# *PhD Offer - Electromagnetic/haptic interfaces for human-centered communications*

**Supervisors:** G. Sacco, M. Zhadobov, and R. Sauleau (IETR, UMR CNRS 6164)

**Key words:** on-body sensors, millimeter-wave (mmWave), wearable stretchable antennas, conformal haptics.

**Context:** 6G will enable delay-sensitive and high-speed communications in many fields such as virtual and augmented reality, IoT, autonomous vehicles, smart wearables, real-time telemedicine, remote surgery and smart factory. Human-centered wireless interfaces are expected to become a part of emerging networks able to collect/transmit data from multiple sensors and provide a feedback to the user. This requires to rethink the antenna design to face the challenges related to integration at the level of the human body as well as integration with on-body sensors.

**Objective of the PhD project:** The project will contribute to the development of the new generation of wearable devices. It aims at the design of super-directive antenna arrays on conformal and stretchable substrates in the upper part of the microwave spectrum (26–28 GHz band and 60 GHz band). Thanks to the high directivity and reconfigurability, these antennas will enable high-data rate communications among wearable devices positioned on different body parts and/or an external transceiver. A network of stretchable haptic actuators will be integrated in the sensors to convey to the users in real time information about their posture or health condition through tactile sensations. The antenna performances will be tested on solid stretchable and reconfigurable phantoms.

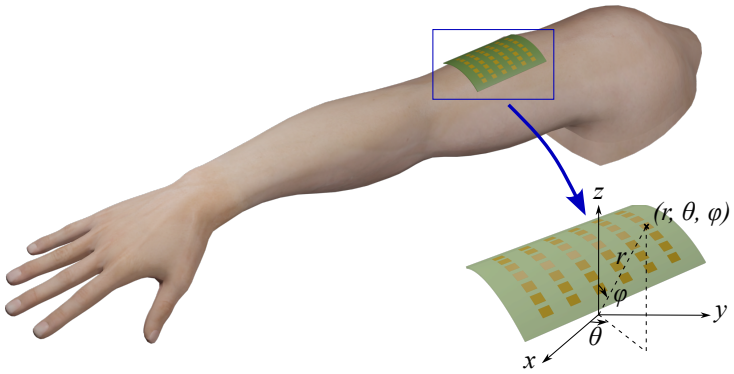


Figure 1: Example of a network of wearable sensors for health and sport performance monitoring.

**Candidate**

- Education: MS or equivalent degree in biomedical engineering, electrical engineering, or physics.
- Background: knowledge in antenna design, electronics, bioelectromagnetics, numerical modelling. Experience with commercial or open-source numerical solvers (e.g., CST, Ansys, SIM4LIFE, COMSOL Multiphysics) and programming skills (e.g., MATLAB, Mathematica) are welcome but not mandatory.
- Fluency in English: the candidate should be conversant and articulate in English and must have strong writing skills. Knowledge of French is not required but would be appreciated.

**Research environment:** The PhD student will join Electromagnetic Waves in Complex Media Team (eWAVES) of the IETR/CNRS. IETR is one of the leading EU research laboratories in electronics, wireless communications, and digital technologies. Our research activities in biomedical electromagnetics cover a wide spectrum of fundamental and applied research spreading from multi-physics and multi-scale modelling to biomedical radars and advanced technologies for body-centric wireless communications. The team was at the origin of pioneering innovations in biomedical electromagnetics, including the first millimeter-wave (mmWave) tissue-equivalent phantoms, novel

Université de Rennes 1, Campus de Beaulieu, Bât. 11D, 35042 Rennes cedex, France
Tél : +33 (0)2 23 23 58 49 giulia.sacco@cnrs.fr https://www.ietr.fr/

reflectivity-based surface phantom concept, new broadband multi-physics characterization technique for Debye-type materials, innovative mmWave textile antennas for smart clothing, ultra-robust miniature implantable UHF antennas, first mmWave reverberation chamber.

**Duration:** 36 months

**Funding:** Full 3 years scholarship provided.

**Application deadline:** May 15, 2024

**Starting date:** flexible (from December 2023 till November 2024)

**How to apply:** please provide your CV, transcripts, motivation letter, and reference letters (optional) to:

- Giulia SACCO, CNRS (giulia.sacco@cnrs.fr)
- Maxim ZHADOBOV, CNRS (maxim.zhadobov@univ-rennes.fr)
- Ronan SAULEAU, University of Rennes (ronan.sauleau@univ-rennes.fr)

**References:**


[1] G. Sacco, D. Nikolayev, R. Sauleau, and M. Zhadobov, "Antenna/human body coupling in 5G millimeter-wave bands: Do age and clothing matter?" *IEEE Journal of Microwaves*, vol. 1, no. 2, pp. 593–600, Apr. 2021.

[2] G. Sacco, S. Pisa, and M. Zhadobov, "Impact of textile on electromagnetic power and heating in near-surface tissues at 26 GHz and 60 GHz," *IEEE Journal of Electromagnetics, RF and Microwaves in Medicine and Biology*, vol. 5, no. 3, pp. 262–268, Dec. 2020, ISSN: 2469-7249, 2469-7257. (visited on 12/21/2020).

[3] X. Yu, Z. Xie, Y. Yu, *et al.*, "Skin-integrated wireless haptic interfaces for virtual and augmented reality," *Nature*, vol. 575, no. 7783, pp. 473–479, Nov. 2019, ISSN: 0028-0836, 1476-4687. (visited on 02/18/2021).

[4] A. R. Guraliuc, M. Zhadobov, O. De Sagazan, and R. Sauleau, "Solid Phantom for Body-Centric Propagation Measurements at 60 GHz," *IEEE Transactions on Microwave Theory and Techniques*, vol. 62, no. 6, pp. 1373–1380, Jun. 2014, ISSN: 0018-9480, 1557-9670. (visited on 12/05/2021).

[5] N. Chahat, M. Zhadobov, S. Anwar Muhammad, L. Le Coq, and R. Sauleau, "60-GHz textile antenna array for body-centric communications," *IEEE Transactions on Antennas and Propagation*, vol. 61, no. 4, p. 9, Apr. 2013.