Example 1: Audience

This example looks at how writing is tailored to different audiences, using the recent discovery of gravity waves as an example. This was reported in all levels of media, and below are four examples of how one element of the experiment, the interferometer, was described for different audiences.

**1) Semi-specialist physics audience (from the paper, Abbott et al, PRL 116, 061102 (2016)))**

“To achieve sufficient sensitivity to measure gravitational waves, the detectors include several enhancements to the basic Michelson interferometer. First, each arm contains a resonant optical cavity, formed by its two test mass mirrors, that multiplies the effect of a gravitational wave on the light phase by a factor of 300 [48]. Second, a partially transmissive power-recycling mirror at the input provides additional resonant buildup of the laser light in the interferometer as a whole [49,50]: 20 W of laser input is increased to 700 W incident on the beam splitter, which is further increased to 100 kW circulating in each arm cavity. Third, a partially transmissive signal-recycling mirror at the output optimizes the gravitational-wave signal extraction by broadening the bandwidth of the arm cavities [51,52]. The interferometer is illuminated with a 1064-nm wavelength Nd:YAG laser, stabilized in amplitude, frequency, and beam geometry [53,54]. The gravitational-wave signal is extracted at the output port using a homodyne readout [55].”

**2) General physics audience (Physics Today 69, 4, 14 (2016))**

“The observed strain, a mere 10−21, implies that the length changes in LIGO’s arms were 1/1000 the radius of an atomic nucleus. At face value, that’s an impossibly small value to measure. LIGO’s solution is to turn each arm into a resonant optical cavity (see figure [2](http://physicstoday.scitation.org/doi/10.1063/PT.3.3123?journalCode=pto&showFTTab=true&containerItemId=content%2Faip%2Fmagazine%2Fphysicstoday%2Fissues)). Light injected into the cavities bounces back and forth hundreds of times before recombining. In effect, the cavity increases the light’s path length from 4 km to more than 1000 km. The attometer-size length change in the arms thus becomes a more manageable, although still impressive, femtometer-size difference in the light’s path length.”

**3) General science audience (from** [**Science**](http://www.sciencemag.org/news/2016/02/gravitational-waves-einstein-s-ripples-spacetime-spotted-first-time)**)**

“LIGO watches for a minuscule stretching of space with what amounts to ultraprecise rulers: two L-shaped contraptions called interferometers with arms 4 kilometers long. Mirrors at the ends of each arm form a long “resonant cavity,” in which laser light of a precise wavelength bounces back and forth, resonating just as sound of a specific pitch rings in an organ pipe. Where the arms meet, the two beams can overlap. If they have traveled different distances along the arms, their waves will wind up out of step and interfere with each other. That will cause some of the light to warble out through an exit called a dark port in synchrony with undulations of the wave.”

**4) general public (from** [**The Verge**](https://www.theverge.com/2016/2/11/10965312/einstein-gravitational-waves-discovered-announced-video)**))**

“The LIGO collaboration has two observatories in Louisiana and Washington State, both funded by the National Science Foundation. Each facility is shaped like a giant "L;" the "arms" of the L are two vacuum-sealed tubes stretching 2.5 miles long, with mirrors at each end. The mirrors are used to measure how gravitational waves warp space-time. When a gravitational wave passes, one mirror gets closer while the other retreats; scientists measure this phenomenon by bouncing lasers off the mirrors. Changes in the amount of time it takes a laser to bounce off a mirror indicate a gravitational wave.”

Example 2: Story

Before my colleagues and I sit down to write a paper, we spend a while working out the story, by asking ourselves questions and then putting the important information into a clear order, which often serves as a basis for the structure of the paper. Below is the story for a paper. Read it and try to answer the questions.

**Story:**

Rare earth crystals are very promising candidates for quantum information technology, such as quantum memories. They have long coherence times on their spin levels, which allows long term quantum state storage, and quantum information can be written onto the spin levels using optical photons, which are easy to transmit and control.

For these reasons, rare earth crystals have been intensively studied for quantum memories. However, getting sufficiently good performance (memory efficiency, storage time, and bandwidth) has proven hard. Many of the problems can be boiled down to the use of low concentration crystals. These crystals tend to be disordered, and have large optical linewidths. In such crystals, we can only work with a small proportion of the atoms over a narrow frequency range, and so the quantum memory efficiency and bandwidth is reduced.

