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Meteorite Hunting and Physics Education

Georgi Nikolov Golemshinski
Bulgarian Academy of Sciences, BULGARIA

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In the recent years meteorite hunting has turned to a well-known recreational activity and become popular among children and the youth. Being such a tempting area of practice, meteorite prospecting draws attention and brings pleasure to the involved individuals thus predisposing them to get acquainted with the hidden secrets and underlying nature of meteorites and the methods and physical laws that make finding meteorites using machines possible. The current article tries to explain why meteorite hunting may attract students to physics and help them better understand certain phenomena of astrophysics and physics. The student may learn much about meteorite structure, chemistry, astrophysical origins, meteoroid atmosphere entry and mechanical dispersion and finally and most importantly the physics of electromagnetism, on which are based the modern meteorite searching metal detectors.

Keywords: meteorite hunting and physics education

INTRODUCTION

In the near past meteorite prospectors were using their naked eyes to identify and gather meteorite pieces around the world. The only tool occasionally was a simple magnet glued on a stick. Because most meteorites contain iron and nickel they tend to attract to magnets especially to rare earth magnets. The latter are very strong magnets. To distinguish a meteorite from a terrestrial iron bearing rock (a "hot rock") the observer needs to have certain experience or should rely on laboratory verification.

Nowadays, modern metal detectors came into play and searching for meteorites has become a much more pleasant and involving experience. Handheld metal detectors are gaining interest among young and elderly for their sophisticated machinery. But what is important for the physics education endeavor is that the prospector and hence the user of the metal detector will inevitably get acquainted with the underlying physics laws that enable the metal to be detected and found by a metal detecting apparatus. Physics students may benefit strongly from such an experience through raising their interest in electromagnetism, astrophysics and other branches of physics related to the meteorite hunting enterprise.

Correspondence: Georgi Nikolov Golemshinski,
Bulgarian Academy of Sciences, BULGARIA
E-mail: gngolem6@abv.bg
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MOTIVATION

What motivates the author to start investigating physics education through meteorite hunting is his personal experience with the metal detector hobby and the observation on how metal detector prospecting of meteorites attracts people and raises their interest in the underlying physics of searching technologies.

Involving people in physics education was proven to be possible thought non-standard approaches such as using computers in education (Zabunov, 2004) and more precisely implementing physical phenomena by the means of computer-aided physics simulations (Zabunov, 2010). The student is further motivated by cutting-edge high-technology utilization such as stereo 3D online e-leaning systems (Zabunov, 2012). Any new modern and attractive technology raises students' attention in the studied subject. Metal detectors are such a technology and meteorite hunting is an activity based on this technology. Through many experiments, the author has acquired the confidence that students are strongly inspired by the meteorite hunting avenue and further, they are willing to understand how things are happening and what physics laws are used in the metal detector.

The author also wants to point out that meteorites of large scale have fallen in his country Bulgaria such as the Belogradchik meteorite (Toshev, 2014).

METEORITE TYPES AND TAXONOMY

About 94% of all meteorites are stony meteorites divided into two major groups - chondrites and achondrites (Bischoff et al., 1995). The rest 6% are iron or stony-iron meteorites. For complete modern classification of meteorites the reader may consult "1.05 Classification of Meteorites". (Krot et al., 2007). Near 86% of all meteorites are chondrites (see Meteoritical Bulletin Database at www.lpi.usra.edu).

Fig. 1. The Hoba meteorite in Namibia is the largest known intact meteorite. Iron meteorite. Length 2.7 m, weight 60 tones. Color online. Author Giraud Patrick. Image used under a GNU Free Documentation License.

Chondrites contain round and small inclusions in the stony matrix that are called chondrules. Chondrules consist of mostly silicate minerals (fig. 2). There are chondrites that contain traces of organic material, for example amino acids. Due to chondrites age of about 4.5 billion years it is speculated that they are part of the asteroid belt that did not merge into large space bodies. Near 8% of all meteorites are achondrites. They are stony meteorites that do not contain chondrules. There is a group of achondrites that comes from the Moon. These achondrites are similar to the rocks brought by Apollo and Luna programs. For another group of achondrites scientists are almost certain that it comes from Mars.

