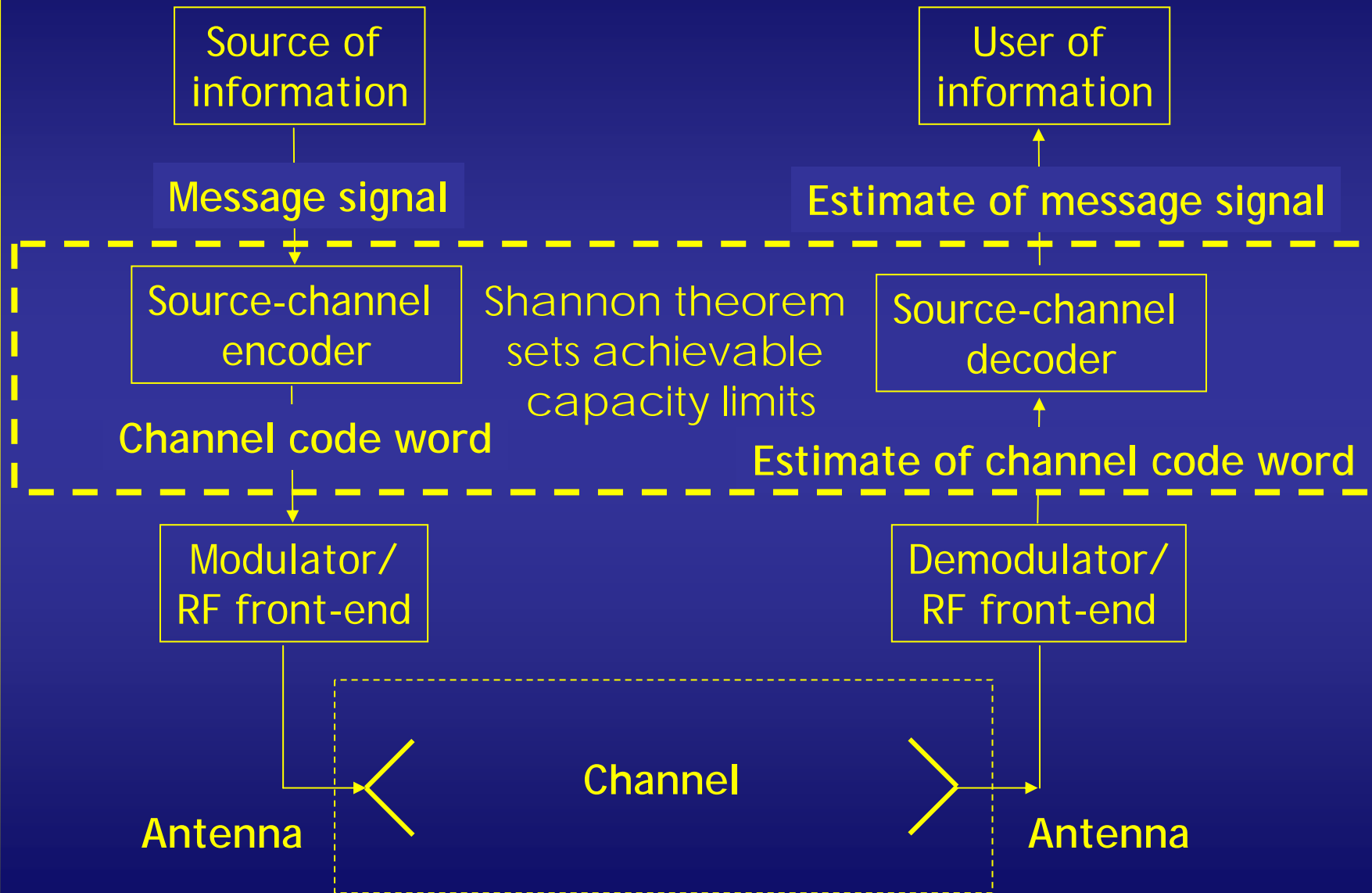


Electromagnetics

- Main theme:
 - Generation, propagation of electromagnetic waves in natural or artificial media



Electromagnetics and Wireless





Electromagnetics and Wireless

NEAR SHANNON LIMIT ERROR - CORRECTING CODING AND DECODING : TURBO-CODES (1)

