



# ICNIRP 7th International NIR Workshop

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## **From static fields up to UV: Mechanisms relevant to health effects due to NIR exposure**

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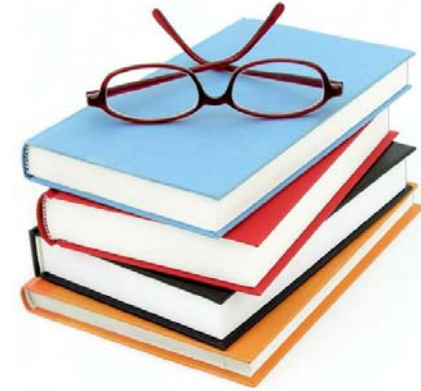
Affiliated with CNRS University of Bordeaux



## SMF

## STATIC MAGNETIC FIELDS

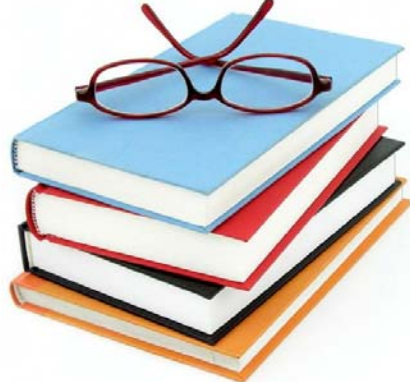
- ICNIRP (2003) blue book  $0 < f < 100$  kHz
- WHO (2006) EHC
- Magnetic induction
- Magnetomechanical effects
  - Torque effect
  - Force effect
- Electronic interactions: radical pair mechanisms (RPM)
- Electric fields may also be induced by movement in a static magnetic field.





**ELF**

## **Extremely-low frequency fields ( $0 < f < 300$ Hz)**

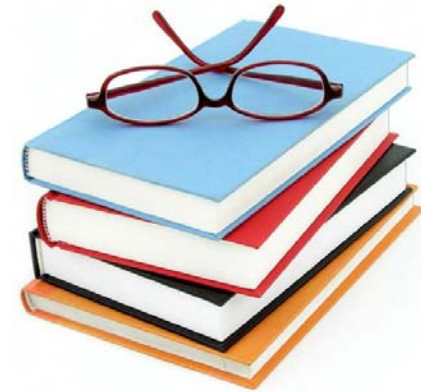
- ICNIRP (2003) blue book
  - WHO (2007) EHC
- 
- A stack of four books with different colored covers (blue, red, black, orange) and a pair of red-rimmed glasses resting on top of the blue book.
- **E:** At ELF, the body is a good conductor, and the perturbed field lines external to the body are nearly perpendicular to the body surface. Oscillating charges are induced on the surface of the exposed body and these produce currents inside the body.
  - **B:** The main interaction of magnetic fields is the Faraday induction of electric fields and associated currents in the tissues.
  - RPM is a mechanism that could play a role at ELF



**RF**

## **RADIOFREQUENCY RANGE**

- Challis (2005)
- Sheppard et al (2008)
- ICNIRP blue book (2009)
- AGNIR/HPA (2012)

