Polarisation of 50 Hz magnetic fields from the UK power distribution network, in relation to childhood leukaemia and other illnesses

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Summary

The authors have been investigating the magnetic field strength and degree of polarisation of the UK's 50 Hz power distribution network, to which humans are typically exposed, in the context of the possible health effects associated with power-frequency magnetic fields. Measurements of the magnetic field strength and vector ellipticity were taken at a variety of locations around the UK. Data was taken from a selection of the National Grid's 400 kV and 275 kV powerlines, and the 132 kV and 11 kV powerlines of several local power distribution companies. The results to date demonstrate that the magnetic field strength and vector ellipticity encountered by the general public vary widely. Magnetic field strengths of up to 10 μT with up to 90% ellipticity have been observed within UK homes sited near to power distribution lines. (Ainsbury and Henshaw, 2004 (a)).

Introduction

Over the last few years, the incidence of certain types of cancer has been on the increase. In England and Wales, for children up to the age of fourteen, this trend has been particularly apparent for leukaemia, lymphoma and cancers of the brain and spinal chord (Stiller *et al*, 2004). Recently, much work has been carried out in order to investigate the effects of human exposure to magnetic fields in residential and work-based environments. Two recently published pooled epidemiological studies have cited a doubling of risk of childhood leukaemia associated with average magnetic field exposure levels above 0.4 μT (Albolm *et al*, 2000 and Greenland *et al*, 2000).

The melatonin hypothesis was introduced to try and explain the link between suppression of melatonin production in the body by light-at-night, in relation to breast and other cancers (Stevens, 1987). The hormone melatonin is known to be highly protective against oxidative damage to the human haemopoeitic system: it is an antioxidant and free radical scavenger and is therefore well known as a powerful natural anti-cancer agent (Reiter, 2003). Melatonin also provides a potential link between magnetic fields and the reported health effects: There are now at least eleven studies in human populations showing that magnetic fields as low as 0.2 μT depress nocturnal production of melatonin (e.g. Davis *et al*, 2001). As the authors have previously demonstrated (Ainsbury *et al*, 2004 (b)), this level of magnetic field strength is frequently exceeded in the vicinity of high voltage powerlines.

To date, investigations exploring the effects of magnetic fields on melatonin production pathways and levels have concentrated mainly on linearly polarised fields. However, in mice, there is evidence to suggest that elliptically polarised magnetic fields are more effective in suppressing pineal melatonin production (Kato *et al*, 1993). The polarisation of a field refers to the processional orientation of the field vector. For linear polarisation, the orientation of the field is constant: An observer of the plane of vibration (towards whom the field wave was travelling) would see a sinusoidal growth and reduction of the field vector about the origin. When two or more fields are present, they can interfere with each other to create elliptically polarised fields. The magnitude of magnetic field strength of an elliptically polarised field does not go to zero, so the average field strength is higher. If two fields of equal amplitude and 90 degree phase difference interact with each other, the special case of circular polarisation is observed. To an observer towards whom the wave is travelling, the field vector is rotating. In this case the magnitude of magnetic field strength is constant at its maximum, so a higher average (RMS) magnetic field is produced. Similarly, circular and elliptical fields have higher power densities and produce higher induced currents in the body

(Ainsbury *et al*, 2004 (b)). The magnitude of this effect is illustrated in figure 1, below. Ellipticity is calculated as percentage major axis / minor axis of the ellipse traced out by the field vector.

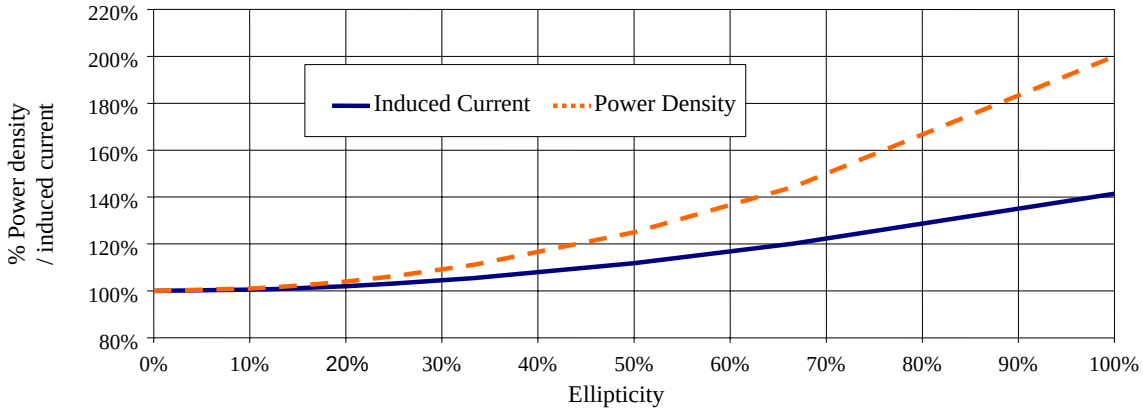

Figure 1. Percentage increase in power density and induced current with percentage ellipticity of the magnetic field.