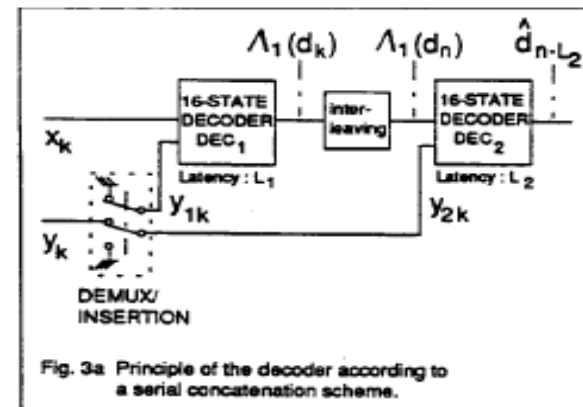
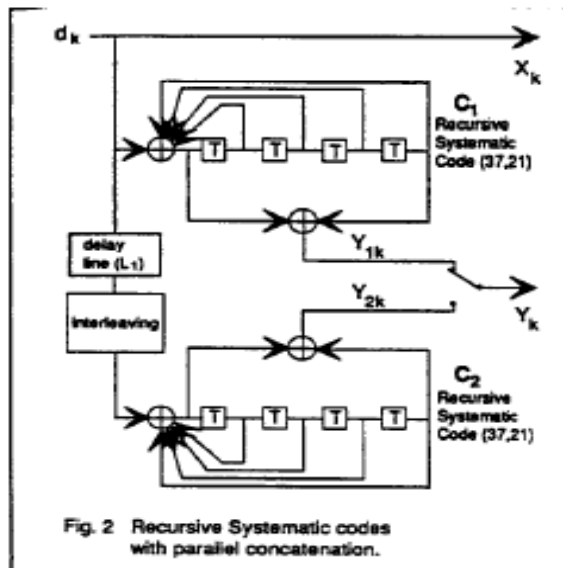
Claude Berrou, Alain Glavieux and Punya Thitimajshima

Claude Berrou, Integrated Circuits for Telecommunication Laboratory

Alain Glavieux and Punya Thitimajshima, Digital Communication Laboratory

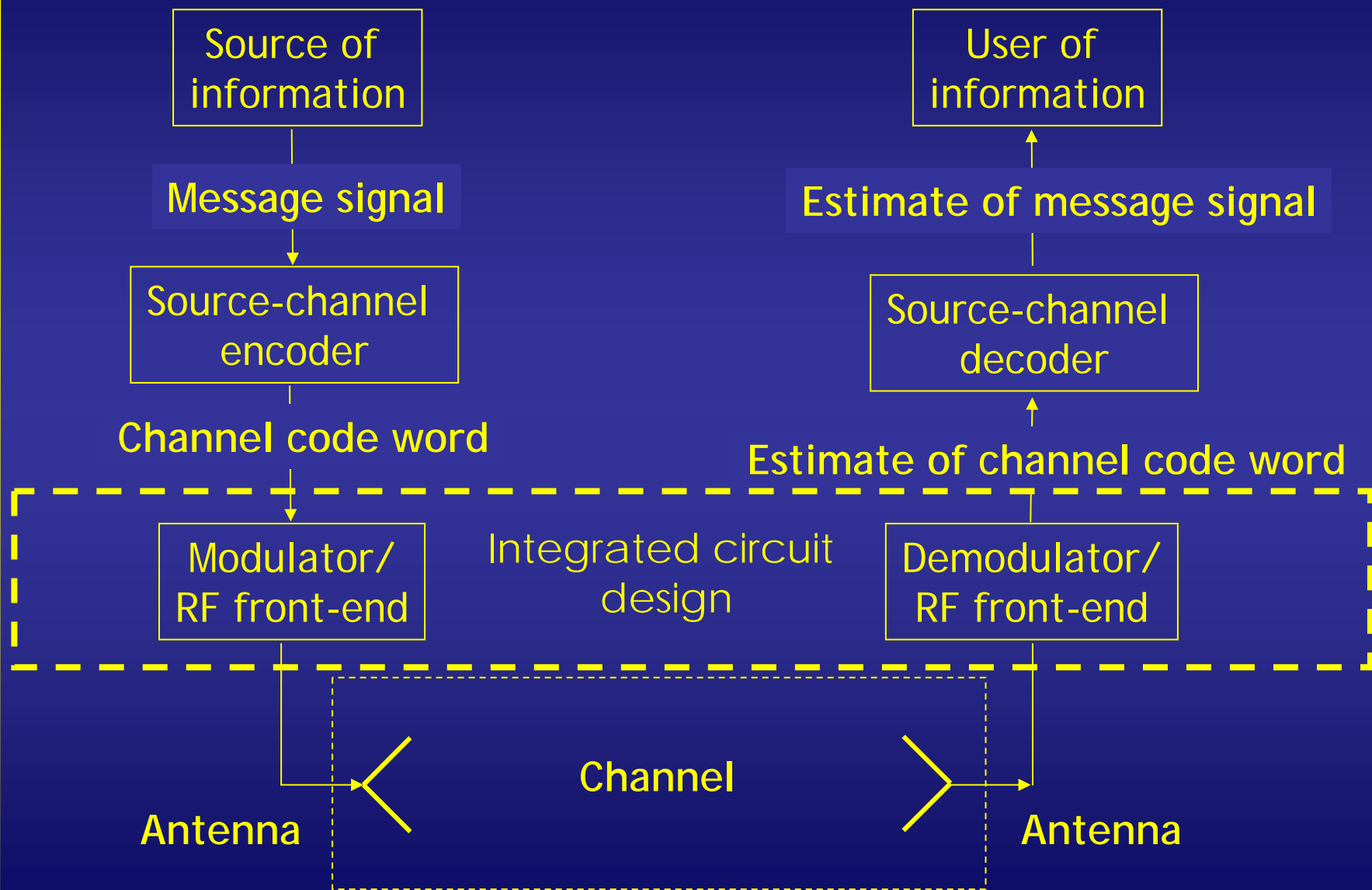
Ecole Nationale Supérieure des Télécommunications de Bretagne, France

