The doctrine of innocuity of electromagnetic waves

Vs

Transitions stimulated by the electromagnetic waves.

The "Doctrine of Innocuity of electromagnetic waves" groups the arguments usually presented to reject biological effects of electromagnetic waves, including the "hν<kT" and the "no non-thermal effects" arguments (used to reject the conceptual possibility of biological effects of electromagnetic waves) and the "not dose-dependent" argument (used to reject otherwise conclusive experimental results).

Transitions stimulated by electromagnetic waves are the underlying physical phenomenon in most non-thermal effects of electromagnetic waves.

Let us examine the arguments of the "Doctrine of Innocuity of waves" and compare them with the correct approach, i.e. Transitions stimulated by electromagnetic waves.

Note: Transitions stimulated by the electromagnetic wave follow basic laws of physics which can be found in textbooks, for example in (Scully & Zubairy). A semi-classical approach (with molecules being treated quantum mechanically and the electromagnetic field being treated classically) is generally sufficient. The concept of "Rabi frequency" plays a major role in these transitions. A more complete approach of the problem in the case of biological systems can be found in (Lauer 2013) sections 1 to 4.

1: The "hv<kT" argument.

This argument states that since the individual energy of a radio-frequency photon (hv) is less than than the thermal energy (kT/2) on any single degree of liberty, the radiofrequency photon cannot cause a system transition which cannot equally be caused by thermal shocks.

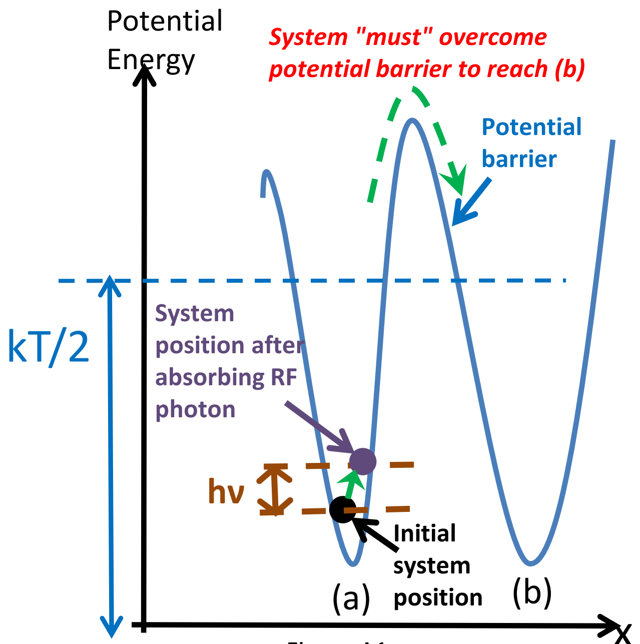

Figure A1

The argument is as follows: a biological system has two conformations corresponding to potential wells (a) and (b). Assume that it is initially in well (a).

-If the potential barrier is lower than kT/2, random thermal movements can bring the system from well (a) to well (b) so that transitions between wells (a) and (b) occur thermally, independent of the presence of an electromagnetic wave, so an electromagnetic wave does not affect these transitions.

- If the potential barrier is higher than kT/2 (as shown), thermal movement cannot cause transitions from (a) to (b). However, since the energy **hv** of the radio-frequency photon is a lot lower than kT/2, absorption of a radio-frequency photon increases the system's energy only slightly, which is insufficient to overcome the energy barrier.

The above argument is based on classical physics (which rules car mechanics) but entirely ignores the fact that at molecular scales the rules which apply are those of quantum physics (which rules lasers and masers, for example).

In quantum physics, the system in well (a) [resp. (b)] exists in a quantum state A [resp. B], the energy of which takes into account both the potential energy and the vibrational energy within each well.

The system can make transitions between states (a) and (b) which are stimulated by an electromagnetic wave having the appropriate Transition Frequency, corresponding to the energy difference between the initial quantum state A and the final quantum state B (divided by Planck's constant h).

