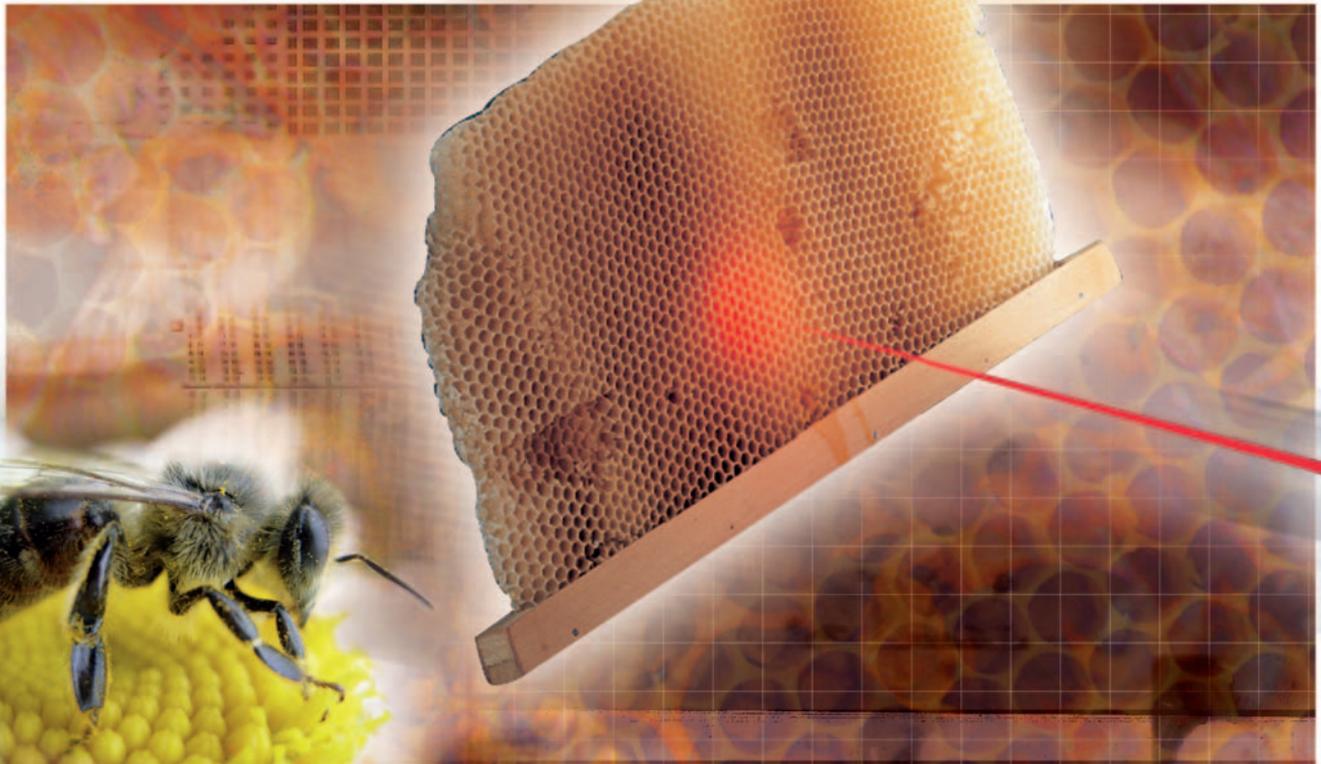


# Good Vibrations



## Dancing Bees Generate Vibrations in the Honeycomb as a Means of Communication

*Honeybees live in colonies containing about 50,000 individuals. We are just beginning to understand the wealth of information exchange in this “super organism”. Modern measurement methods allow us to significantly extend our understanding of the use of mechanical signals for communication between honeybees.*

### Feeding Ground Recruitment among Honeybees

Collecting bees which have discovered a new feeding ground perform the so-called bee dance or waggle dance in the dark hive. The information on the geographical position of the feeding ground is in the time-space construction of the dance move. This information is transferred during the dance movements from the dancer to the follower bees which are dancing in direct body contact with her.

The highly complex chain of information transmission starts in the hive by the other bees noticing a dancer and going to her. Often several dancers are

moving a few bee lengths apart from each other, whereby different feeding grounds can be shown at the same time. The enticing signals which these dancers emit should only have a short range so as to minimize disruptions to each other and so as not to attract too many bees.