(1) Patents N° 9105279 (France), N° 92460011.7 (Europe), N° 07/870,483 (USA)





Electromagnetics and Wireless





TECHWORLD

The UK's infrastructure & network knowledge centre

Gordon Moore Says Moore's Law is Dead

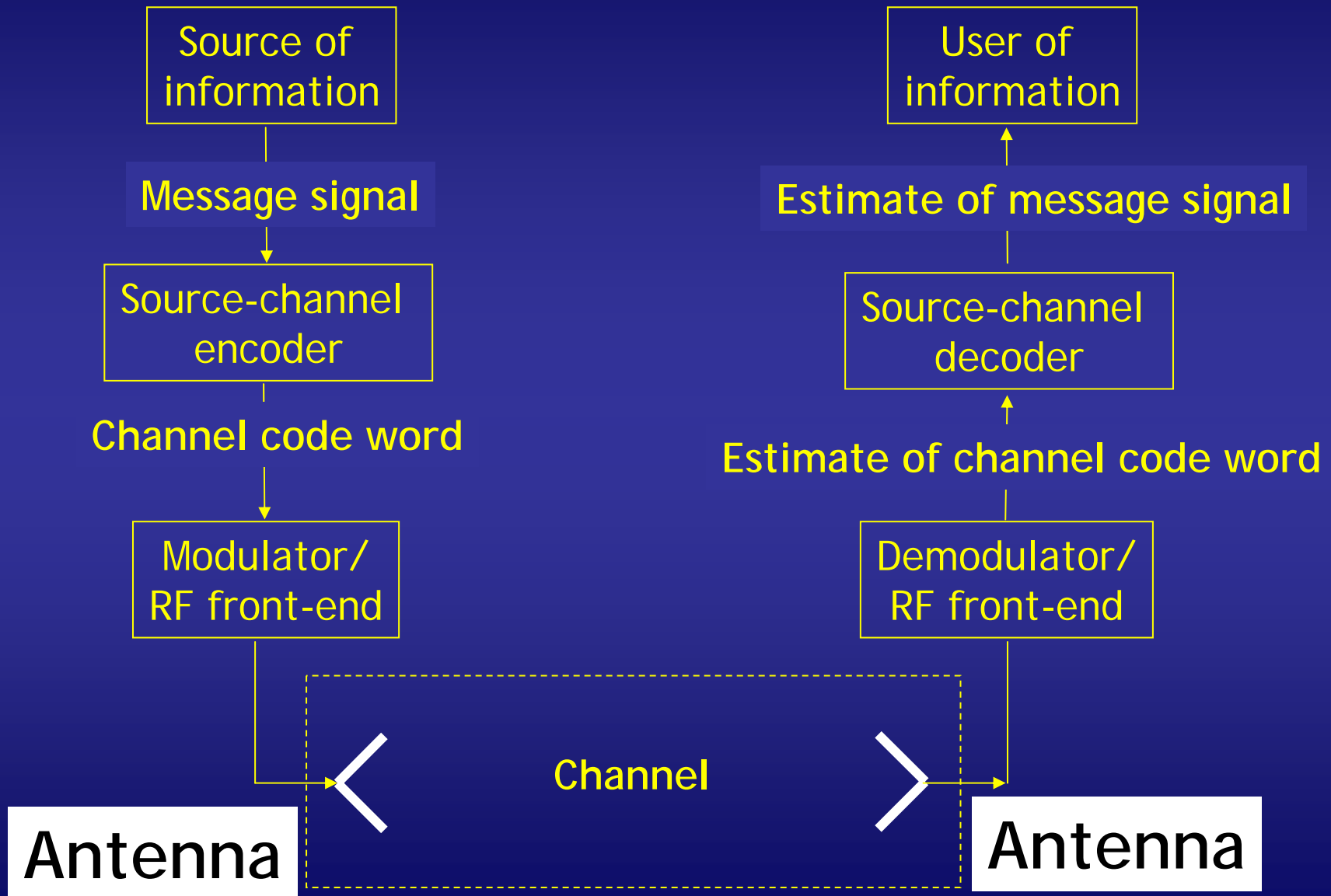
Back at the start of the computer revolution Gordon Moore came up with the fabled Moore's Law which states that transistor density on integrated circuits doubles about every two years.

