Science Exemplary Text
Student Handout

Sung to the tune of “The Times They Are A-Changin’”:

Come gather ‘round, math phobes,
Wherever you roam
And admit that the cosmos
Around you has grown
And accept it that soon
You won’t know what’s worth knowin’
Until Einstein to you
Becomes clearer.
So you’d better start listenin’
Or you’ll drift cold and lone
For the cosmos is weird, gettin’ weirder.
—The Editors (with apologies to Bob Dylan)

Cosmology has always been weird. Worlds resting on the backs of turtles, matter and energy coming into existence out of much less than thin air. And now, just when you’d gotten familiar, if not really comfortable, with the idea of a big bang, along comes something new to worry about. A mysterious and universal pressure pervades all of space and acts against the cosmic gravity that has tried to drag the universe back together ever since the big bang. On top of that, “negative gravity” has forced the expansion of the universe to accelerate exponentially, and cosmic gravity is losing the tug-of-war.

For these and similarly mind-warping ideas in twentieth-century physics, just blame Albert Einstein.

Einstein hardly ever set foot in the laboratory; he didn’t test phenomena or use elaborate equipment. He was a theorist who perfected the “thought experiment,” in which you engage nature through your imagination, inventing a situation or a model and then working out the consequences of some physical principle.

If—as was the case for Einstein—a physicist’s model is intended to represent the entire universe, then manipulating the model should be tantamount to manipulating the universe itself. Observers and experimentalists can then go out and look for the phenomena predicted by that model. If the model is flawed, or if the theorists make a mistake in their calculations, the observers will detect a mismatch between the model’s predictions and the way things happen in the real universe. That's the first cue to try again, either by adjusting the old model or by creating a new one.

Media Text
NOVA animation of an Einstein "thought experiment"
http://www.pbs.org/wgbh/nova/einstein/relativity

Tyson, Neil deGrasse. (2003). "Gravity in Reverse: The Tale of Albert Einstein's 'Greatest Blunder.'" *Natural History*. 112.10 (Dec 2003).

NOTE The following article is an example of a comparison document about Negative Gravity to accompany "Gravity in Reverse: The Tale of Albert Einstein's 'Greatest Blunder.'"

A photograph of a distant exploding star has given astronomers the first direct evidence that a mysterious ''negative gravity'' force swept through and still pervades the universe, scientists announced at a NASA news conference yesterday in Washington.

The Hubble Space Telescope by chance photographed the exploding star, the most distant ever observed, in 1997. Scientists say subsequent detective work on the relative intensity of its light confirms one of Einstein's conjectures about the universe: that all of space is bubbling with an invisible form of energy that creates a mutual repulsion between objects normally attracted to each other by gravity.

Einstein himself thought the force, which he called the cosmological constant, was so strange that he later repudiated his conjecture. But the idea gained theoretical support in 1998 with findings suggesting that the expansion of the universe was accelerating and that the force accelerating the expansion, negative gravity -- the manifestation of the cosmological constant -- overtook the force of gravity in the last few billion years.

The new findings confirm that crucial part of the theory. And they rule out several competing explanations.

Because the amount of negative gravity in any given volume should be minuscule, its effects would not be felt in everyday life. But over vast distances involving huge volumes of space, the effect would be powerful enough to push galaxies and clusters of galaxies apart from one another.

Exploding stars, or supernovas, like the one that turned up unexpectedly on a photograph made by the Hubble telescope, can be excellent probes of those grand forces. The new observation is of a star that exploded about 11 billion years ago, when the universe was a quarter of its present age and when, scientists theorized, the cosmological constant, often called ''dark energy,'' was less powerful than gravity, the opposite of what prevails today.

As a result, the expansion of the universe was slowing at that time. This meant that the star was closer to earth when it exploded than it would have been if dark energy had dominated gravity then -- a fact discernable in its brightness. Astronomers said it was twice as bright as it would have been under competing theories about the universe.

A team led by Dr. Adam G. Riess, an astrophysist at the Space Telescope Science Institute in Baltimore analyzed the data. Dr. Riess, who worked with Dr. Peter E. Nugent of Lawrence Berkeley National Laboratory, said the measurement "nails the existence of the dark energy."

Dr. Michael S. Turner, an astrophysicist at the University of Chicago not involved in the work, called the dark energy "one of the most important discoveries in all of science."

"If Einstein were around today, he would get another Nobel Prize for his prediction of repulsive gravity," Dr. Turner said.

He added that research would now shift to a hunt for the source of the energy and efforts to observe many other distant supernovas to pin down the characteristics of the dark energy.

