Olfaction and Far Infrared Signaling by Moths

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***Abstract*— Olfaction by shape theory extended to the mating of moths relies on the extremely unlikely probabilty of the pheromone (sex scent) molecule fitting into matched receptors on the moth antenna. Olfaction is proposed assisted by far infrared (FIR) signaling to explain the indisputable fact that moths do indeed mate. The FIR signal is the spectral response of the pheromone molecule induced upon contact with surfaces along the trail of the female moth. Contact is required for the pheromone molecule to absorb the thermal kT energy of atoms in the surfaces. Upon loss of contact, the pheromone molecule cannot conserve the absorbed energy by an increase in temperature because of the quantum mechanics (QM) restriction that the specific heat of an individual molecule vanishes. Instead, conservation proceeds by the QED induced emission of the unique FIR spectra of the pheromone. QED stands for quantum electrodynamics. Upon each contact, a burst of radiation in the FIR spectrum of the pheromone conserves the absorbed energy. Moths mate as the male follows the trail of FIR spectral emissions of the pheromone left by the female.**

Keyword- mpth, olfaction, shape theory, quantum mechanics, quantum electrodynamics

I. INTRODUCTION

Olfaction in humans is given by Buck and Axel's mainstream [1] shape theory where odorant molecules find and fit into perfectly matching receptors on the epithelial surfaces inside the nose. Later, Turin [2] proposed an electromagnetic (EM) alternative [2] to olfaction whereby the odorant fitted in the receptor is identified through vibration spectra induced by electron tunneling. However, both theories require the receptor to have the precise matching shape of the odorant molecule. Since the probability of the odorant finding such a receptor is extremely unlikely, Prevenslik [3] proposed the odorant molecule need only contact the inside surface of the nose. Odorant contact absorbs thermal kT energy of the surface atoms. k stands for Boltzmann's constant and T for absolute temperature. Upon loss of contact, the isolated molecule cannot conserve the absorbed energy by an increase in temperature because of the QM restriction that an individual molecule has zero specific heat. Instead, conservation proceeds by the QED induced emission of the odorant by its FIR spectra of the odorant molecule. Odorants encoded in the brain allow recognition by their FIR spectra

Unlike humans, insects evolved with a pair of antenna provided with sensilla disposed along their length. Olfaction in insects is thought to follow shape theory in humans. However, like humans, olfaction is questionable because the probability of the pheromone in the atmosphere finding the receptor on the sensilla is extremely unlikely. Electromagnetic (EM) communication would greatly increase the probability of the pheromone finding the receptor and enhance mating. But absorption by water vapor limits EM signaling to the FIR. For example, Callahan [4] showed corn earworm moths *Heliothis zea* respond to the FIR through atmospheric windows at 200, 280, 350, and 450 microns, i.e., from 200 to 1000 microns (< 50 / cm). Indeed, mercury quartz lamps that attract moths have excellent transmission wavelengths at 218, 300, and 343 microns. Optimum transmission [5] at (< 30 / cm) or wavelengths > 300 microns that includes microwaves (MWs) (< 1 / cm).

However, insect research is not usually conducted in the FIR (< 30 / cm) range. Hsiao [5] measured the response of cabbage looper moths *Trichophsia ni* and found agreement with olfactory theory. In addition, the moth response to EM communication using (1) characteristic IR vibration frequencies of the synthesized pheromone, and (2) the FIR spectra of the pheromone excited by IR radiation. Unlike olfaction, the moths did not respond to EM communication. However, the moths in the experiment were not directly exposed to the EM excitations, but rather through an interposed NaCl window that only passed EM signals from 0.2 to 20 microns (> 500 / cm). Hence, the moth could not have responded to FIR placing in question the conclusion that EM communication was not significant.

In Nature, moths are known to mate with the male either upwind or downwind of the female. Upwind mating may only occur by EM signaling while both olfaction and EM signaling may occur in downwind mating. Regardless, the pheromone molecules released by the female move in the wind and repeatedly contact nearby or distant surface from the male, say as the pheromone molecules bounce along the ground. Male moths downwind of the female therefore find the female following the trail of bursts of FIR spectra left by the pheromone molecules.

II. PURPOSE

The purpose here is to show the moth pheromone molecules conserve absorbed thermal kT energy by a burst of EM radiation given by the FIR spectrum of the pheromone.

III. THEORY

Similar olfaction of odorants in man, EM communication in moths proceeds by contact induced EM spectra is illustrated in Fig. 1.