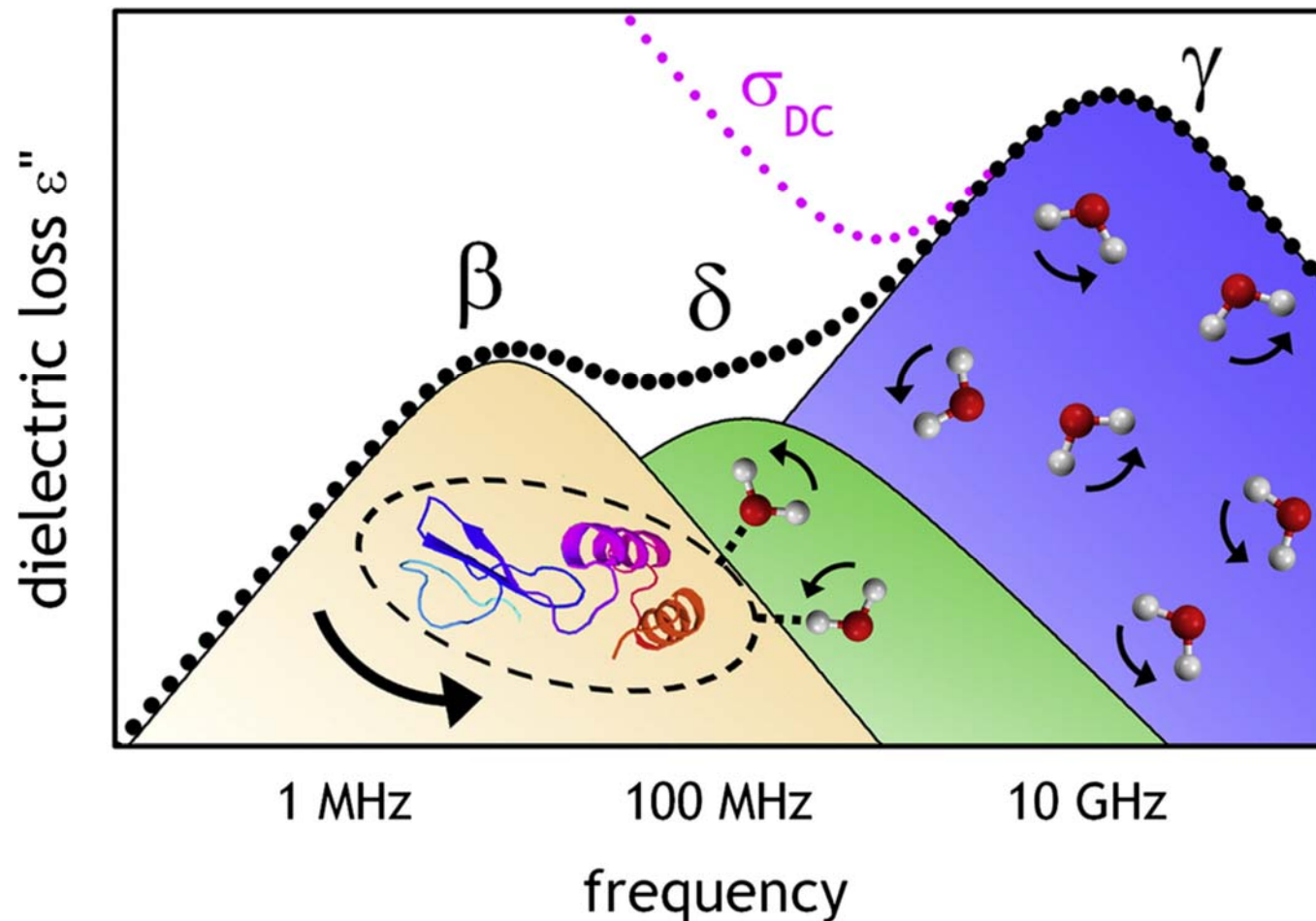




RF

## DIELECTRIC RELAXATION

- Dominant mechanisms are dielectric relaxation and ohmic loss (conduction), giving rise to an increase in temperature





**RF**

## **NON-THERMAL MECHANISMS**

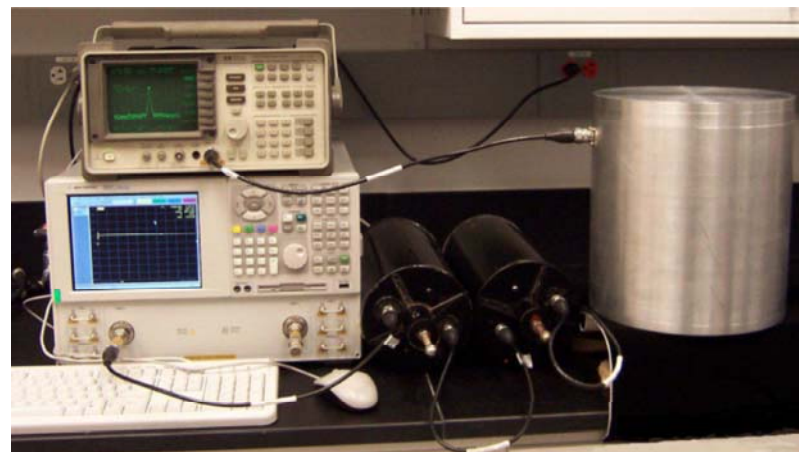
- Most other possible mechanisms, many based upon direct coupling to specific modes in molecules, cells or tissues, are implausible as means for independent energy deposition
- Resonant molecular or sub- molecular vibrational modes are precluded because they are too heavily damped
- Conditions where an RF field interacts directly with charges or dipoles require field strengths that are greatly in excess of those that would cause dielectric heating.
- Spatial temperature gradients
  - thermal diffusion in tissue prevents the creation of high spatial gradients on the cellular scale, and any tendency to create localised hotspots cannot occur.