Traditionally, investigations exploring the effects of magnetic fields on the human body ignore the polarisation of the field. Here the authors have been investigating the importance of polarisation in relation to the potential health risks from magnetic fields, by looking at the typical ellipticities experienced by the public on a day to day basis.

Materials and Methods

Equipment

The field strength (x, y and z components), frequency and phase of the magnetic field were measured using the Multiwave® System II ('Multiwave II,' Electric Research and Management Ltd, California). The EMDEX II in conjunction with the EMCALC ™ 95 software (ENERTECH Consultants, US, 1997) was used to measure x, y and z components and the resultants of the harmonic (100-800 Hz) and broadband (40-800 Hz) magnetic fields.

Data collection

Measurements of the 50 Hz magnetic field strength and phase information were taken underneath and at a variety of distances from the National Grid's 400 kV and 275 kV powerlines, and the 132 kV and 11 kV powerlines of several local power companies. Data was collected for powerlines both near to and away from residential areas. In the case of residential housing being located near to the powerlines, 24-hour measurements of the magnetic field strength and phase were taken in the one or more rooms of each property, at various distances from the powerlines. It should be noted here that properties near to powerlines, from which the data was collected, are all owned by members of the general public personally known to the authors and their neighbours who were asked to volunteer.

Data analysis

The phase and field strength data can then be used to calculate the ellipticity of the field. The EMDEX II is one of the most common measuring devices used in epidemiological studies looking at personal exposure to magnetic fields. The EMDEX was used to give comparable data between the traditional measures of magnetic flux density and the results from the Multiwave II.

Results

Figure 2 shows the magnetic field strength in micro tesla (μT) measured over 24 hours in two houses in the North of England. The first set of data was taken at a stationary position at the approximate position of the chest when the subject is lying on the bed, in the smallest (child's) bedroom which is located directly underneath the lowest conductor of a 132 kV powerline. The daytime variation in the magnetic field, which is directly related to the current being drawn from the line, is clearly visible. The second set of data was taken at a similar position in the smallest bedroom of a house far away from any visible sources of magnetic field external to the property. The peak in magnetic field up to 0.90 μT occurred when the television and radio in the room were in use; the average magnetic field strength in the room is still 0.20 μT which is below the levels associated with childhood leukaemia and well below the 2.21 μT magnetic field found in the bedroom under the powerline.

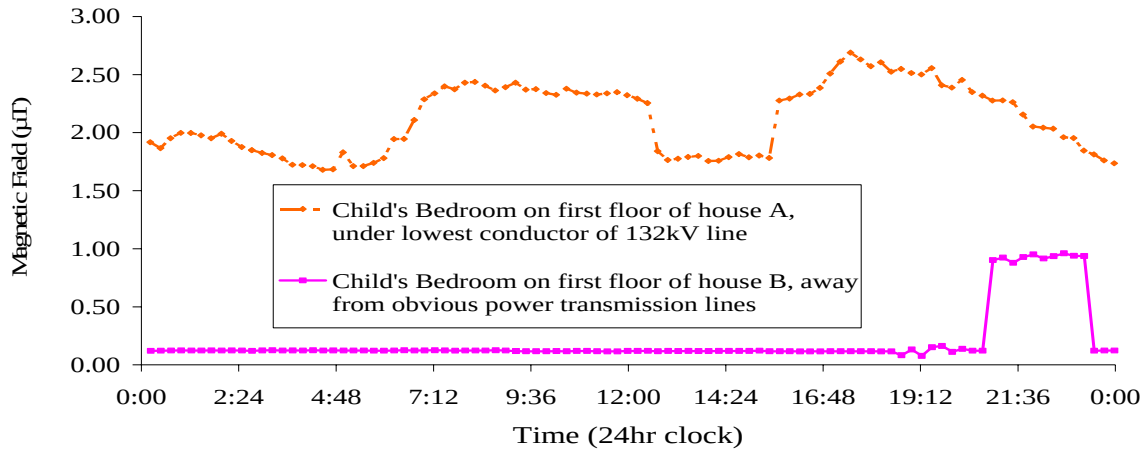

Figure 2. 24 hour measurement of the 50 Hz magnetic field in a child's bedroom of a 3 bedroomed house in the North West of England, February and May 2004.

