Speed of Sound in Meteorites: A Preliminary Report

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Introduction

Our lab has conducted studies modeling asteroid disruptions using meteorite analogs. Studying physical characteristics including speed of sound, density, and compression strength have recently become a focus. The speed of sound through the sample provides information about the porosity of meteorites and may give insight into the behavior of the disrupting material. Methods for measuring density and compression strength have been established in our lab; speed of sound measurements are still being developed.

Figure 1. A top view of the initial set up within the Ames Vertical Gun Range. The ring in the base of the chamber is about 100 cm across. In the corners, four passive foil detectors are visible; they are spaced approximately 90^{o} apart. The projectile comes in and strikes the sample on the right side.

Figure 2. A top view of a projectile striking a sample in the Ames Vertical Gun Range. When a sample is impacted the debris scatters in every direction. The four passive foil indicators detect debris that passes through them.

Figure 3. A side view after a sample has been impacted in the Ames Vertical Gun Range. The sample breaks into various sized fragments. We hope to use our physical characteristics experiments to be able to determine information regarding whether it will be a disruption or cratering event as well as amount and size of debris.

Experiment

The speed of sound through the materials is tested using a function generator, oscilloscope, and piezoelectric transducers. Originally our setup consisted of one transducer connected to the function generator which sent a wave through the material then the transducer connected to the oscilloscope would read the outbound wave. Adjusting the frequency input would vary the output voltage due to interference of reflected waves within the sample. By plotting consecutive resonance frequencies the speed of sound would be calculated by finding the slope of the best-fit line.

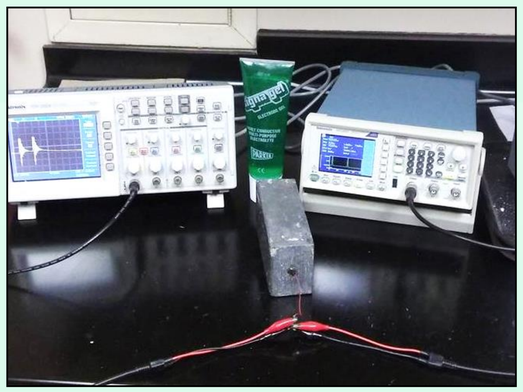

Figure 4. The most recently used configuration. Right: function generator set up to send two pulses with a variable delay. Left: oscilloscope set up to read the two pulses and the resulting echoes. Center, top: the electrode gel used to bond the transducer to the sample. Top, bottom: a terrestrial sample of lead used for calibration testing with a transducer attached.

Recently we have begun using a new set up derived from work done by Proctor[1]. This new set up (Fig. 4) uses the same equipment, but only one transducer. This transducer acts as sender and receiver. Two pulses are sent through the material with varying time between pulses. When the reflection of the two pulses overlap in a way to cancel each other out as in Figure 5, the time of traversal is said to be the same as the time between the pulses.

Results and Discussion

So far tests have yielded no data due to several problems that are being resolved. First, the original transducers were not functioning in a way to give us the desired outcomes. Secondly, our first procedure proved to be too impractical for using small meteorite samples. Finally, a broken pipe flooded our lab, setting back our work a couple of weeks. Current tests on terrestrial samples and future tests on meteorites will allow the lab to determine physical characteristics that can be extrapolated to asteroids, which will be useful for future analysis of asteroid disruptions.

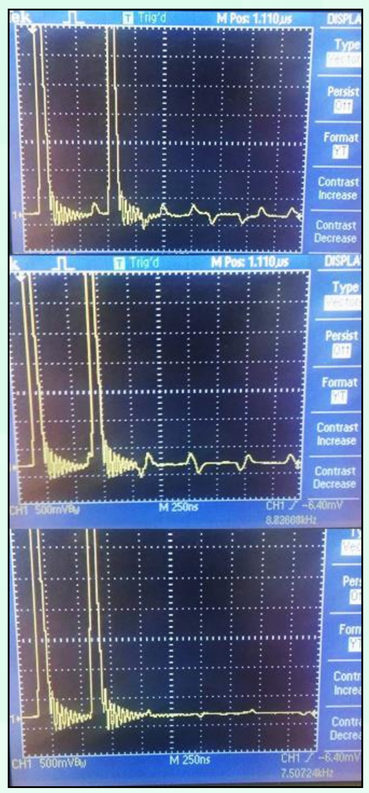

Figure 5. The desired oscilloscope output. As the time between pulses is changed, the reflections, in opposite phase, approach each other until they overlap one another leaving a flat line.

Future Work

In the near future we plan to finalize our method of calculating the speed of sound and perform some initial tests on terrestrial samples. After that we will begin collecting data from tests on meteorites.

References

[1] Proctor, T. M., Jr. (1970). Sound Speed Measurements in solids: Absolute Accuracy of an Improved Transient Pulse Method. *Journal of Research of the National Bureau of Standards, 75C*(1), 33-40.