**Nanoscale effects of gigahertz light on genomic DNA**

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**Abstract**

Electromagnetic radiation is known to interact with living matter through a range of mechanisms, many of which lie on the nanoscale. The effect of gigahertz radiation in the form of millimetre waves (MMWs) (30 – 300 GHz, 1 – 10 mm) on biological processes is less understood than many other frequencies as it is strongly attenuated by atmospheric oxygen, so natural exposure has historically been minimal.

However, studies have shown that these frequencies have non-trivial effects on humans, with therapeutic applications that utilise MMWs to treat a number of ailments emerging in several Eastern European nations. Additionally, multiple frequency bands within this range are being adopted in 5G mobile networking technologies, meaning it is important to investigate the biological effects from the context of both increased natural exposure and potential medical applications.

It has been established that exposure to MMWs induces a number of biological responses, including changes to the properties of biological membranes (Zhadobov *et al.* 2006), altered neuronal action potentials (Romanenko *et al*. 2019) and modified gene expression in cells (Millenbaugh *et al.* 2008), however the source of these effects is largely unknown. Initially attributed to the thermal effects associated with absorption, it has been shown that the changes in gene expression are distinct from the heating that occurs and are now thought to arise from nanoscale interactions with the genome (Habauzit *et al.* 2014).

G-quadruplexes (G4s) are nanoscale DNA secondary structures that can form within repetitive guanine-rich (G-rich) sequences of DNA or RNA. They consist of stacked G-quartet tetramers, in which four guanines exist in a cyclical Hoogsteen hydrogen-bonding arrangement. In DNA these structures form when transient single strandedness occurs, meaning they are more common in gene promoters and telomeres and have been linked to the regulation of gene expression (Verma *et al.* 2008). A number of mechanisms have been proposed by which MMWs may interact with DNA to modify G4 formation conditions, including the induction of resonances that cause transient single strandedness on the order of tens of base pairs, or several nanometers.

I will illustrate the effect of MMWs on biological processes, specifically describing the changes in gene expression and how these relate to nanometre modifications of the structure of DNA, such as G4 formation. Techniques including COL1 and BG4 immunofluorescene, and targeted qPCR allow for an understanding of the effects on gene expression and the formation of G4s to be described, relating the changes to the nanoscale interactions of MMWs with DNA.

**References**

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