

## **The Presence of Science and Math in Everyday Communication**

A great deal of information about scientific research and discovery is available in popular media, including newspapers, magazines, television shows, and websites ranging from institutional outlets to public-source venues such as YouTube. How well does this diversity of publication address key tenets of scientific and mathematical practices? One *New York Times* article, “Third Gravitational Wave Detection, From Black-Hole Merger 3 Billion Light Years Away,” does it well with respect to three basic tenets of science and three basic tenets of mathematics.

In 2015, scientists confirmed Albert Einstein’s century-old prediction that the acceleration of massive objects would produce gravitational waves, alternately stretching and shrinking spacetime itself. The engineering challenges presented by the detection of these minute waves are so formidable that once their detection was actually contemplated, it took forty years to design, fund, and construct an observatory that was both sensitive enough to detect them and also capable of screening out the abundant background noise present in any Earth-based detector. But in 2015, the LIGO observatory, a pair of detectors in the United States separated by thousands of miles,

became operational, and detected gravitational waves almost immediately.

Since then, LIGO has made further discoveries. Reporting on them, Dennis Overbye of *The New York Times* supports a number of tenets central to the natures of science and mathematics.

### **Science Tenets**

#### **Scientific knowledge is based on empirical evidence**

In this case, over the course of four decades, a large and evolving group of physicists and engineers constructed an unusual observatory specifically for the purpose of detecting Einstein's predicted gravitational waves through observation. Clearly, much of astronomy relies on observation; it might be the quintessential observational science given its reliance on a wide variety of detectors, including many forms of telescope that do not seem to the casual observer to be telescopes at all, such as arrays of radar dishes. Overbye writes, "Because of the merger's great distance, the LIGO scientists were able to verify that different frequencies of gravity waves all travel at the same speed, presumably the speed of light." [ CITATION Den17 \l 1033 ]. Analysis of the signals received by LIGO constitute scientific evidence that Einstein's prediction was accurate and provides a means

of understanding relativity and stellar mass phenomena more thoroughly.

### **Science Models, Laws, Mechanisms, and Theories Explain**

#### **Natural Phenomena**

In this case, the “natural phenomenon” is the distortion of spacetime by the acceleration of massive objects. The theory of relativity is the explanation for this phenomenon, and the detection of gravitational waves is a perfect and impressive example of empirical evidence used to support a prediction: “It validated Einstein’s longstanding prediction that space-time can shake like a bowlful of jelly when massive objects swing their weight around...” [ CITATION Den17 \l 1033 ].

#### **Science is a human endeavor**

The article indicates that in total, more than 1300 scientists are involved in LIGO and its European counterpart, Virgo. These people come from a wide variety of nations and they work and publish collaboratively. In fact, 1300 authors are listed in a report on gravitational wave findings. [ CITATION Den17 \l 1033 ].

#### **Mathematical Tenets**

The article is less strong in its support for mathematical tenets. Given that this is a general interest article appearing in a popular newspaper

rather than in a specialized publication, it is not surprising that it hews less closely to mathematical tenets per se than it does to scientific one. This is especially true given the widespread notion—and I presume here to speak from my own experience, without research citation—that mathematical reasoning and specific mathematical knowledge are both somewhat weak in the general population. Below, I address three particular tenets of math.

### **Reason abstractly and quantitatively**

The Common Core Standards states that “Mathematically proficient students make sense of quantities and their relationships in problem situations.” [ CITATION Com18 \l 1033 ]. A great deal of mathematical reasoning is involved in gravitational wave research. Everything from calculations of the different and total solar masses involved, to distances from Earth, to quantities of energy released, to frequencies of that energy, and so on, is reported in this article. For example:

After a journey lasting 3 billion years, that is to say, a quarter of the age of the universe, those waves started jiggling LIGO’s mirrors back and forth by a fraction of an atomic diameter 20 times a second. The pitch rose to 180 cycles per second in about a tenth of a second before cutting off. [ CITATION Den17 \l 1033 ].

In this passage, various quantities are expressed and in various ways. The duration of the journey is compared to the age of the universe in order to give a sense of scale; on the other hand, the vibration of the mirrors is not rendered in terms of conventional units, most likely because the author judged those units to be too foreign to the lay reader (picometers not being commonly used except by scientists).

In addition, research into black holes must be done in the *absence* of conventional forms of observation, since, by definition, black holes cannot be observed directly. Therefore, much of the reasoning about black holes is abstract and quantitative, not empirical (until LIGO, that is).

### **Attend to precision**

The article does not specifically attend to precision. Precision in this case refers to clarity of communication. For example, definitions are clarified, symbols are either defined or adhere to common usage practices, units of measure are specified, mathematical calculations are accurate and expressed with an appropriate degree of precision, and so on. [ CITATION Com18 \l 1033 ]. That said, the example given in the previous subsection, to do with abstract and quantitative reasoning, does itself provide several examples of correct usage of units and precision. Units used include those of time (years, age of

universe, seconds) and of distance, at least by analogy (diameter of an atom).

### **Model with mathematics**

Modeling with math means that known mathematical principles are applied to problems as they arise. [ CITATION Com18 \l 1033 ]. It would probably be correct to say that relativity is a known mathematical model; therefore it follows that its application to LIGO's observations constitutes mathematical modeling. Indeed, if not for modeling, scientists would not have known what to look for.

In summary, Overbye's article does well in conforming to tenets of science and math. Readers ought to be glad for the work of writers who can adhere to such important ideas as these and simultaneously communicate complex ideas to a general audience.

### **Sources**

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