Under the influence of an electromagnetic wave at the Transition Frequency, the system alternates between quantum states A and B at a frequency called the « Rabi Frequency », which is proportional to the power of the electromagnetic wave, i.e. to the number of photons.

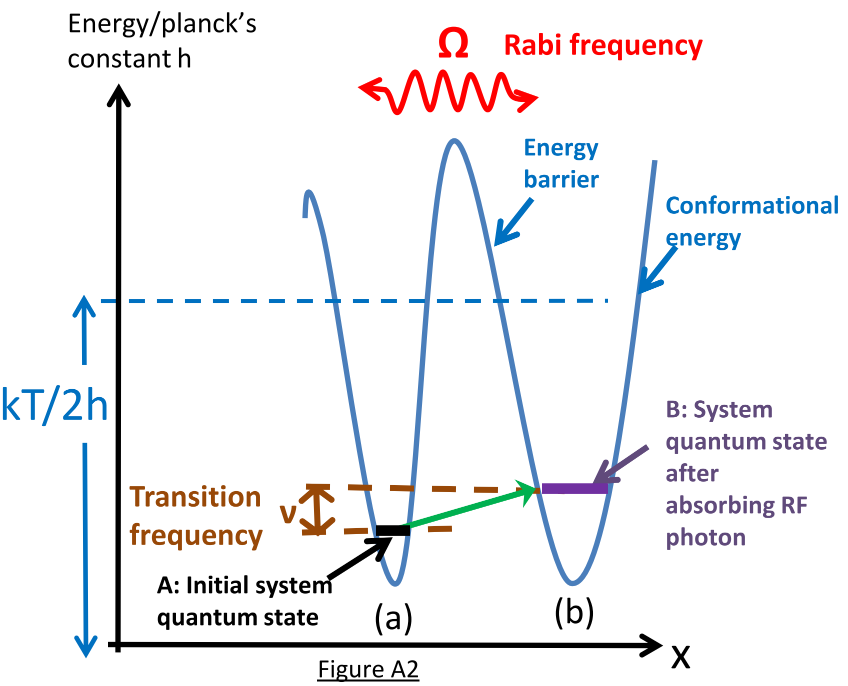

Figure A2

If the energy difference between the initial and final quantum states is low, the frequency of the stimulating electromagnetic wave (Transition Frequency) is low, i.e. in the RF domain. How fast the transition occurs depends on the number of RF photons, not on their individual energy. Thus <u>in the real world, the system can make (a) to (b) transitions stimulated by a radiofrequency electromagnetic wave, unlike is the case in the inappropriate « classical picture ».</u>

2: The "no non-thermal effects" argument.

