Voltaire: A Study in Finding a Needle in a Haystack

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A few years ago, while working on the problem of falling down a hole through the earth, I found a quote by Leonhard Euler who was explaining a version of the problem to a German princess:

> You will remember how Voltaire used to laugh about a hole going to the center of the earth. But there is no harm in imagining it to see what would happen [3, p.178].

Finding the context for Voltaire's laughter would add historical color to my account of the hole problem. Maybe it was more than an after dinner anecdote. Perhaps he wrote about it. How hard could it be to find?

Voltaire used 108 different pen names. He often disavowed much of what he wrote, both as a marketing ploy to enchant people into buying his works, and as a ruse to avoid some of the inevitable political and ecclesiastical fallout that followed and inspired his output. He wrote thousands of letters. Much of his writing is lost. He called himself the "innkeeper of Europe" because he entertained guests frequently. Voltaire's collected works run for forty-two volumes in the King College Library. My quest was like finding a needle buried in a haystack, if indeed the needle existed. The last volume in the collection was an index. Looking up *hole* and *earth* and *falling* led to nothing. Voltaire's work consists of letters, essays, histories, romances, plays, and a philosophical dictionary. The essays sounded promising. Sure enough, I found where Voltaire laughed about the hole. But was it the only instance? As I read, looking for citations, Voltaire's word magic intrigued me. Who was this man?

In college, I had read the classic Candide, a utopian or anti-utopian romance depending on one's point of view. I vaguely associated Voltaire with atheism, ridicule of the church, the French revolution, and being an old man who died in bitterness, ostracized by society. But reading his work challenged these perspectives. Throughout his writing, he demonstrates a mastery of the scripture; he proceeds with wit, example, and logic; he champions the notion of creation by design and of a Creator; he pleads tirelessly for justice and religious toleration. Although some of his writing is dated or repetitious, his style is fresh and his arguments are interesting. After a few months of reading passages from several volumes, I began reading Voltaire systematically, pacing myself for a three or four year marathon.

Then I encountered *Micromegas.*

Voltaire's story of Micromegas is about an alien giant who visits the earth in 1737 and meets a shipload of French mathematicians returning from the arctic where they had been taking measurements testing Newton's claim that the earth was flattened at the poles. The story is about measuring things, from the small to the very large, from gnats and worms to planets and astronomical distances, from the penchant for man to make war to dreams of understanding the soul. It is upon this story that we focus.

This paper consists of three parts (1) Voltaire, the want-to-be mathematician, (2) an outline of some of the mathematics related to the Micromegas story, and (3) some speculation about the story's strange conclusion.

Voltaire: a want-to-be mathematician

When Voltaire (1694--1778) was faced in 1726 with another stint in the Bastille over controversy involving what he had written, he opted for exile in England. There, he was received as a celebrity---for at age 32, he had already written a number of very successful plays. He met the English literary figures of the day, including Jonathan Swift whose Gulliver's Travels had just been published. Shortly after his arrival, Isaac Newton (1643--1727) died. The entire country mourned. Nobles vied to be his pall-bearers. Nothing like this could occur in Voltaire's France. The gulf between commoner and noble was too great. Voltaire was intrigued. What manner of man had Newton been? On the continent, Newton was more or less held in derision. Being an historian as well as playwright and poet, Voltaire resolved to write a biography of Newton. Towards that end, he interviewed Newton's niece who told him the story of Newton's inspiration of discovering gravity in 1666 when observing an apple falling from a tree on his estate.

Voltaire is the first to write the story. It was embellished by Euler so that the apple landed on Newton's head [**3**, Letter LII, p. 185]. Allowed to return to France in 1728, Voltaire hired two mathematicians to tutor him so that he could better understand Newton's work: Pierre-Louis Moreau de Maupertuis and Alexis Claude Clairaut, mathematicians of note both in Voltaire's day and today. By chance, he struck up a relationship with a most unusual woman, the duchess Emilie de Chatelet (1706--1749), who had been well-educated in her youth both in mathematics and physics. She was intrigued with this poet-turned-natural-philosopher. For the next fifteen years until her death, the two of them were inseparable. Inspired by Voltaire's work, she resolved to translate Newton's Principia from Latin into French. Voltaire enlisted his two tutors for help on the project. During this time, Voltaire and Emilie resided for the most part outside of Paris at a country estate where they entertained guests, wrote extensively, experimented with scientific gadgets, and put on plays.

For example, in 1737, the essay prize question of the year as sponsored by the French Academy of Science was on the nature of fire and how it spreads. Emilie and Voltaire busied themselves with fire-related experiments. They both submitted essays. No surprise: Euler's essay won first place. But both Emilie's and Voltaire's papers were published as honorable-mention submissions. In fact, Emilie's paper was the first published Academy paper by a woman.

When Voltaire's Elements of Newton's Philosophy appeared in 1738, the secretary of the Academy, Bernard le Bovier de Fontenelle, told Voltaire that he really should have studied Newton's work for three more years before beginning to write. Stung by the criticism, Voltaire asked Clairaut for a second opinion, who concurred that Voltaire's talents lay more with linguistics than with formulae.

