

**Michael T. Ryan**

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Dear Mr Ryan

We are dismayed by the way in which ICNIRP have apparently used our 2007 paper (Glover *et al.*, 2007) to draw up its the recent Guidelines on low frequency magnetic field exposure (Ziegelberger, 2014). It appears that these Guidelines are going to be incorporated into the EMF Directive and made legally binding within the 28 member countries of the European Union without further scrutiny (Directive 2013/35/EU See Article 11(2) (2013)).

The guidelines' limits aimed at preventing vertigo are based entirely on our paper, which was effectively the first in the field, and which has not been replicated by anyone else. Although we stand by our data, it was a very small study, and the lines on figure 1 of the guidelines have been drawn about single data points from a single subjects at two frequencies (Ziegelberger, 2014). This seems to be a remarkably flimsy basis on which to make international guidelines.

However we are keen to point out that there was a more serious problem with using that data in this way. At the time we wrote the paper we proposed that the dominant mechanism was induced electric currents. However, as ICNIRP noted in the new guidelines, this mechanism has been questioned by Roberts who proposed a Lorentz force mechanism (Roberts *et al.*, 2011). Crucially ICNIRP apparently failed to realise that this Lorentz force mechanism depends on the amplitude and direction of the field, whereas the induced current mechanism depends on the absolute rate of change of field. In our experiment we asked subjects to move their head at high field: this would induce an electric current and would have also produced a Lorentz force, so our previous data was consistent with both mechanisms.

We have now carried out further studies that support Roberts' Lorentz force mechanism (Antunes *et al.*, 2012; Glover *et al.*, 2014; Mian *et al.*, 2013). Furthermore the new mechanism explains the previously anomalous observation of apparent vertigo-type effects in small rodents which are physically too small to be able to develop sufficient current densities in their heads to cause nerve excitation (Haupt and Haupt, 2010).

It now seems likely that the perceptual effects of the changing Lorentz force are the primary reason why movement causes vertigo. Unfortunately this does not lead to neat, frequency-dependent limits that can be dovetailed with other limits. We propose that at the current stage of knowledge, a practical way to limit the experience of vertigo would be to accept some disconnect in the limits, and simply apply the previous static field limit. I.e. 2 T for uncontrolled exposure and 8 T for controlled exposures.

Yours Sincerely

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