Figure 3 shows the percentage ellipticity over a 24 hour period in the child's bedroom of a house situated directly under the lowest conductor of a 132 kV powerline. The data was taken at the estimated position of the chest for a subject lying down on the child's bed. One set of data was taken on the 5th February 2004 and one on the 28th May 2004. In February, the average (24 hour) magnetic field strength at this position in the child's room was 2.12 $\pm$ 0.30 μT; in May, the field strength was 1.47 $\pm$ 0.15 μT. These results illustrate the seasonal variation in ellipticity and magnetic field strength, which are directly dependent on the current being drawn from the powerline: In February it is cooler, so heaters are used and it gets dark earlier so more electricity is used in lighting homes.

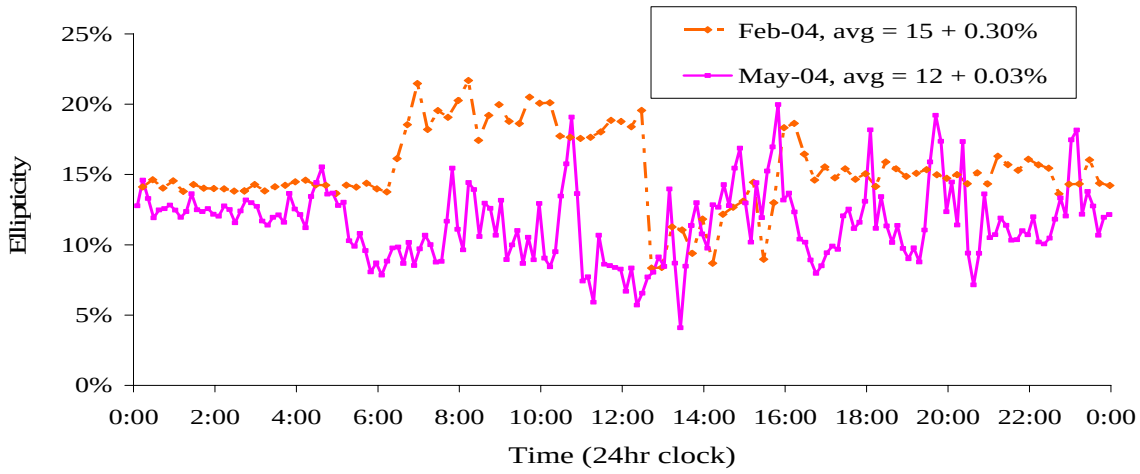

Figure 3. 24 hour measurement of the polarisation of the 50 Hz magnetic field in the child's bedroom of a 3 bedroomed house, February and May 2004.

Discussion and preliminary conclusions

The importance of polarisation in relation to the potential health risks from magnetic fields depends on the magnitude of the field ellipticity. The work to date demonstrates that the magnitude of magnetic field strength and the degree of vector ellipticity encountered by the general public vary widely. Traditionally it is thought that humans are typically exposed to linearly polarised magnetic fields, however the research here suggests that this is not the case: in many everyday situations some degree of elliptical polarisation is observed, whether this is from powerlines, appliances in the home and work place or both. Figure 3 demonstrates the variation of the field polarisation both on a daily and annual basis. Here the levels of ellipticity are low, but the fields are not linear. Results show that, in contrast to the magnetic field strength, as we move away from powerlines the ellipticity of the field increases. This indicates the imbalance in the field on the two sides of the line, and could have important implications for the epidemiological studies. Measurements in a variety of locations have shown that typical ellipticities >10% are the norm.

These preliminary results suggest that polarisation may be an important factor in epidemiological studies of magnetic field exposures. The authors intend to continue the research looking the levels of magnetic fields and field ellipticities experienced by the general public. If, as expected, elliptical fields are found to be an integral part of everyday human exposure, then field ellipticity will become an important metric to be considered in future epidemiological studies.

Acknowledgement

This work is supported by the charity CHILDREN with LEUKAEMIA, Registered Charity Number 298405. The authors would also like to thank the members of the Bristol University Human Radiation Effects Group for their continued assistance with many aspects of the work.

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