Fig. 2. Ochansk Meteorite - a fusion-crusted H4 chondrite found in 1887 in Russia (FMNH Me 1442, Field Museum of Natural History, Chicago, Illinois, USA). Color online. Author James St. John.

Of the 6% non-stony meteorites about 5% are iron meteorites and 1% are stony-iron meteorites. Iron meteorites are composed of iron-nickel alloys (kamacite and taenite). The largest meteorite on Earth is an iron meteorite (see Fig. 1). Stony-iron meteorites contain iron-nickel metal and silicate minerals. A typical representative of the stony-iron group is the pallasite (Fig. 3). Another major group of stony-iron meteorites is the mesosiderites.

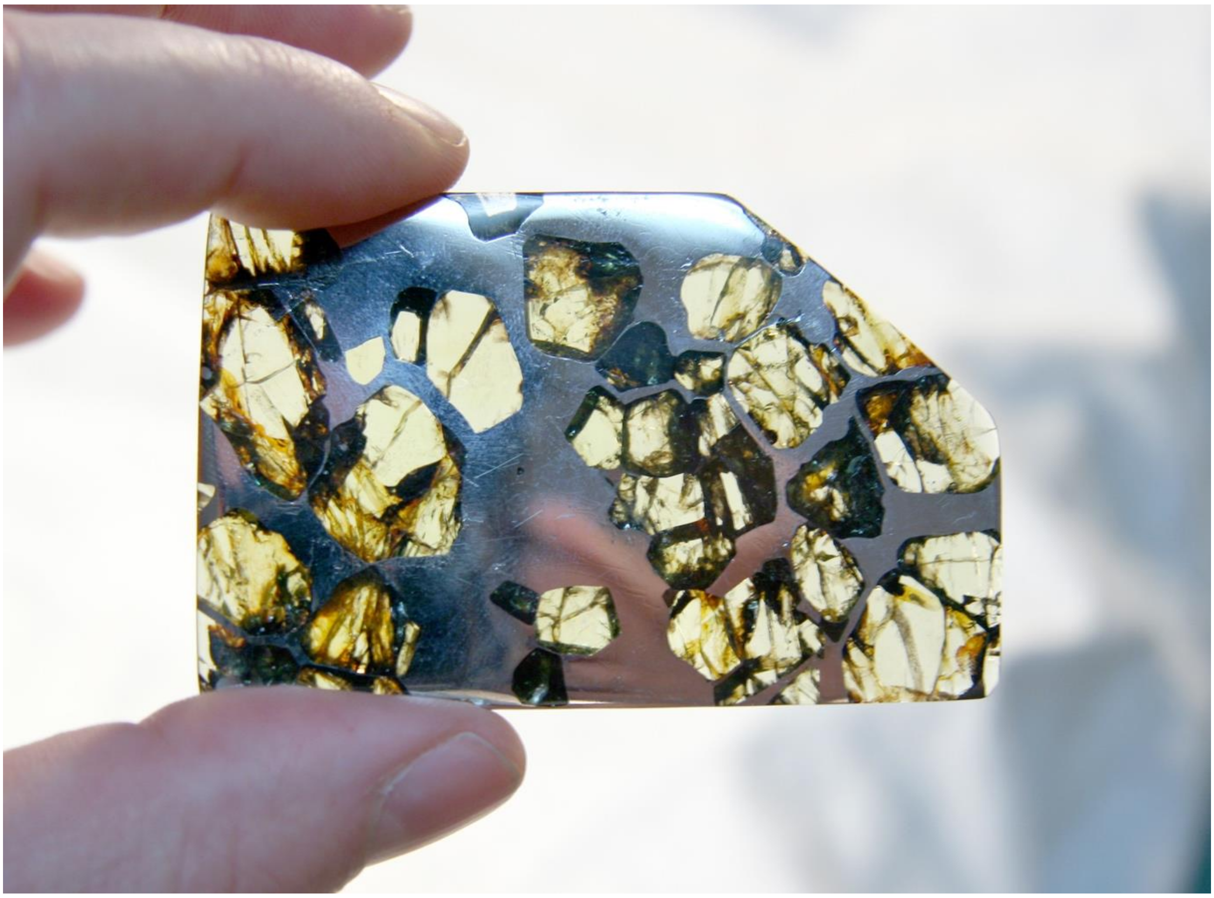


Fig. 3. A slice of the Esquel meteorite (pallasite). This type of meteorite is from the core-mantle boundary of an ancient planetoid that was smacked apart billions of years ago. The metal is iron/nickel core material and the crystals are peridot from the mantle area. At the interface, they mix together as you can see. Author Doug Bowman.

METAL DETECTORS AS A TECHNOLOGY FOR ATTRACTIVE PHYSICS EDUCATION

Metal detectors exhibit a lot of physical phenomena to the user and in this manner they utilize physical properties of the ground and target objects in order to derive information about the underlying material. Metal detectors use various physics laws such as acoustics, electromagnetism, ionizing