Moore himself is now saying that his law will be obsolete in two to three generations on integrated circuits. In a quote from [TechWorld](#) Moore states that the exponential growth cannot continue forever.

Moore goes on to say that, we have another 10-20 years before we reach a fundamental limit, the size of the atom. He reckons that by then we will have the ability to make bigger chips with transistor budgets in the billions.



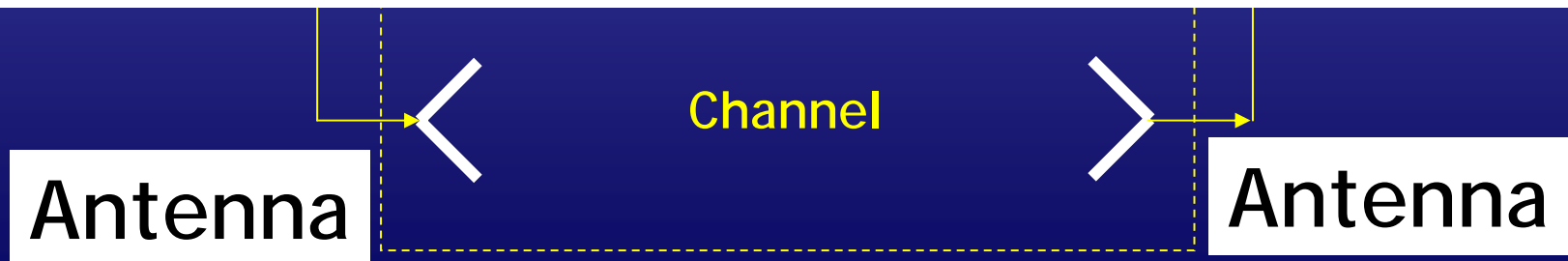
Electromagnetics and Wireless (II)





Electromagnetics and Wireless (II)

Antenna design,
optimization,
miniaturization
is a broadly open
question





Electromagnetics: Metamaterials

OPTICS

Lens Once Deemed Impossible Now Rules the Waves

The new lens, which George Eleftheriades and Anthony Grbic of the University of Toronto describe in an upcoming issue of *Physical Review Letters*, fo-

The new lens, which George Eleftheriades and Anthony Grbic of the University of Toronto describe in an upcoming issue of *Physical Review Letters*, focuses microwaves—long-wavelength radiation that falls next to radio waves in the electromagnetic spectrum. By etching a flat plane of plastic with a wire grid studded with capacitors and inductors, the researchers created a material with a negative refractive index—one that bends waves in the opposite direction from normal materials. Because of transmission losses, lenses made from nor-

Unnatural lens. Wire grid flouts optical limits by boosting trapped microwaves.

mal materials cannot distinguish objects less than half a wavelength apart, but “left-handed” (negative-index) materials can. The new lens, for example, resolves objects just one-sixth of a microwave wavelength apart.