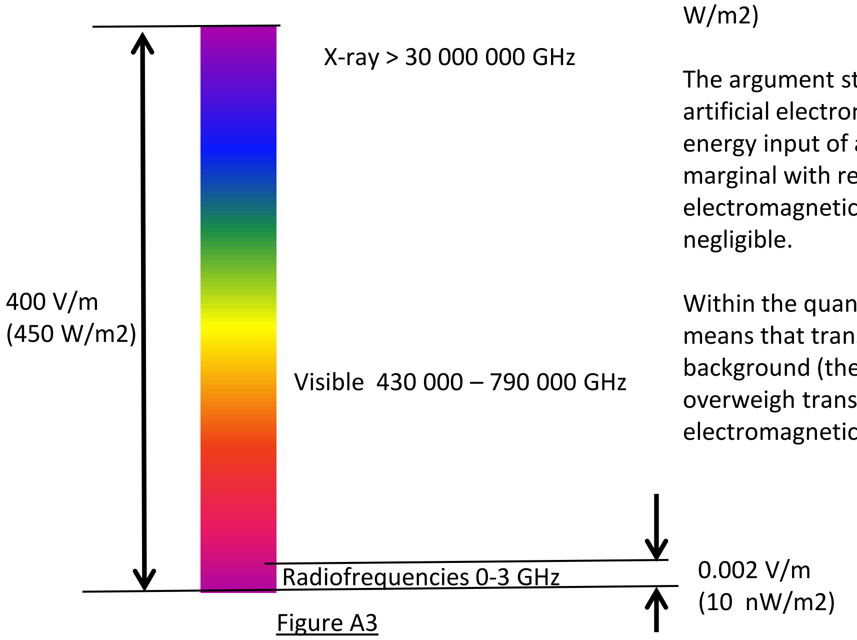

Figure A3

The total power of naturally present electromagnetic waves (thermal background) is about 400 V/m (450 W/m2)

The argument states that as long as the power of artificial electromagnetic waves is below that limit, the energy input of artificial electromagnetic waves is marginal with respect to the energy of natural electromagnetic fields so any biological effects are negligible.

Within the quantum model already discussed, this means that transitions stimulated by the thermal background (thermally stimulated transitions) overweigh transitions stimulated by artificial electromagnetic waves.

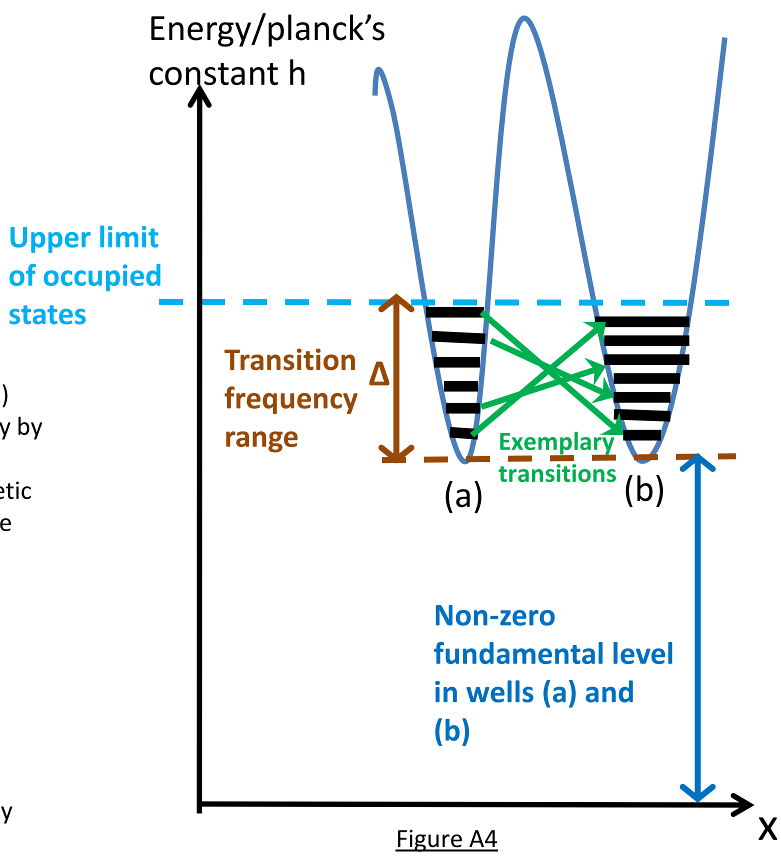

Figure A4

However if transitions between wells (a) and (b) can be thermally stimulated only by waves in (for example) the 0-3 GHz frequency range, artificial electromagnetic waves compete only with the part of the thermal background which is in the 0-3 GHz range, i.e. about 0.002 V/m (10 nW/m2).

In this exemplary case an artificial radiofrequency electromagnetic wave having a power sufficiently higher that 0.002 V/m can stimulate an (a) to (b) transition which would not be thermally attainable.

3: The "not dose-dependent" argument.