The universe is expanding as a legacy of its violent birth, which is believed to have occurred in a great explosion or "big bang" roughly 14 billion years ago. Until recently, scientists were all but certain that the gravitational attraction among the galaxies would slow the expansion.

But in 1998, two teams began presenting data on supernovas that they had observed as a way to measure the change in the expansion rate over the last few billion years. They used a class of supernovas that explode with nearly the same brightness each time, like bulbs of a known wattage. This constancy enabled scientists to measure the speed at which the expansion of the universe had swept these supernovas away: the dimmer they appeared from earth, the farther away they were.

Those observations revealed unexpectedly dim supernovas, suggesting that something, perhaps clouds of cosmic dust, was obscuring them or that they were farther away than expected, perhaps driven away by an anti-gravity force.

To find the explanation, astronomers tried to observe objects so distant that their light had been traveling to Earth for billions of years.

"You need things that you can see across to the other side of the universe," Dr. Nugent said.

If cosmic dust were dimming this light, they reasoned, the objects would be dimmer the farther they were from Earth. But if Einstein's explanation were correct, extremely distant supernovas should appear to brighten relative to some standard, rather than continuing to dim.

Because they are so faint and are obscured by Earth's atmosphere, very distant supernova explosions are rarely seen. But a break came in 1997 when teams led by Dr. Ronald L. Gilliland of the space telescope institute and Dr. Mark Phillips of the Carnegie Institution of Washington made long-exposure Hubble photographs of a tiny part of the sky. The pictures revealed a supernova in the distant gloom of space.

A difficult and time-consuming analysis of light from the star showed that it was twice as bright as it would have been if cosmic dust had been obscuring it or, as another hypothesis held, if supernovas had somehow evolved steadily in brightness over the history of the cosmos.

The finding, said Dr. Saul Perlmutter, a physicist and supernova-hunter at the Berkeley laboratory not involved in the work, was ''not very consistent with simple dust or evolution models.''

''That's the standout story here,'' Dr. Perlmutter said.

Cosmologists will have to cope with a universe that seems increasingly filled with mysterious stuff that scientists cannot see and do not fully understand. The dark energy joins dark matter as an invisible constituent of the cosmos. Dark matter's gravitational effects are known, and despite its invisibility it is presumed to give the universe much of its mass.

Physicists will try to explain the source and exact nature of the dark energy. Dr. Turner said these questions appeared to lie at the crossroads of several of the most important problems in physics.

''In 'The Graduate,' that guy told young Dustin Hoffman, 'plastics,' '' Dr. Turner said. ''My advice to the next generation of particle physicists and astrophysicists: dark energy.''

Glanz, James. (2001). “Photo Gives Weight To Einstein's Thesis Of Negative Gravity.” *New York Times*. (Apr 2001). http://www.nytimes.com/2001/04/03/us/photo-gives-weight-to-einstein-s-thesis-of-negative-gravity.html?pagewanted=print&src=pm

Science Exemplary Text
Teacher Resource

Sung to the tune of "The Times They Are A-Changin'":

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If—as was the case for Einstein—a physicist's model is intended to represent the entire universe, then manipulating the model should be

Teacher introduces the text with minimal commentary and students read it independently. Teacher then reads passage aloud. Give a brief definition to words students would likely not be able to define from context (underlined in text). Teacher guides the students through a series of text-dependent questions. Complete the performance task as a cumulative evaluation of the close-reading.

Text-Dependent Questions

1. Summarize the poem at the start of this passage.
2. What examples does the author give of why cosmology is "weird?"
3. How is cosmology changing?
4. How did Einstein create his models and how did that make him different?
5. What message does the passage give you overall?
6. What argument is the author making? Support with evidence from the text.

Performance Tasks for Informational Texts
Students will explain what this article says about ways to model scientific experiments. What is the procedure to figuring out a hypothesis if Einstein were doing it? [RST.11-12.6]

Using several sources, challenge or support the theories of negative gravity, the big bang, or cosmic gravity. Use evidence from each resource to verify your conclusions. [RST.11-12.8]

This is an example of exemplary text found in *Common Core Standards for English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects: Appendix B Text Exemplars and Sample Performance Tasks.* Retrieved from http://www.corestandards.org/assets/Appendix_B.pdf

tantamount to manipulating the universe itself. Observers and experimentalists can then go out and look for the phenomena predicted by that model. If the model is flawed, or if the theorists make a mistake in their calculations, the observers will detect a mismatch between the model's predictions and the way things happen in the real universe. That's the first cue to try again, either by adjusting the old model or by creating a new one.

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