The left-handed lens achieves super-resolution by resurrecting waves that carry the subwavelength details of an object. Such so-called evanescent waves usually fizzle to nothing before they pass through a conven-

for Theoretical and Applied Electromagnetics in Moscow announced a super-resolving lens, but their technique required the object to be almost touching the lens, making it impractical for real-life applications. The new lens overcomes that limitation.

Eleftheriades dreams of applying the left-handed lens to medical imaging. “If you were to scale down to the frequencies of an MRI (20 megahertz), you could place the human body 1 meter away and still get super-resolution,” he says—a vast improvement over current instruments. —KIM KRIEGER



Who we are

- The Electromagnetics Group
 - 5 professors
 - Balmain (Ph.D., Illinois)
 - Eleftheriades (Ph.D., Michigan)
 - Hum (Ph.D., Calgary)
 - Mojahedi (Ph.D., UNM)
 - Sarris (Ph.D., Michigan)



Who we are (II)

- The Electromagnetics Group
 - State-of-the-art facilities
 - nanofabrication
 - antenna chamber
 - 96 processor cluster
 - radar cross-section measurement facility



Who we are: Research

- Metamaterials

Balmain, Eleftheriades, Mojahedi, Sarris

- Antennas, RF Components, Wireless Tech (UWB)

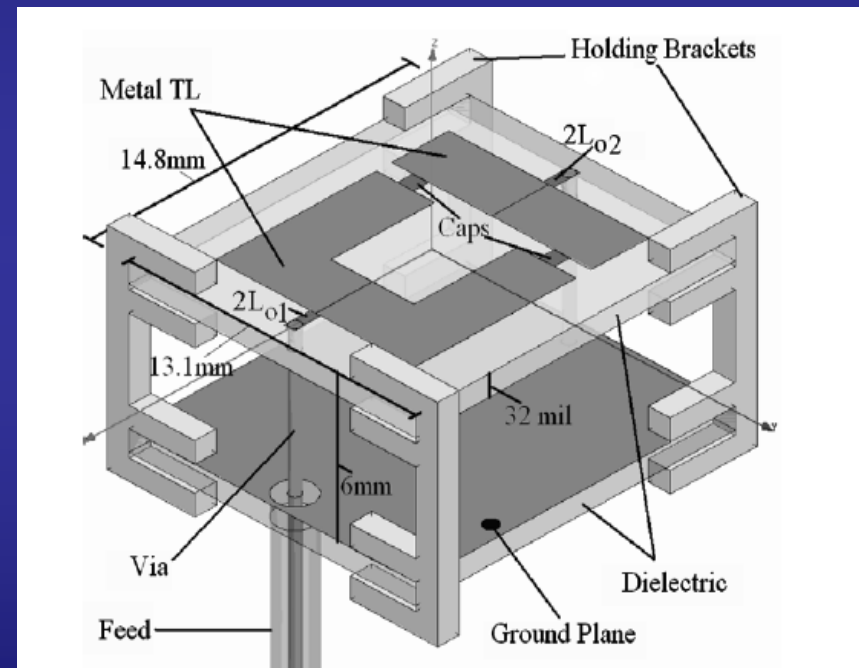
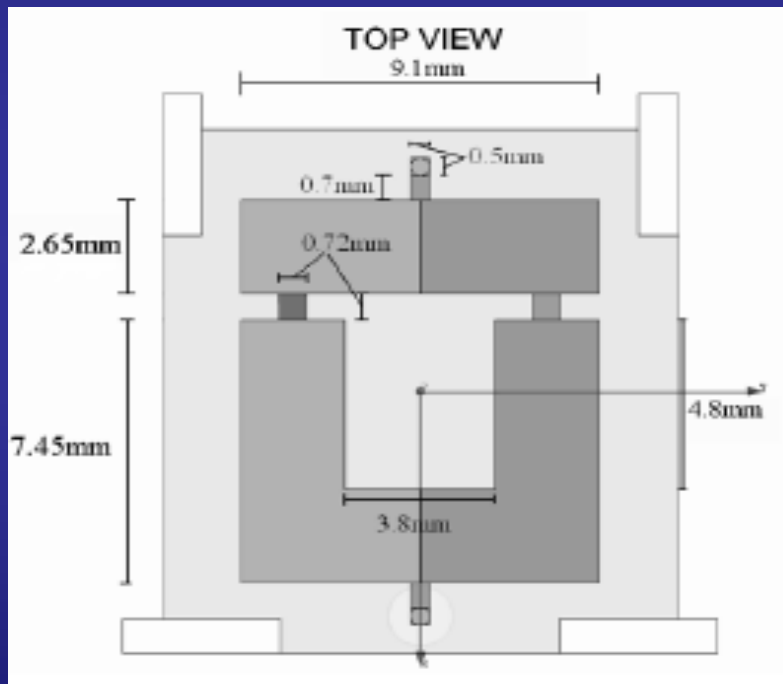
Balmain, Eleftheriades, Hum, Mojahedi, Sarris