radiation, etc. Most wide-spread metal detectors are those based on electromagnetism. These are the induction balance detector, the ground penetrating radar and the pulse induction detector. The most ubiquitous metal detector type is the induction balance metal detector. These devices have moderate weight, cost, and the lowest power consumption among all types of detectors.

The ever increasing capabilities of induction balance metal detectors make them practical winners in the meteorite hunting enterprise. They are also affordable to universities for educational purpose.

METAL DETECTORS THROUGH THE YEARS

First metal detectors were implemented in searching for artillery shells and landmines. One of the first metal detectors was the French “Alpha” (see Fig. 4) developed by M. Guitton after WWI (F. Honoré, 1919).

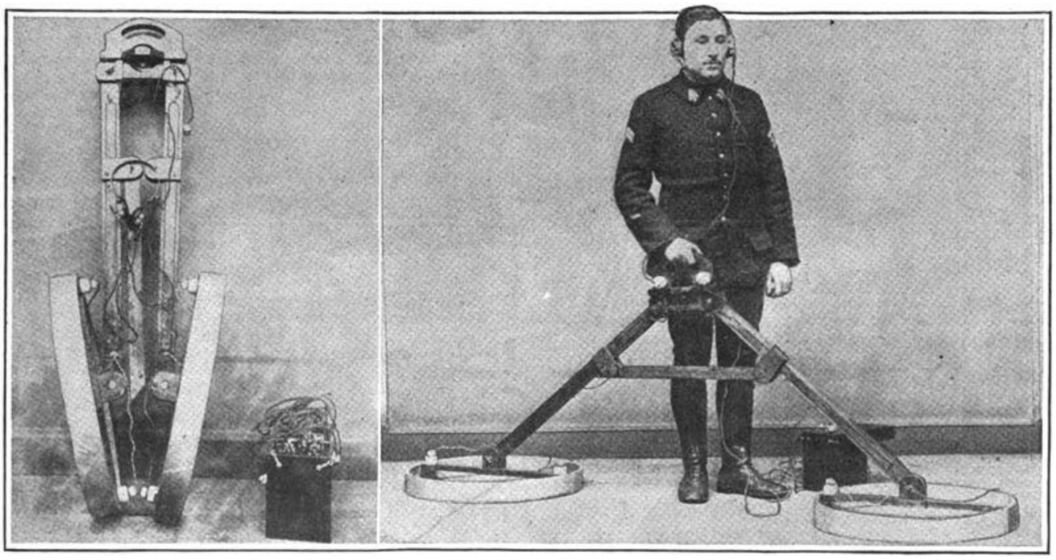


Fig. 4. “Alpha” metal detector. Invented immediately after WWI in France by M. Guitton

Another early development, but with modern characteristics is the Polish Mine detector Mark I (see Fig. 5). It was a metal detector for searching of landmines and was developed during the Second World War. After Germany invaded Poland in 1939 and occupied France in 1940, work on the detector was interrupted and was restarted in the winter of 1941–1942. The inventor of this modern detector was Polish lieutenant Józef Kosacki.