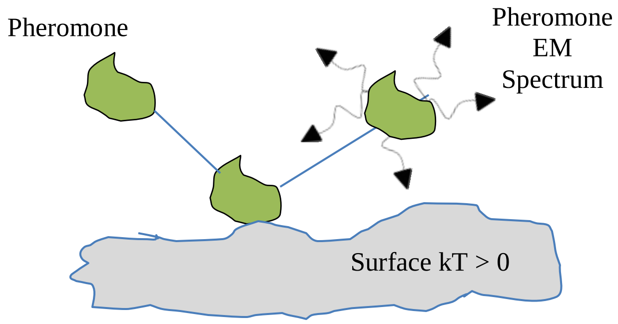

Figure 1 Contact Induced EM Spectra

In mating, the female moth releases many pheromone molecules that repeatedly emit their FIR spectra each time contact is made with macroscopic surfaces, thereby leaving a trail of bursts of EM radiation for the male to follow, but for clarity only the burst of EM radiation from a single contact is depicted. Unlike contact with other molecules, macroscopic surfaces provide an infinite sink of thermal energy from which the pheromone molecule may acquire the thermal kT energy that is emitted upon loss of contact emits its EM spectrum.

Thermal Energy absorbed upon contact with Surfaces
Sex pheromones are long chain alcohols, acetates, or aldehydes with molecular weights of < 300 while macroscopic surfaces are sources of ambient kT energy. Prior to contact, the pheromone has kT energy at least at the first contact given by its thermal velocity. But prior to subsequent contacts, the pheromone molecule may not have any thermal energy because of the last spectral emissions. Regardless, the pheromone upon contact spontaneously acquires the ambient temperature of the macroscopic surface, the total energy U dependent on the number N_A of atoms,

$$U = \frac{3}{2}kT\ N_A = \frac{3}{2}kT\ N_G\ N_{A/G} \qquad (3)$$

where, N_G is the number of groups of C-H-O atoms, $N_{A/G} = 3$ is the number of atoms/group.

Upon leaving the surface, the pheromone is no longer a part of the macroscopic body that by QM is not allowed to have thermal kT energy, and therefore the energy U acquired in contact is promptly emitted by its EM spectrum far faster than the molecule acquires a rebound velocity from its kT energy. Since the low frequency modes are occupied at ambient temperature, the FIR spectrum of the pheromone is emitted. Fig. 2 shows the FIR at frequencies < 1000 cm-1 having U < 0.125 eV is excited by all pheromones, e.g. pheromones having groups of 3 (carbon-hydrogen-oxygen) atoms with atomic weight 19.

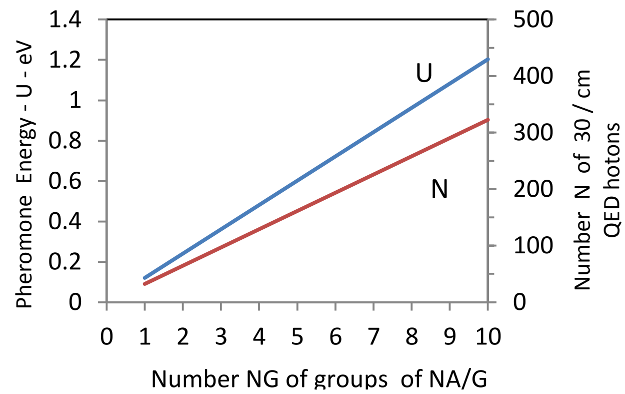

Figure 2 Contact Induced QED Photon Emission

Number of Signaling QED Photons Emitted
The thermal energy U absorbed upon contact is conserved by creating number N of signaling QED photons having Planck energy E,

$$U = NE \qquad (2)$$

The number N of QED photons is given in Fig. 2.

IV. DISCUSSION

In the following discussion, the outline follows Oschman [5] in comparing olfaction and EM communication of insects to illustrate QED induced contact FIR spectra. Supporting references are cited.

Probability of Olfaction Olfaction by shape theory that requires the pheromone in the wind to find and fit into antenna receptors has a statistical probability close to zero. By shape theory, the simplest biological event of a hormone activating a receptor would require thousands of years. Similar to olfaction in man, Nature in insects is simply too subtle to require that pheromones wander around only to be sensed by olfaction until they just happen to fit into the right receptors. Indeed, olfaction is extremely unlikely without assistance by FIR signaling.