We solved this problem by making a fully concentrated crystal with very low disorder by eliminating one of the chlorine isotopes. The crystal has a narrow linewidth of 25 MHz and has resolved hyperfine structure for the first time. This means we can use all the atoms in the crystal for a quantum memory, and this means a much higher efficiency and bandwidth. There are other things we can do for the first time in a crystal. We can make a Raman quantum memory, and we can investigate many body physics interactions. Both of these applications were only previously possible in atomic gases.

**What is the key result/problem to solve?**

**What did we do?**

**How did we do this?**

**Why is this important?**

**How does this relate to other work?**

**What impact will this have?**

Typically, the story is summarised in the abstract, and the rest of the paper expands on the basic information in the story. To give you some idea what this looks like, below is the abstract.

**Abstract:**

We obtain a low optical inhomogeneous linewidth of 25 MHz in the stoichiometric rare-earth crystal EuCl3 · 6H2O by isotopically purifying the crystal in 35Cl. With this linewidth, an important limit for stoichiometric rare-earth crystals is surpassed: the hyperfine structure of 153Eu is spectrally resolved, allowing the whole population of 153Eu3+ ions to be prepared in the same hyperfine state using hole-burning techniques. This material also has a very high optical density, and can have long coherence times when deuterated. This combination of properties offers new prospects for quantum information applications. We consider two of these: quantum memories and quantum many-body studies. We detail the improvements in the performance of current memory protocols possible in these high optical depth crystals, and describe how certain memory protocols, such as off-resonant Raman memories, can be implemented for the first time in a solid-state system. We explain how the strong excitation-induced interactions observed in this material resemble those seen in Rydberg systems, and describe how these interactions can lead to quantum many-body states that could be observed using standard optical spectroscopy techniques.

Example 3: Paragraph structure

The paragraph below is an example of how *not* to structure your writing. It is the first paragraph of the introduction to a paper, and describes the reason for the experiment done. Try to identify the main idea of the paragraph, and think about why the paragraph is hard to read. Then, read the rewritten version.

**Original text (230 words)**

Calcium fluoride is a cubic material. Rare-earth ions were known to occupy different sites due to charge compensation. Hamers *et al.*1 identified five different sites in CaF2 :Eu3+ 0.1% whose 7F0→5D0 absorption wavelengths fall at 579 0.6 nm. High-resolution spectral studies were also performed on these materials by the hole-burning technique. Hole-burning studies of the tetragonal site2 and oxygen-compensated trigonal site were performed in the past.3 – 5 Hole burning was also pursued in several other europium-doped crystals and glasses.6 – 10 The 5D0 and 7F0 states of Eu3+ are singlets in the crystal field. A transition between these two states is expected to reveal a single peak either in absorption or emission, in defect free perfect crystals. A recent investigation11 on the 7F0→5D0 transition of Eu3+ doped Y2SiO5 revealed more than 40 different satellite lines for the dopant though the prior studies revealed only two sites.12 Similar observations were made in EuVO413 and YAlO3:Eu3 14 also. The satellite lines were ascribed to ions that were on the sites differently perturbed, by defects or clustering of Eu3+ ions. It is not clear yet whether this multisite behavior is universal or dependent on the host material. So, we reinvestigated the high-resolution spectroscopy and hole-burning phenomena in CaF2 :Eu3 . Our studies revealed more than 40 different sites for the Eu3+ ion whose transition wavelengths (7F0→5D0) fall within 1 nm centered around 579.5 nm.

**Edited text (167 words)**

Rare earth dopant ions normally exist in crystals as substitutional defects. The number of substitutional sites the dopant occupies in the crystal can be determined from the number of lines in the optical spectrum of the dopant ion. For this purpose, the 7F0-5D0 transition of Eu3+ is particularly useful, since both levels are singlets and so each site gives rise to only a single peak in the emission or absorption spectrum.

Recent measurements in Eu:Y2SiO5[1], EuVO4 [2], and Eu:YAlO3[3], found many more sites than previously seen. In Eu:Y2SiO5, for example, two sites were expected but over forty sites were observed. The extra lines were ascribed to ions in either perturbed sites, or in Eu3+ clusters.

In this study, we revisit Eu3+ :CaF2, in which five sites have previously been seen [4], to determine whether the same perturbed and cluster sites are present. Using high resolution and holeburning spectroscopy, we find over forty different Eu sites with wavelengths for the 7F0-5D0 transition within 1 nm of 579.5 nm.