Thereafter, Voltaire followed that advice, but continued to encourage Emilie in her translation of the great work. In 1749, on her deathbed, she posted the finished manuscript to the publishers. It has become the definitive (and only) French translation of the Principia.

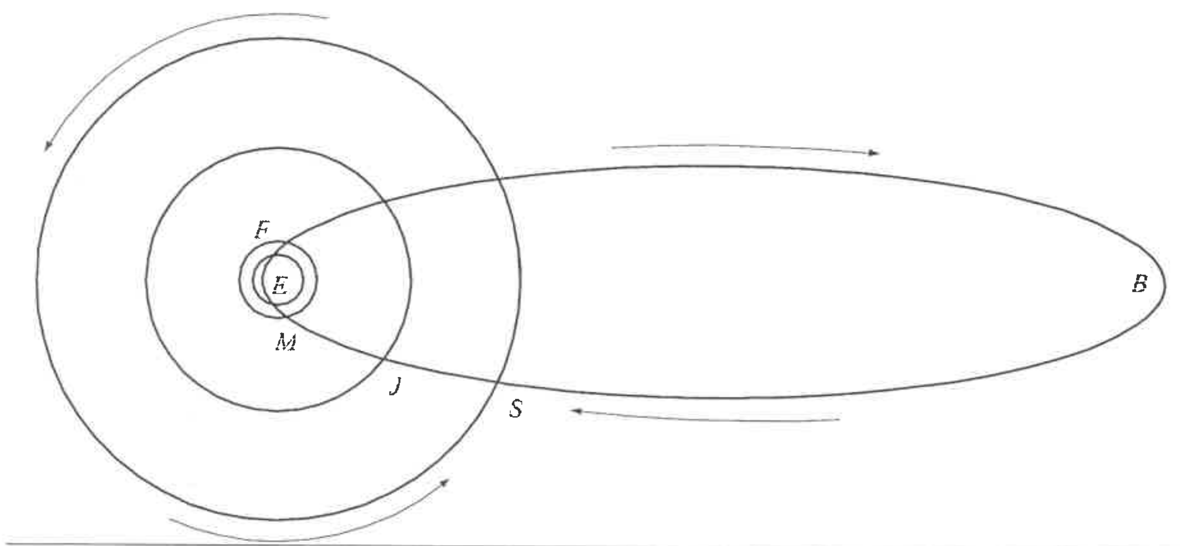


Figure 1. Orbits of earth, Mars, Jupiter, Saturn, and a comet

The mathematics behind Micromegas

In 1736, Voltaire received a fan letter from the crown prince of Prussia, Frederick the Great (1712--1786), telling Voltaire how much he admired his writings and hoping to one day implement enlightened principles as king. Voltaire was charmed. Maupertuis facilitated a dinner meeting between the two. In 1739, Voltaire wrote an early version of Micromegas: a philosophical fable raising basic questions with which an enlightened ruler must wrestle. He based the story on an expedition underwritten by Louis XV in 1736: Maupertuis and Clairaut and several others (including Anders Celsius of thermometer fame) were charged with measuring a degree of earth's arc along a line of longitude in Lapland.

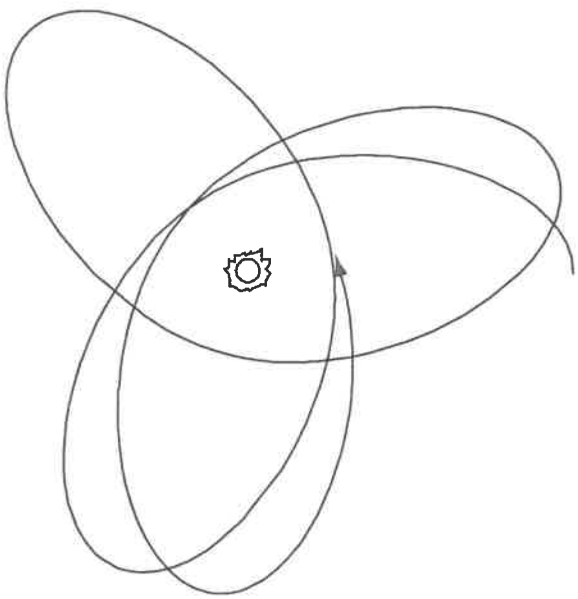
Here, in outline form, are some natural and related questions behind this expedition.

A degree of arc. How does one measure a degree of arc along the surface of a very large spheroid?

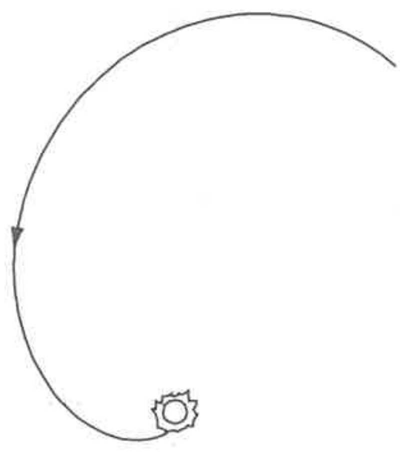
The flattened earth. From basic calculus, given the approximate radius of the earth and a 24 hour period, determine the amount of flattening at the poles and the bulging at the equator. Newton predicted a flattening of poles by about 4.5 miles, and a bulging of the equator of about 9 miles, values within a half mile of the actual values.

