Measuring Distances with Walkie-Talkies

Marcelo M.F. Saba, Instituto Nacional de Pesquisas Espaciais – INPE, Brazil

Rafael Antônio da S. Rosa, Clube de Ciências Quark / ITA – S.J. Campos, Brazil

This paper describes how big distances in open areas can be calculated using the speed of sound and a pair of walkie-talkies. This low-cost experiment challenges the students to solve a very common problem and at the same time uses some basic concepts like the speed of sound and of electromagnetic waves. The idea was partly inspired during an outdoor activity with a group of students. The class was divided into two groups, each one working at opposite sides of a lake. We could see each other and communicate using walkie-talkies. Suddenly, a student asked: "How far away do you think they are?"After some guesses and suggesting ideas to find the answer, we realized that we could use walkie-talkies to solve the problem.

We noted that any sharp and loud sound produced by the other group was heard twice. The sound was first heard through the walkie-talkies and then was heard again after propagating through the air at the speed of sound. The observation of the time delay was clear to everybody, and for us it happened to be a good opportunity to explain that the sound captured by the walkie-talkies was converted to electromagnetic waves, and that these waves propagate at the speed of light, reaching us much faster than the sound, a mechanical wave.

Having understood this, everybody agreed that by knowing the speed of sound the distance of the source could be found if we managed to measure the time delay—a method very similar to the well-known one used to estimate the distance of lightning. The problem was now to find an easy way to measure a time delay so short. After some debate, we decided that the next day we would gather again in an open area with a tape recorder and a thermometer to check the ambient temperature in order to have an accurate value of sound speed and a measuring tape to check the method.

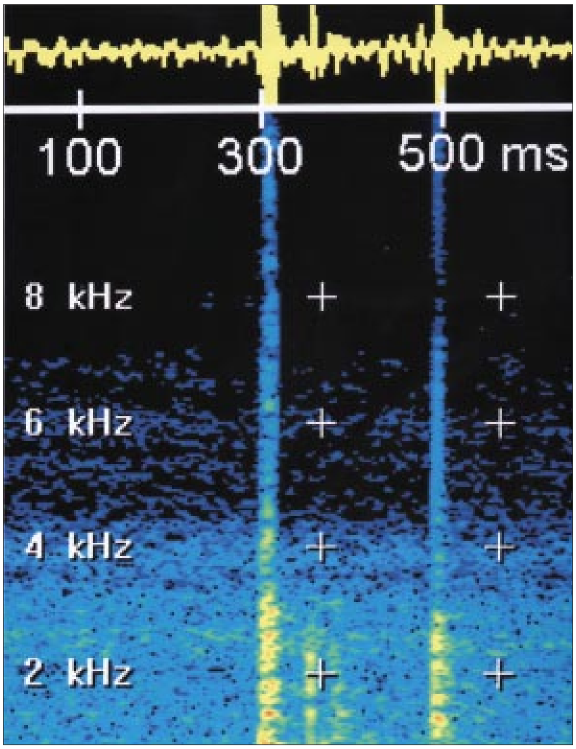

Fig. 1. Spectrogram showing a duplicated sharp sound.

The next day, after taking several temperature measurements and recordings of sharp sounds produced by

DOI: 10.1119/1.1888075

Table I. Measured distances for different time delays and their actual values.

Time delay (ms)	Distance (m) (method proposed)	Distance (m) (measuring tape)	Error (%)
72	24.8	25	0.8
144	49.6	50	0.8
219	75.4	75	0.5
294	101.3	100	1.3

sources situated at different distances, we digitized the sounds and found the time delays with an accuracy of 1 ms using the software GRAM.[1] Although the main purpose of this software is to make spectrograms, we used it to find the time between the successive sharp sounds. Several other types of similar freeware software can be used. Figure 1 shows the output of this software.

In the case shown in Fig. 1, the time delay was 190 ms and the ambient temperature equal to 23°C. Calculating the velocity of sound by the expression[2]

$$v_{\text{sound in air}} \approx (331.4 + 0.6T_c)\text{m/s},$$

where T_C is the celsius temperature, we found that the correspondent distance was 65.5 m. Table I shows some other results that confirm the accuracy of the method.

Comments

Walkie-talkies and a tape recorder are usually easy to obtain and to carry in a field exercise like this. The sounds recorded can be digitized afterward when returning to the classroom. Most computers have a sound input plug.

The error in distance measurement by this method is of the order of 1%, and it is especially useful for the measurement of long distances that would require long measuring tapes. The distance limit depends on the intensity of the sound produced and the walkie-talkies range.

Care was taken to keep the sound source and the tape recorder as close as possible to the walkie-talkies. This prevents the need for corrections due to the delay caused by the sound transit time through air from the source to the transmitting walkie-talkie and from the receiving walkie-talkie to the tape recorder.

For us the most interesting aspect of this experiment was the opportunity of showing a "real-life" physics experiment. In fact, most often simple questions from students can be very useful to motivate debates, revise some physical concepts, and provide new opportunities to use physics to solve common problems.

Acknowledgments

The authors would like to thank the students Gustavo Fernandes Guerra, Bruno Muta Vivas, and Colégio Poliedro for their help with this work.

References

1. GRAM software, by R.S. Horne, available at: http://www.visualizationsoftware.com/gram.html. Links to other commercial and freeware programs for audio spectrum analysis: http://www.visualizationsoftware.com/gram/links.html.
2. E. Hecht, *Physics: Algebra/Trig*, 2nd ed. (Brooks/Cole, Pacific Grove, CA, 1997), p. 401.

PACS codes: 01.50M, 06.30Bp, 43.85

Marcelo Saba *received his Ph.D. in space science from the National Institute for Space Research in Brazil. His research interest is in the area of lightning physics and physics education. He coordinates the Quark Science Club (www.clubequark.cjb.net) where high school and undergraduate students have a lot of fun developing new hands-on physics research projects.*

Instituto Nacional de Pesquisas Espaciais, INPE, Brazil; msaba@dge.inpe.br

Rafael Antônio da S. Rosa *received his B.S. in electrical engineering at Instituto Tecnológico de Aeronáutica. He has been advising high school students at Quark Science Club since 1999, providing young people the opportunity to embrace the wonder of physics and rewards through scientific competitions.*

Clube de Ciências Quark, Instituto Tecnológico de Aeronáutica, Brazil.