## RF

### NON-LINEAR DEMODULATION

- Non-linear demodulation may create a low frequency electromagnetic field that may directly affect tissue (Foster & Repacholi (2004))
- Second-harmonic generation is a necessary and sufficient condition for demodulation
- Doubly-resonant cavity to expose a wide range of cell or tissue samples to low-level continuous EMF at the resonant frequency of the loaded cavity (890 MHz) and sought evidence of the generation of the second harmonic (Kowalczyk et al (2010) also reported by Davis and Balzano, 2010)
- No evidence of non-linear energy conversion by any of the samples was found

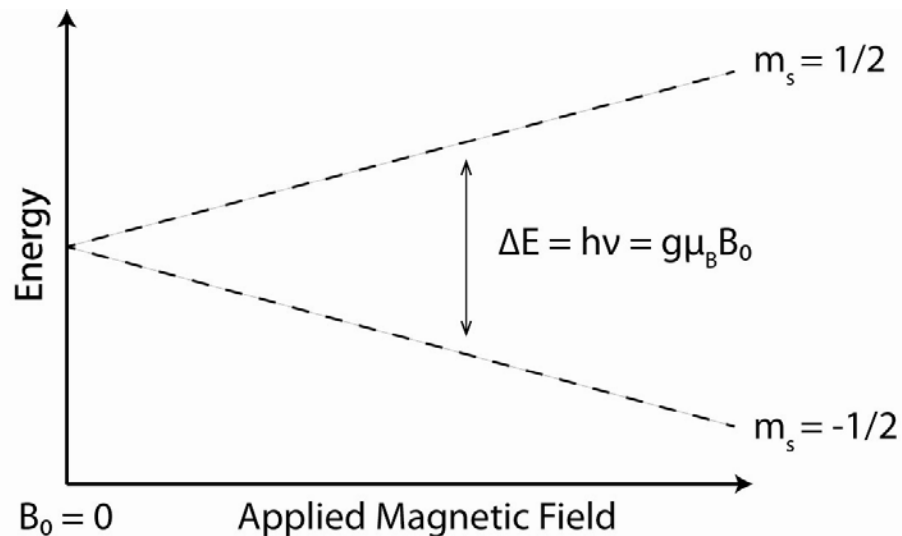




## RF

### RADICAL PAIR MECHANISM

- Spin-correlated interactions between radical pairs, and their dependence on magnetic field strength, may be the basis for bird navigation
- Behavioural effects in birds exposed below 100 MHz have been attributed to changes in RPM (supported by associated theoretical work).
- It has been concluded that magnetic field effects on the radical pair mechanism are not a general feature of biochemistry above 10 MHz, and especially not above 100 MHz.



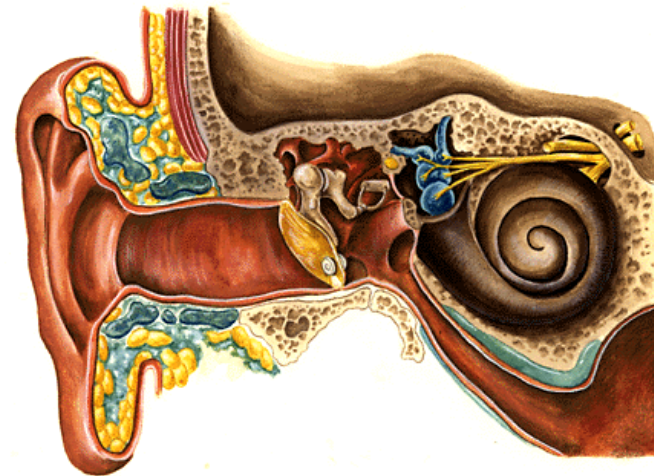




**RF**

## **MICROWAVE HEARING**

- Under conditions of high peak power, a pulsed microwave-stimulated auditory response occurs (Lin and Wang, 2007).
- Transient localised heating, and associated tissue expansion, generates an acoustic wave that stimulates the ear directly.
- Peak power densities of a few  $\text{kW/m}^2$  are required to exceed the threshold acoustic pressure for hearing in humans (20 mPa).





**RF**

## **CONCLUSION**

- Evaluation of a wide range of possible mechanisms suggests that dielectric heating, with its associated **temperature rise** in tissue, is the **dominant**, and perhaps the only, **mechanism** needing serious consideration over the RF spectral range.
- However, some recent findings which are not well-established (EEG spectrum) suggest that other mechanisms cannot be excluded yet