- Modeling and Electromagnetic Compatibility

Eleftheriades, Sarris

Research examples

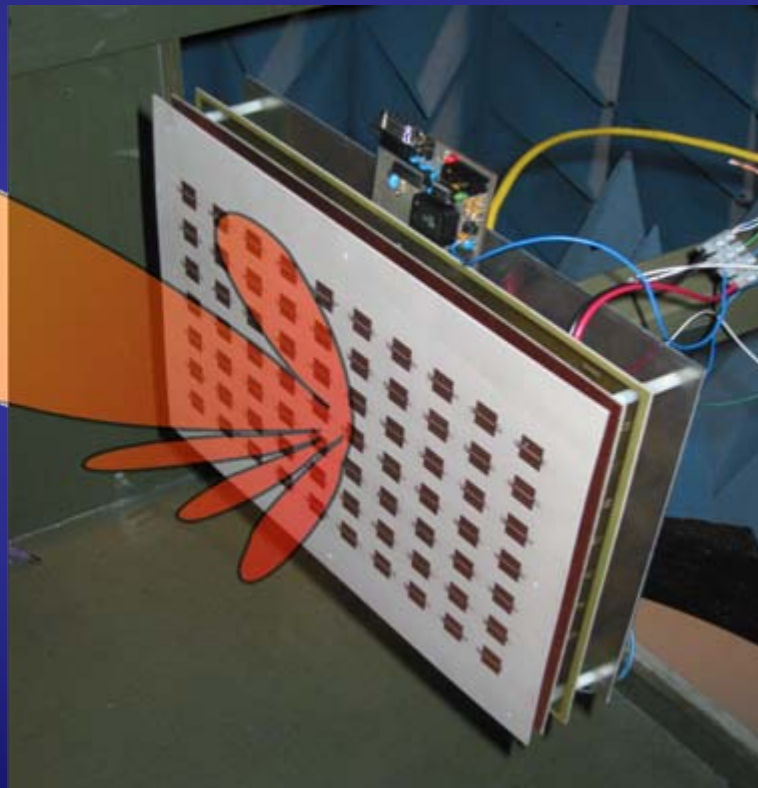
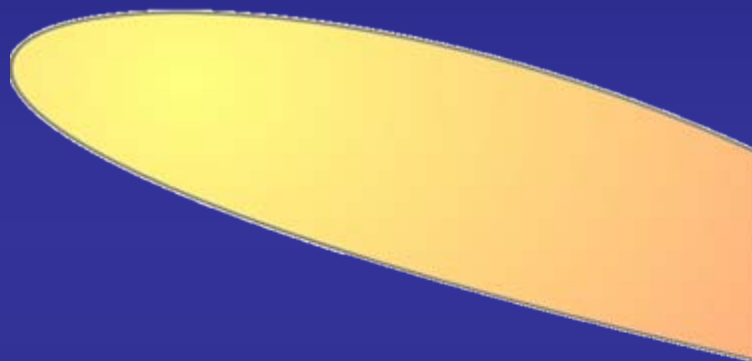
Small Antennas for Laptops (Prof. Eleftheriades; sponsor: Nortel)





