Preface

Clapham Common, Britain, 1797

Henry Cavendish dropped exhausted onto the only chair in his laboratory. He had just finished lifting the second 12-inch, 350-pound lead sphere into place using block and tackle, and needed to rest before he could start the final suspension. He was building an apparatus to weigh the earth. He had seen something like it in the lab of a geologist who recently passed away, John Michell, who had never completed his experiment.

It was a large affair; a support frame ten feet high and ten wide, supporting delicately from its center a balanced six-foot horizontal rod, with two 2-inch lead spheres hanging off either end. And just inside the arc described by the two small lead weights when the beam swung were the two large lead spheres hung on their own rotating suspension. He was going to measure just how much gravitational force was felt by the small moving weights as they were close to the large lead spheres. It was very delicate work, but this is where Henry loved to be, alone in his lab.

Henry Cavendish hated crowds, hated interacting with people; but he loved numbers, measurement and experimenting with chemicals and apparatus. His father, the gregarious Lord Charles Cavendish, politician and scientist, brought young Henry along to his assignments in the British Museum and to the Royal Society to hear reports on the treasures unearthed in foreign lands and in small laboratories alike, to hear tales of discovery in the sciences, in physics, in chemistry, in geology and geography, in archaeology, all the wonders that Henry found so absorbing.

And there in the halls of the Royal Society Henry heard of Newton. Isaac Newton, who had lead the Royal Society for a time and had died just five years before Henry was born. The great physicist and alchemist, it was Newton who came up with a scientific law describing the gravitational attraction of one mass for another. It was a straightforward relationship between the two masses of interest multiplied by each other, divided by the distance between them squared, all multiplied again by a constant. And that constant was Henry’s goal. Big G, the universal gravitational constant, was unknown.

Big G was small, too small to observe in the presence of the Earth, itself a very, very large mass. The apparatus of Michell was just the thing to measure the force of gravity in a different direction from that of Earth’s gravity; it would measure the small force of gravity acting sideways.

It took Henry a week to get the masses positioned and measured as precisely as possible. He had the advantage of access to the best scientific equipment through his father’s wealth and his own connections into the great scientific community around London. His measurements were the rate of rotation when the weights felt that very small gravitational force. Henry set up his apparatus well; he could measure distances and could measure deflections of 0.01 inches.

His plan was simple: measure Big G and use that to find the mass of the earth using Newton’s Law of Gravitation equation. The Universal Gravitational Constant, responsible for keeping the planets in their orbits, and for holding galaxies together, could be known. Big G was a constant. Henry was about to measure the value.

Massachusetts Institute of Technology 1999

Timothy Farnsworth walked into an auditorium filled with the buzz of excitement. Everyone in the packed hall was chatting, questioning, and some were attempting to explain the new observations. This hastily-gathered convention of physicists, astronomers and cosmologists was brought together on the news from the latest cosmological survey.

Timothy found a seat on the side, near the wall. Like Cavendish, he was a shy associate professor, holding to himself more than to crowds. And, like Cavendish, more at home with apparatus than with people.

Someone Timothy didn't know was at the podium, trying to get everyone's attention.

"Ladies and Gentlemen, we're here to hear about some of the latest discoveries in cosmology. We know this is an exciting day, but if you in the back can quiet down, we can get started." The crowd in the back of the hall, who seem to have started a debate of some kind, quieted and sat down.

"Our first speaker, Dr. Elise Butler of MIT, will speak briefly on the Galactic Shape Survey. Then we will hear from Dr. Stuart Gains, Cal Tech, on the latest results from the Spacial Flatness Survey, and finally we will hear at length from Dr. William McGinty of Harvard on the measurement of the universal gravitational constant calculated from the galactic cluster survey."

As Timothy listened to each speaker, he did as he almost always did when listening to scientific lectures, translate the scientific vernacular into one his freshmen students could understand. In his mind he was giving his own lecture to his students.

"As we examine a galaxy, we find they are spinning. We can measure the rate of spin by looking for galaxies that appear to us slightly on end, and measuring the color of the stars at the sides. Stars with colors shifter to the blue end of the color spectrum are coming toward us, as a siren passing on the street sounds higher in pitch as the ambulance approaches. And similarly, colors that are shifter toward the red end of the spectrum are moving away, as you may also have heard. The speed of the stars moving toward us and away can be calculated from the amount of shift. How do we know how far the spectrum has shifted? Because atoms shine at certain frequencies which have never in our experience changed. Hydrogen has four well-known lines of color. We find those lines in the stars and measure where they appear to us.