Fig. 5. Mine detector Mark I used by sappers of the Royal Engineers corps, North Africa, 28 August 1942.

The Polish detector was also of induction balance technology, having two coils in its search head positioned in induction balance. One coil was transmitting coil and the other was a receiving coil. It was operated by headphones (see fig. 5). The whole apparatus was 14 kg in weight (Croll, 1998). During the World War Two a few hundred thousand detectors were manufactured for the Allies.

MODERN MODELS OF INDUCTION BALANCE METAL DETECTORS

A famous pioneer in modern metal detector design is Gerhard Fisher. He invented a radio direction-finding system. His system was used for navigation. While performing tests, Fisher noticed errors in navigation data in areas rich in ore-bearing rocks. His further developments in this direction led to the 1925 patent grant for metal detector.

Today numerous manufacturers offer complex metal detectors to the market (see fig. 6).

Fig. 6. Modern handheld computerized induction balance metal detectors. The LCD screen is a standard among the high-end metal detectors nowadays.

Modern high-end metal detectors are controlled by a microprocessor. Further enhancements include multi-frequency transmission, digital signal processing, graphical visualization of the search data, etc.

METEORITE HUNTING WITH METAL DETECTORS AND PHYSICS EDUCATION

A successful approach to involving young people into physics topics is by demonstrating physical phenomena through the means of metal detectors. It is thrilling for everyone to hold in their hands a metal detector and to hunt for hidden objects. How about hunting meteorites?

Using an induction balance metal detector, the teacher may carry out education in the laboratory or in the open. The instructor would demonstrate the basic principals upon which a metal detector works by hiding metal objects in their hands or clothes and detecting them using the metal detector. Further, the theoretical principals of electromagnetic metal detection may be disclosed.

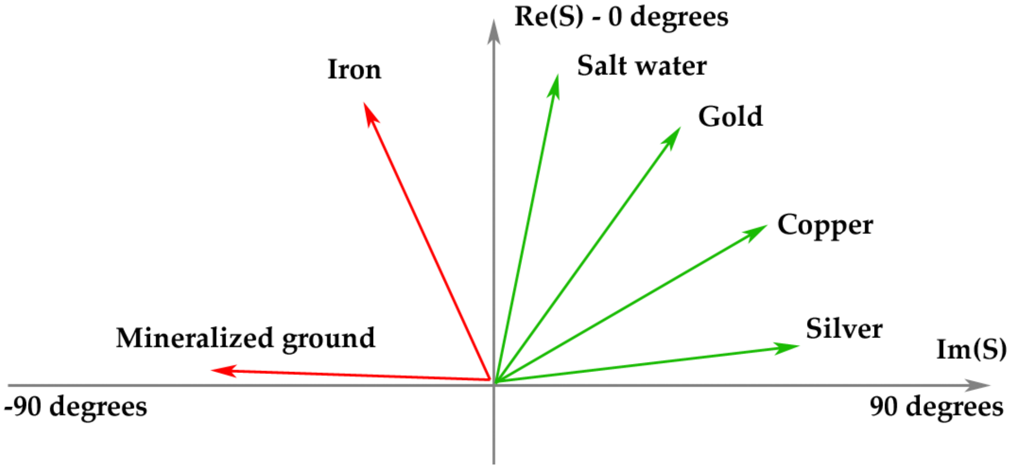


Fig. 7. Phase shift in the resultant magnetic field for different metals and substances.