Pheromone Excitation Pheromone molecules need to be excited to emit their FIR spectra. Experiments show neither the pheromone nor IR radiation alone is the attractant. Instead, the IR excitation of the pheromone molecules is important. But natural blackbody IR from the surroundings thought to excite the pheromone molecules released by the female moth is unlikely because the pheromone is in thermal equilibrium with the surroundings. In contrast, contact induced FIR emission is not in equilibrium with the surroundings, thereby allowing the transmission of the FIR signal for male recognition.

Similarly, Callahan [6]commenting on Great Peacock moths, noted that males are attracted to a candle instead of a nearby female because the EM radiation from the candle pumps the pheromone molecules to a higher energy than from that released by the female, and therefore the males are attracted to the higher intensity of FIR emission from the candle. Alternatively, the candle raises the thermal kT energy absorbed by the pheromone molecule above that of the ambient temperature as it leaves the female abdomen.

Antenna Rubbing Constant rubbing of the antenna by all species of insects is thought to spread the scent molecules uniformly over the sensilla surface and allow the female to emit coherent FIR signals. Contact induced FIR signaling differs in that the pheromone molecules in contact with the macroscopic sensilla surface have acquired thermal kT energy, and therefore rubbing simply knocks pheromone molecules loose allowing them to signal other insects by emitting their FIR spectra.

Ant Tapping Ants by rapid tapping of antenna on the ground or on the antenna of other ants does indeed create scent trails by knocking off pheromone molecules, but not by olfaction alone. Neighbors are signaled as the thermal kT energy acquired pheromone during contact is released as the FIR spectra of the pheromone.

Moth tapping or palpitation with their antenna is common with insects. Callahan [7] notes palpation implies actually touching a surface during antenna vibrations. E.g., the wasp parasite *Orgalis Lepidus* locates the presence of the host potato tubeworm from the heptanoic acid on the potato surface by palpating its antenna. Since olfaction need only contact the acid for recognition, palpation suggests the acid molecules are being knocked off to allow recognition from the FIR emission.

Wing Beating Bees, mosquitoes, flies, crickets, and locusts are thought to increase their temperature by beating their wings, e.g., the female moth receptive to mating sits in one spot and vibrates her wings to increases the wing temperature about 6 C allowing thermal blackbody emission in the IR at 9.7 microns. In contrast, contact induced FIR spectra are emitted as pheromone molecules lose contact with wing surfaces.

Narrow Band Frequencies Most research on EM communication in insects is directed to narrowband frequencies in the IR that fit into the atmospheric windows of water vapor absorption between 2 and 30 microns. Unfortunately, the FIR from 300 to 1000 microns (< 30 / cm) may be optimum for atmospheric transmission.

Callahan [8] found the antenna spines of the *Saturnidae* moth responded to frequencies across the entire visible spectrum. But no response was found from IR to FIR radiation even though the 60 micron long spines should have been excited. Griffith and Susskind [9] made a scaled model of the sensillum coelooconicium peg of *Heliothis zea* that scaled back gave an IR wavelength of about 4 microns. But nothing in the peg had the highly specific structure to suggestive of EM communication. Instead, surface pores in the form of highly specific receptors for the pheromones suggest olfaction as the moth's sensor mechanism.

V. SUMMARY AND CONC LUSIONS

1. In human olfaction, the probability of the odorant molecule finding and fitting into the appropriate receptor in the nose by the theories of Buck and Axel's shape and extensions thereof by Turin's electron tunneling is extremely unlikely.

2. Similar to humans, the probability of insect olfaction by the pheromone molecule moving in the wind to find and fit into receptors on the antenna is extremely unlikely.

3. Contact induced FIR spectra allows prompt olfaction by odorants in the human nose and by pheromones with insect antenna.

VI. EXTENSIONS

Even the FIR may not be the optimum frequencies of EM communication used by insects. Instead, MWs in the 1-10 GHz range may be optimum because of consistency with the highly specific structure of the insect body itself thereby allowing detection by the inherent absorption of the rotational bands of pheromones. *Heliothis zea* has body dimensions of about 21 mm corresponding to the half wavelength of MWs of about 7 GHz. Mating then occurs as the pheromone molecules released by the female emit their MW spectra upon contact with surfaces, i.e., candles, street lights, etc. The male detects the pheromone MW signal by body absorption following the trail of pheromone molecules. Unlike the IR and FIR, MW communication in the 1- 10 GHz range is unaffected by atmospheric water vapor.

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