"We can then estimate the diameter of the galaxy from the rotational speed. Now here is the neat thing about galaxies: the total mass of the galaxy, the weight of all the stars and all the dust and everything, thins out toward the edges, which are furthest away. The inner parts of the galactic disk, because most galaxies start as rotating disks of stars and dust, rotate a little faster than the outside, having a shorter distance to go around, and a beautiful spiral pattern emerges over the millions of years or billions of years needed for the dust to assemble into stars because of gravity and to light up. Our own Milky Way galaxy is just such an example of a spiral arm galaxy."

"Hmmm," Timothy thought to himself as he listened to the talk, "here is where it gets interesting."

"In a recent survey of the shapes of galaxies we are observing anomalous behavior. When we simulate the formation of a galaxy, we get a slightly different shape than we are seeing. Not every galaxy is different, just a few. And what explanations do we have for these anomalies? They seem to have more matter at the center then we can see. We call this 'Dark Matter.' Or perhaps the universal gravitational constant is a little higher there than elsewhere, but we know it to be a constant, so let's stick with dark matter. What is dark matter? We don't know. We've never seen it. It's not dust or planets or stars which can't shine, because they would block the light from stars behind them, and that light isn't being blocked. We just don't know what dark matter is."

It was a short talk, and reported information already reported before and discussed.

The next talk was also short and went over material already reported. In Timothy's head he continued his lecture to the freshmen: "Space can have a shape. Now, this is very difficult to picture, so we have found ways of picturing what might happen when space is curved. Imagine a plane, flat, infinite, stretchy as rubber, no bumps anywhere. This represents space. Everywhere there is a planet or star or something very heavy, we imagine what it would do to this imaginary plane. Heavy object would distort the plane, make a sort of hole for themselves. Like steel balls might in a thin, stretchy rubber plane. We might call these local distortions. And every heavy object does this to space itself, creates what we call a local curvature.

"But let's take a longer look at the universe, the entire cosmos. The whole thing might be bent, warped in some way so that the normal laws of the universe might be changed a little. In a flat plane, if we distribute galaxies evenly over the surface, we'll see something remarkable: every time you count the galaxies at a certain distance, when you double the distance you always count exactly four-times the number of galaxies. You can keep doing this doubling thing forever, or until you reach the edge of the universe, and the four-times law holds strictly true.

"But what if the universe were bent into a sphere? How would that counting thing work? Every time you double the distance, when you count the galaxies, you get a number less than four-times, maybe 3.8 times. And it gets smaller every time you double, until you get to the other side of the sphere where there are no more galaxies to count.

"Or what if the universe were saddle-shaped, where two opposite corners are bent up while the two remaining were bent down? Then you'd count more than four-times, maybe 4.2, and counting further out that ratio gets larger.

"In this survey they counted exactly four-times. It was a tricky piece of work, because you need to know how far away each galaxy is. I'm not going into that in this lecture, but it's tricky work. But four-times exactly means the universe as we know it is flat."

The last lecture, the one everyone had waited for since the first news was published three days ago. Something new in cosmology. Timothy continued lecturing to his students in his head. "Now lets take a look at the expansion of the universe. This was quite a discovery in its time, and is still a source of amazement for me. When looking at all the galaxies, and there are millions of them, they all look too red to us. This is the same red shift we talked about earlier. All galaxies, taken as a whole, are moving away from us. You've heard of the Big Bang? That was a facetious name given to this observation, and it stuck. Somewhere, the theorists propose, something happened to bring the entirety of the universe into existence. All the mass, all the energy we have now appeared in an instant, and began to expand. Eventually atoms formed, then they were attracted to other atoms to form a sort of dust, and the dust gathered into masses, which attracted more dust until the stars lit up! And the stars gathered into galaxies. Or maybe it was the other way, dust gathered into galaxies, and stars formed there. It's hard to say when we live such a short time to observe the process, and the galaxies hang together for billions of years."

Wait, what did he just say? Timothy was surprised by the announcement that the expansion seems to be accelerating! If gravity is operating over the whole of the universe, expansion should always be slowing. No matter what. But accelerating? How could that be?

He listened closely, and no specific proposal was given. Someone mentioned "Dark Energy?" What was that? Energy is such that it is visible. How can it be energy, and dark at the same time? Perhaps antimatter would exhibit antigravity, but that has been examined and proved false. Antimatter would have normal gravity. What sort of energy could push galaxies apart, and accelerate them?

The lecture ended with a battery of unanswerable questions.

Timothy walked slowly back to his office, head bent in concentration, trying to make sense of this bombshell.

As the days and weeks went by, the problem seemed to consume more of Timothy's time. He forgot to teach a class, and as he delved deeper into the problem, this became more common. His colleagues in the department noticed this and tried to find out what was wrong, but he could not shake this problem of acceleration. It was consuming him.

Five months later he resigned his position and dropped out of academic life entirely.

Timothy Farnsworth then disappeared.