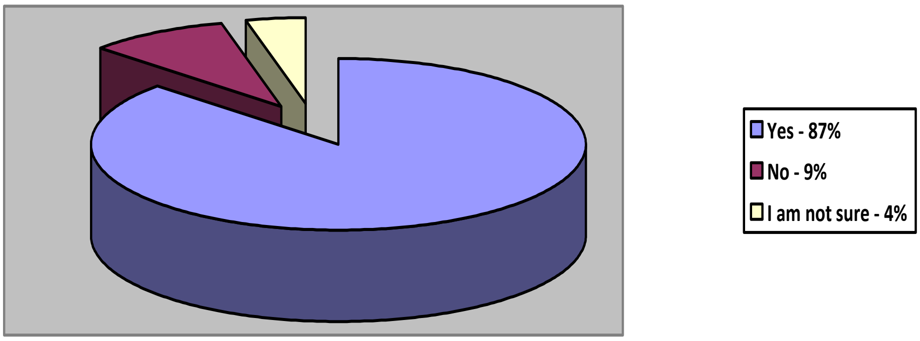
The metal detection physical laws for ferromagnetic and non-ferromagnetic objects are different. An induction balance metal detector can distinguish between the two metal types. The ability of the metal detector to make difference between metal types is called discrimination. The ferromagnetic metals tend to magnetize under magnetic field while non-ferromagnetic do not. On the other hand, any metal is conductive and conductivity yields eddy currents in the conductor. These two physical phenomena are separate. But in some objects they coexist. Upon magnetization using alternating magnetic field the magnetized material will produce secondary alternating magnetic field. The secondary field will have its phase lagging behind the transmitted field and the resultant magnetic field will also lag. We say that the phase shift is negative (see fig. 7). With the eddy currents phenomenon things are in reverse. The eddy currents are induced in the object by the alternating magnetic field of the transmitting coil of the detector. These eddy currents create secondary alternating magnetic field with positive phase shift (see fig. 7). Thus conduction materials may be discriminated from ferromagnetic materials. Even salt water, which is an electrolyte, is spotted by the detector although it is not a metal. Further, a ferromagnetic metal that is grained and has pour conductivity is well recognized by the metal detector as ferromagnetic target.

Most meteorites contain iron, nickel and cobalt, which are ferromagnetic metals. Thus the meteorite hunter should use its metal detector to search for ferromagnetic targets. The meteorite hunter is stimulated to understand the physical laws just described, because this knowledge makes the hunter more successful in their search. Everyone would like to know more about the physics of metal detecting in order to gain the most of their detectors. Also, the whole process of adjusting the detector, the interpretation of its information on the display and the digging for a target is fun and predisposes the student to perceive physics education with pleasure, not with fear.

STATISTICAL REVIEW

The author has performed a survey using students at Sofia University with the aim to account for the actual interest among students in a proposed educational process involving metal detectors and meteorite hunting. Two questions were asked in an inquiry in order not to make the investigation too cumbersome to the students and to receive adequate and real answers. A whole of 27 students were inquired (Fig. 8).

Would you like to participate in a physics education course that engages in meteorite hunting activities using metal detectors?



Are you interested to know how a metal detector works?

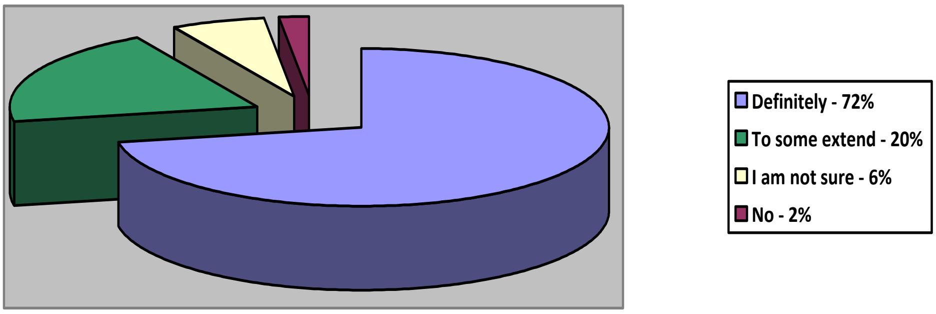


Fig 8. An inquiry of students on meteorite hunting with metal detectors as means of physics education.

From the statistical observations it is obvious the definite interest among students in the proposed learning methodology.

CONCLUSIONS

The implementation of meteorite hunting using metal detectors as an attractive method of teaching physics at schools and universities is to be implemented in the near future. A team at Sofia University, Bulgaria, is planning to establish meteorite hunting and metal detectors in tutoring courses in order to increase the interest in physics among the youth and also to enhance students understanding of electromagnetic processes.

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