Research examples

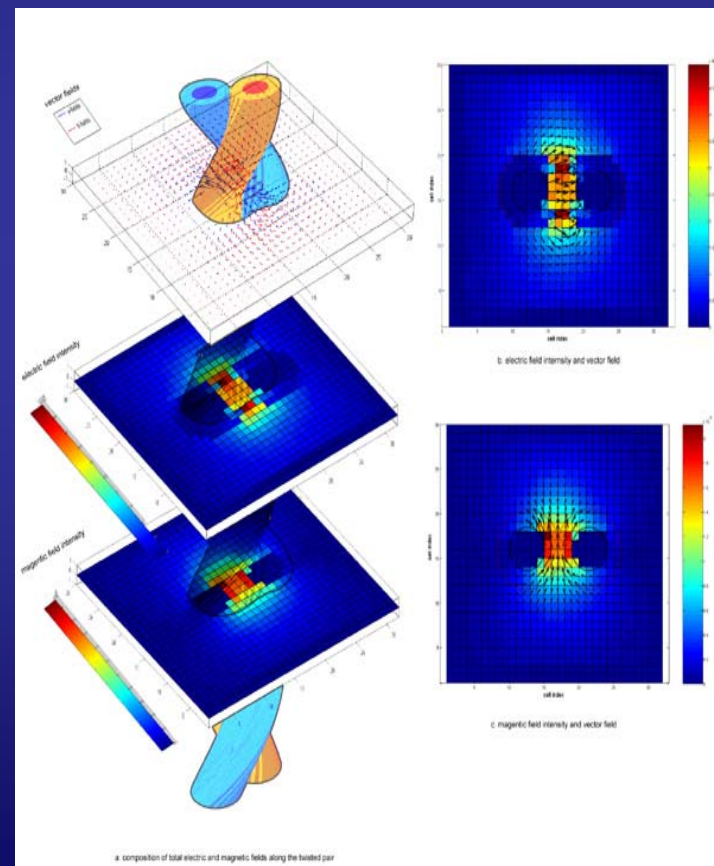
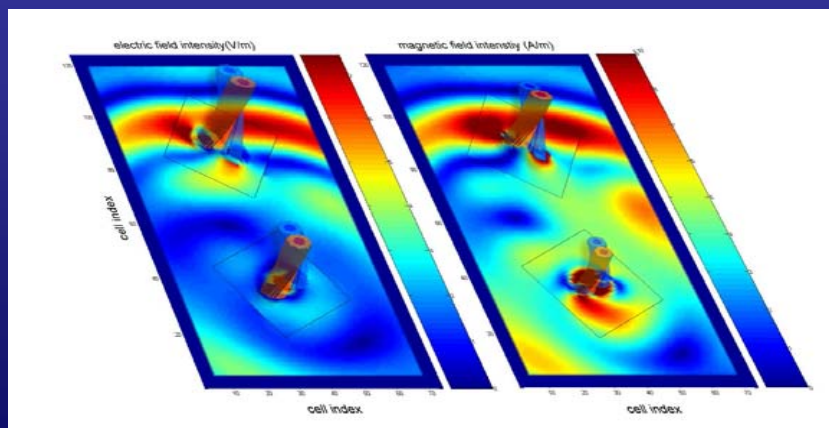
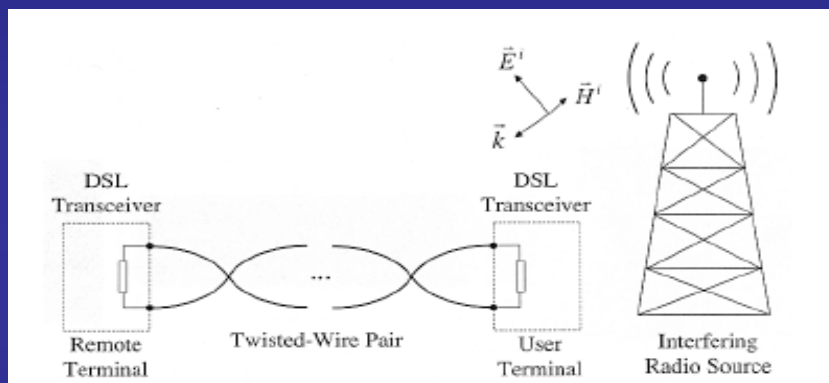
Tunable Reflectarrays (Prof. Hum)