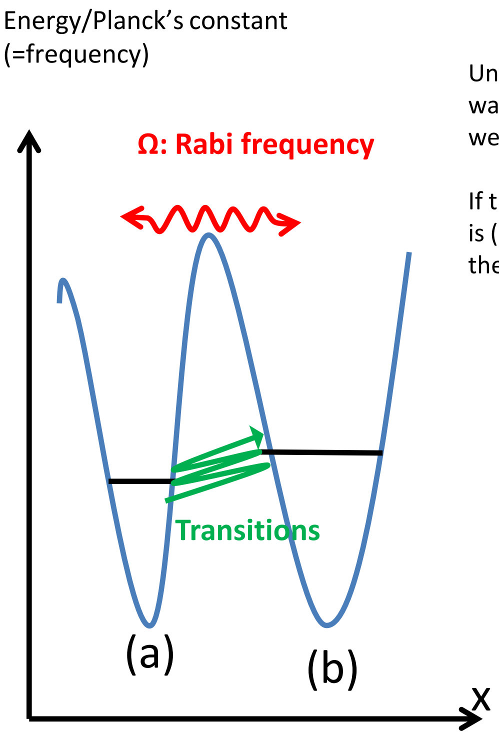

Figure A5

Under the influence of an artificial electromagnetic wave, the biological system oscillates between two wells at a Rabi frequency which increases with power.

If the artificial wave is pulsed, assuming the initial well is (a), there is a change to well (b) only if at the end of the pulse the system is left in well (b).

As the power of the artificial wave increases (at constant pulse length) the Rabi frequency increases and the state in which the system is left at the end of the pulse changes from (a) to (b) then (a) again and (b) again etc … yielding to power windows.

Essentially the same occurs where instead of being pulsed the artificial wave is amplitude modulated.

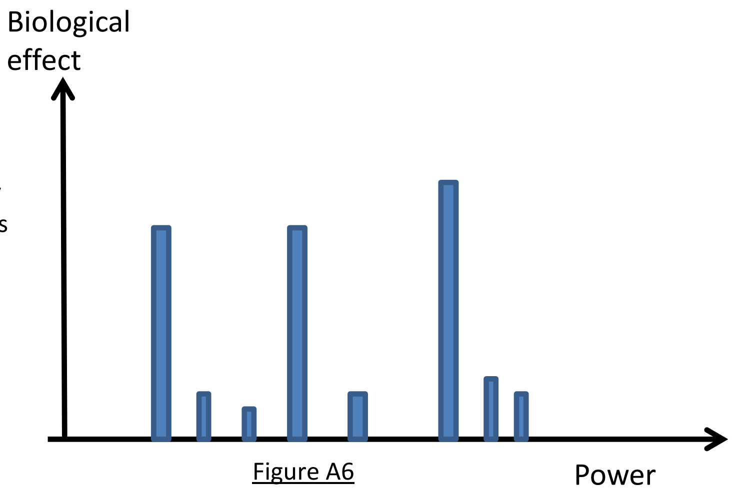

Figure A6

These power windows are a signature of stimulated transitions which is found in many biological effects of electromagnetic waves, including calcium efflux (Blackman) or effects of GSM on the reproduction of flies (Panagopoulos). Yet many researchers continue to erroneously reject results which exhibit such power windows, stating that the effect is "not dose-dependent" (for example, see Jacobs Univ. 2008) .

Incidentally, these power windows confirm that most non-thermal effects of electromagnetic waves are caused by stimulated transitions, and thus they confirm that such stimulated transitions occur at low, non-thermal power.

4. Conclusion

Transitions stimulated by the artificial electromagnetic wave are generally the basic mechanism underlying non-thermal biological effects of electromagnetic waves.

These transitions often yield power windows which are their signature. These power windows should not yield to the rejection of a result for lack of a regular dose-dependency. In fact, the do confirm the origin of the observed phenomenon.

The Doctrine of innocuity of electromagnetic waves, which refuses non-thermal effects and rejects experimental results showing power windows, is a misconception.

References:

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