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ON BIG QUESTIONS AND A CENTURY OF EINSTEIN

By Robert Bluhm

Albert Einstein published his theory of relativity 100 years ago, and the anniversary has been noted with fanfare around the world. Colby asked Professor Robert Bluhm, an authority on Einstein, to reflect on Einstein's contribution to physics and our world.

I cannot imagine physics without Einstein. While it is certainly true that the subject has been around since well before Einstein burst on the scene 100 years ago—and there have been other great physicists both before and after—it is nonetheless Einstein's work that touches the heart and soul of what it means to me to be a physicist.

Since this is the centennial year of Einstein's relativity and has been declared the Year of Physics by the United Nations, I find myself thinking more and more about Einstein lately and what his work has meant to my teaching and research.

To me, there are basically two types of physicists. First there are those who like to take stuff apart and figure out how things work. Then there are those who like to ask the big questions: where did the universe come from, and why are we all here? Of course, most physicists—including Einstein—are a little of both. But for those who lean more toward the big questions (myself included) there is no greater role model than Albert Einstein.

Perhaps the most astonishing thing about Einstein is that he was able to come up with the theory of relativity largely on his own and from outside the academic community. While he was aware of much of the work of his contemporaries and had all the benefits of a university education, he had nonetheless fallen into obscurity by his mid-20s, taking a job as a patent clerk in Bern, Switzerland. Somehow Einstein thrived, and in 1905 he published five papers that forever changed physics.

By far the most important of his papers that year were the two dealing with the special theory of relativity. The implications of this theory are mind boggling: the passage of time and spatial distances are all relative, and mass and energy become equivalent as stated in the famous equation $E=mc^2$.

According to relativity, how one person ages compared to another depends on how fast they are moving relative to each other. This means that if I were to go off for one day in a relativistic rocket at, say, 99.9999999 percent the speed of light, when I returned I would be one day older, but my children would have aged by over 60 years!

Of course, in our slowpoke existence we do not have to worry about such scenarios. Even in the fastest jet planes the relative time shift due to relativity is only a fraction of a microsecond for a one-day trip. This is far too little for anyone to notice—though it has been measured with precise atomic clocks.

Indeed, there have been numerous high-precision tests of relativity over the years, and much of my research for the past seven or eight years has been concerned with looking for better ways to test relativity. In the end, as bizarre as relativity may seem, its main predictions do appear to be correct. Time and space do not behave as we naively assume based on ordinary experience.

However, the relative nature of space and time is just the beginning of the story. Einstein's 1905 theory of special relativity concerns only steady (or non-accelerated) motion. In the years 1907-1915, Einstein generalized the theory to include the effects of acceleration—the resulting theory is known as general relativity. Since gravity causes objects to fall with an acceleration, what Einstein ultimately had to do when he developed general relativity was to invent a new theory of gravity.

In general relativity, massive objects like planets, stars, and galaxies cause the space and time around them to curve. This distortion of space and time can become so extreme that in objects called black holes not even light can escape. Perhaps most intriguing of all, one can model the whole universe in the context of general relativity. The solutions describe a dynamical universe that can expand, contract, or even accelerate. When combined with experimental observations, we find that the observable universe appears to have a beginning. Projecting back about 14 billion years, there appears to be a moment of creation or Big Bang in which all matter and energy erupted from a single point of extremely high density and hot temperature.

As a teacher at Colby, I never tire of retelling the story of Einstein's discoveries and how they have reshaped our understanding of the universe. I see the initial looks of total disbelief on students' faces as I tell them about the strange behavior of space in time in special relativity. In my upper-level course on general relativity, we work our way slowly through the

mathematical intricacies of describing warped space and time and how very recent discoveries have altered our understanding of the evolution and makeup of the universe.

As much as I admire Einstein's relativity, it is still just the latest installment of an ongoing (and probably never-ending) effort to understand all of physics at the most fundamental level. Indeed, much of the current research in theoretical physics is devoted to finding a quantum theory of gravity that will supercede Einstein's general relativity.

Ultimately, though, when a deeper, more fundamental theory is uncovered I suspect it will be the result of a huge collaborative effort. It is hard for me to imagine that there will ever again be a single person emerging from near total obscurity who will singlehandedly change our view of the entire universe. For this reason, I believe Einstein will always remain a unique figure in physics, one who will inspire and amaze physics students for years to come.

Robert Bluhm is the Sunrise Professor of Physics. He has been at Colby since 1990. His research interests include theoretical particle physics, atomic physics, gravity, and cosmology.