Research examples

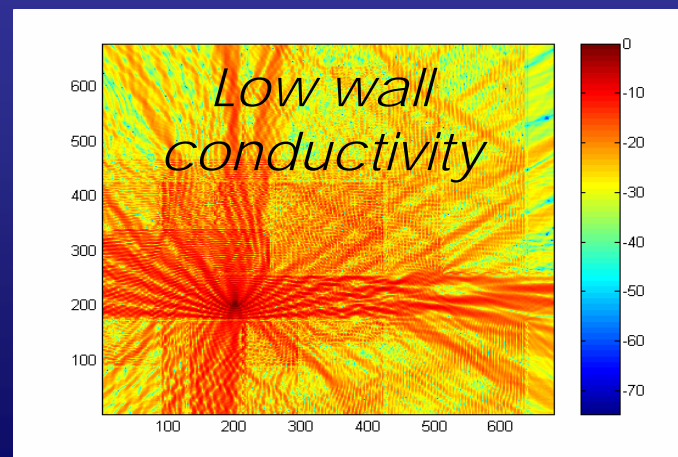
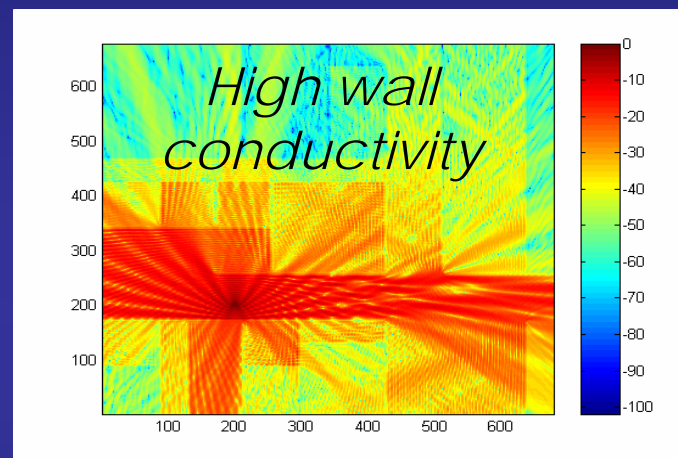
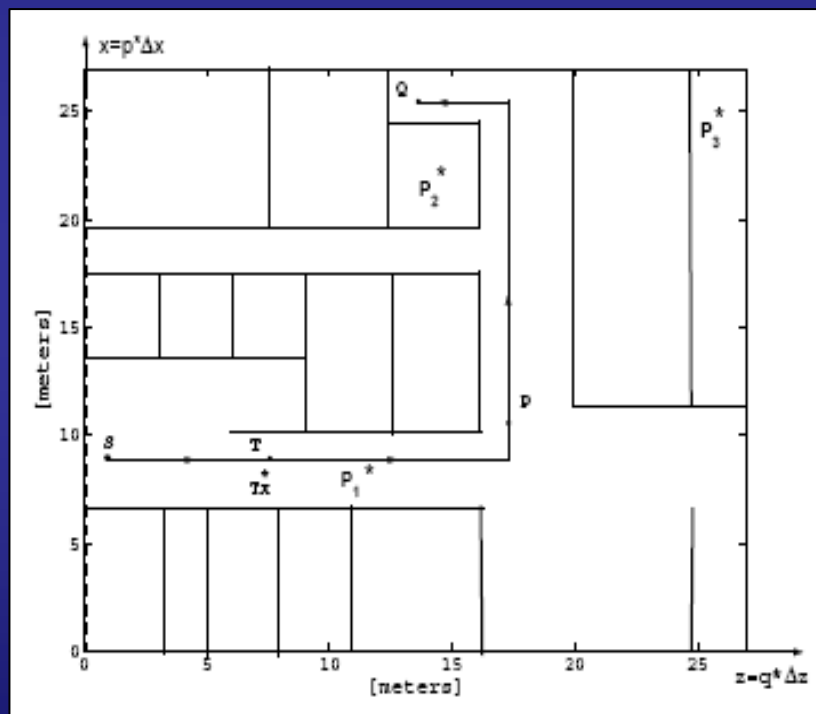
Electromagnetic Compatibility of DSL (Prof. Sarris; Sponsor: Bell Canada/NSERC/CITO)





Research examples

Ultra-Wideband Wireless Channel Modeling (Prof. Sarris; Sponsor: Bell Canada/NSERC)





EM Graduate Students

- EM graduate students have won several prestigious paper awards in international conferences:
 - Marco Antoniadis (1st place, IEEE International Symposium on Antennas and Propagation, July 2006).
 - Joshua Wong (1st place, IEEE International Symposium on Metamaterial Technology for Antennas, March 2006).
 - Several others..



Careers

- EM group graduates have received excellent positions in academia and industry:
 - **Tony Grbic**, Assistant Prof. at **Michigan**
 - **Ramesh Abhari**, Assistant Prof. at **McGill**
 - **J.-J. Laurin**, Prof. at **Ecole Polytechnique**, Montreal
 - Recent employers of EM graduates:
 - Nortel, IBM, Motorola, Free scale, RIM, ComDev



Questions?

Thank you !

www.waves.utoronto.ca