### The Dancer as a Source of Honeycomb Vibrations

This function is fulfilled by honeycomb vibrations which are generated by the dancers. Measuring these honeycomb vibrations has proved to be extremely difficult, as an active colony generates an incredible continuous level of noise. Using non-contact laser Doppler vibrometry, we managed to make a measure-

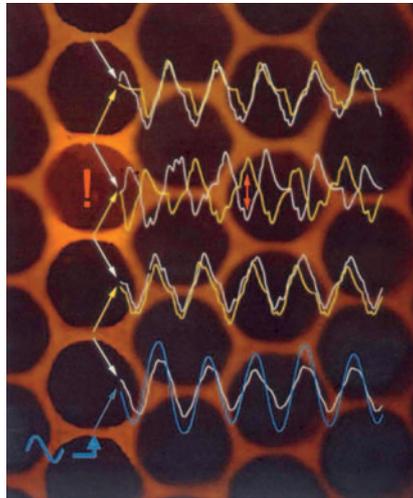
ment directly on the honeycomb next to a dancer, providing we aligned the movement phases of the bee and the time window of analysis very precisely.

The frequencies caused by the dance which can thereby be measured are in the range between 200 and 300 Hz and produced in pulses of approx. 30 – 50 milliseconds in length. These pulses are generally in the time sequence of the abdominal movement so that the reverse phase of the abdominal movement is emphasized. This leads to the assumption that an important role of the movement of the abdomen we can see is to effectively couple the vibration pulse of the flight muscles to the honeycomb.

## How Well do Honeycombs Conduct Vibrations?

Subject to a few simplifying assumptions, it has been calculated that a dancer exerts a force of a maximum of 1 mN on the edges of the cells during the waggle phase. On this basis an experiment was conducted in which the edges of the cells of an empty honeycomb were examined while being excited with this force and the frequency and time pattern as measured for the dancers to see how, which and how well vibrations are conducted via the honeycomb.

In doing so, it could be seen that the honeycomb best conducts the vibrations in the frequency range examined as a horizontal shift of the net made up of the edges of cells. A problem appears if one considers that in a noise-type excitation as occurs through the activity of all the bees on a honeycomb, vibrations of the honeycomb also occur in the transmission range of the dancers. The signal can thus be hidden in the noise. The behavioral reaction of the bees standing or walking near a dancer on the honeycomb however shows that the dancer is very reliably recognized. Apart from the high probability that in parallel to the "dance" there are other information channels used such as air movement, higher body temperature of the dancer, and chemical stimulants, the honey-



**Figure 2: Measurement results from a row of adjoining cells. The opposite walls of the individual cell marked with "!" are vibrating in the opposite beat**

comb vibration itself also offers options to solve this signal/noise problem.

Bees are standing on six feet on the edges of the cells and thus have six sensors working simultaneously. With the aid of two identical Polytec OFV Laser Vibrometer single-point Sensor Heads, the vibration of the cell edges were measured on empty honeycombs in two places at the same time. Thus, it was possible to duplicate what at least two of the six bee legs can perceive at the same time.

It was apparent that at the frequency transmitted best, in a whole row of cells across the entire honeycomb, all

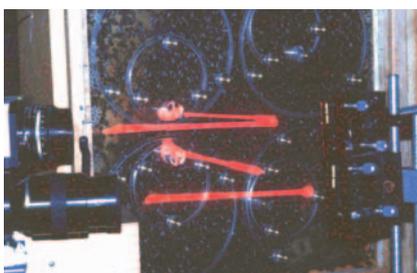
opposite walls of every individual cell are vibrating in the same direction. However, in every row of cells, there is a single cell whose walls vibrate precisely in the counter-phase (vibration node). Depending on the position of the excitation point, this cell is between one and seven cells away from the point of excitation. It is plausible that the bees standing or walking in the edges of the cells recognize this particular cell and know it indicates the proximity of a dancer. Because the maximum distance from which follower bees are still attracted to the dancer is precisely seven cells.

## Conclusions

Social insects are excellent subjects for study. Understanding their mechanical systems and the evolution of differentiated meaningful communication signals is important. The use of innovative methods for quantitative acquisition of signals and their transmission has shown how brilliantly the honeybees have utilized the vibration signals they produce, the way in which they transmit such signals via the honeycomb and the respective size of the audience for each dancer.

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**Figure 1: Test setup. The colony is covered with a clear plastic window with moveable circular panes. With the aid of other moveable and transparent elements and 90° deflecting mirrors, almost every position on the honeycomb can be measured without bees walking into the measurement beam.**

