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## The human skin as a sub-THz receiver – Does 5G pose a danger to it or not?

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## ABSTRACT

In the interaction of microwave radiation and human beings, the skin is traditionally considered as just an absorbing sponge stratum filled with water. In previous works, we showed that this view is flawed when we demonstrated that the coiled portion of the sweat duct in upper skin layer is regarded as a helical antenna in the sub-THz band. Experimentally we showed that the reflectance of the human skin in the sub-THz region depends on the intensity of perspiration, i.e. sweat duct's conductivity, and correlates with levels of human stress (physical, mental and emotional). Later on, we detected circular dichroism in the reflectance from the skin, a signature of the axial mode of a helical antenna. The full ramifications of what these findings represent in the human condition are still unclear. We also revealed correlation of electrocardiography (ECG) parameters to the sub-THz reflection coefficient of human skin. In a recent work, we developed a unique simulation tool of human skin, taking into account the skin multi-layer structure together with the helical segment of the sweat duct embedded in it. The presence of the sweat duct led to a high specific absorption rate (SAR) of the skin in extremely high frequency band. In this paper, we summarize the physical evidence for this phenomenon and consider its implication for the future exploitation of the electromagnetic spectrum by wireless communication. Starting from July 2016 the US Federal Communications Commission (FCC) has adopted new rules for wireless broadband operations above 24 GHz (5 G). This trend of exploitation is predicted to expand to higher frequencies in the sub-THz region. One must consider the implications of human immersion in the electromagnetic noise, caused by devices working at the very same frequencies as those, to which the sweat duct (as a helical antenna) is most attuned. We are raising a warning flag against the unrestricted use of sub-THz technologies for communication, before the possible consequences for public health are explored.

## 1. Introduction

The world is galloping towards a bright new future, or at least so industry would like us to think. The advent of 5 G promises unforetold connectivity and unparalleled integration with the virtual world (Agiwal et al., 2016). Technology will interact with almost every aspect of our daily lives (Boccardi et al., 2014), as well as expose us to rich and varied data streaming on our cellular and Wi-Fi devices. While all of this may be true it comes with a price tag. To afford such heavy data traffic we must accept an expansion in data channels (Ben Ishai et al., 2016), something that is not possible in the currently used frequency channels, and an attendant explosion in base stations (Ge et al., 2016). This is the rationale to move to 5 G, a FCC standard, which will start at 28 GHz (FCC Report 16–89), soon utilize frequencies up to 60 GHz and may eventually reach the sub - Terahertz range (FCC 50–50 Report).

Industry has assumed that there will be no health risks from this advance (T. Wu et al., 2015a, 2015b) and consequently it has based its

planning on the recommendations of the International Commission on Non-Ionizing Radiation Protection (ICNIRP), published in 1998 (Guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields (up to 300 GHz). International Commission on Non-Ionizing Radiation Protection," 1998). This recommendation limits exposure in the 5 G range to a power density of 10 W/m<sup>2</sup> for the general public and to 50 W/m<sup>2</sup> for occupational exposure ("Guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields (up to 300 GHz). International Commission on Non-Ionizing Radiation Protection," 1998).

However, in recent years concerns have surfaced about possible non-thermal biological effects, and ensuing health issues, arising from cellular electromagnetic radiation (Adams et al., 2014; Blank and Goodman, 2009; Darbandi et al., 2017; Hardell and Sage, 2008; Liu et al., 2013; Panagopoulos, 2017; Sage and Carpenter, 2009; Terzi et al., 2016). These should raise a red flag for the implementation of the 5 G standard. One reason being that the modality of our interaction

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