Period of earth's pole. From the moon's and sun's pull on earth's bulge at the equator, determine the period of the earth's polar direction. Hipparchus (190--120 B.C.), the father of astronomy, had noticed this shift had period about 26,000 years. That is, spring comes a bit earlier each year. Two thousand years from now spring will be at the end of February rather than at the end of March.

Elliptical orbits. Micromegas toured the solar system by riding a comet, as in Figure 1 where the retrograde orbit of Halley's Comet is superimposed on the planetary orbits. Voltaire gives the distances between Saturn (*S*) and Jupiter (*J*), and between Jupiter and Mars (*M*), and the time between Mars and earth (*E*), saying of the latter that it is ``a very long time." How good are these guesses? As one critic points out, ``It is a curious fact that there is not one single proportion in the whole story accurately given" [7, p.148].



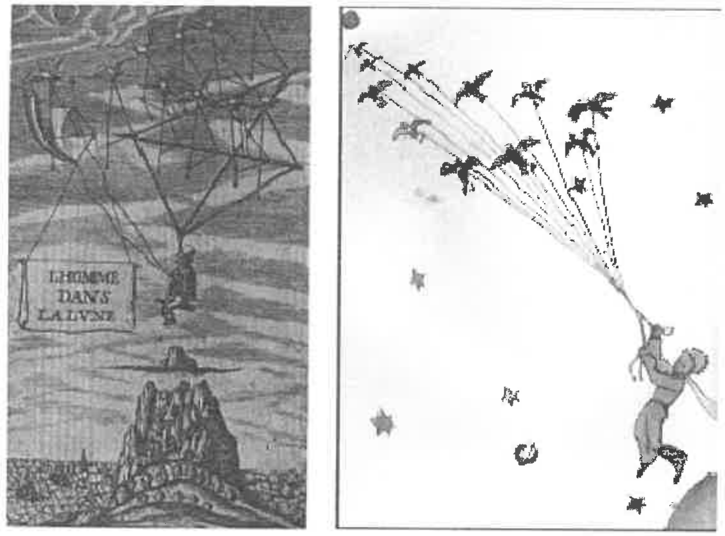
a. A Flatland comet



b. A 4-D comet

Figure 2. Comet trajectories in other dimensions

Comets in Flatland and 4-D. In light of the previous question, what are the trajectories of comet-like objects in Flatland or in 4-dimensions? Rather than an ellipse, in Flatland a planet would orbit the sun in a precessing ellipse as in Figure 2(a), and in 4-D any planet will spiral into its sun as in Figure 2(b).



(a) via a wedge of swans (b) via a flock of wild birds

Figure 3. Space travel

A pursuit problem. The 1599 science fiction story, ``The Man in the Moon," by the Anglican bishop Francis Godwin gives a pre-Newtonian perspective to trajectories. In that story, an astronaut harnesses a wedge of swans to tow him to the moon, as shown in Figure 3(a) [**1**, plate facing p.,118]; (the sketch in Figure 3(b) from the classic children's tale The Little Prince of 1943 [**2**, p. 2] shows the lasting influence of Godwin's tale). The swans fly at constant speed, always flying toward the moon. They reach the moon in twelve days and return home in eight days. How good a guess was Godwin's? Figure 4 shows the swans' trajectory to the moon. This pursuit problem is sometimes referred to as the pursuit problem of Maupertuis who published a way to solve this kind of problem using Newton's calculus in 1735.

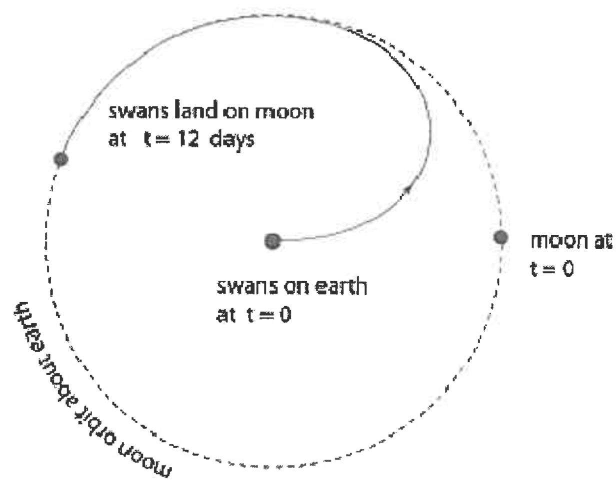


Figure 4 The trajectory from the earth to the moon.}

A brachistochrone problem. In one evening, after a long day at the Mint, Newton solved the brachistochrone problem, which is to find the path between two points of least time through a flat earth with constant gravity and no resistance. The answer is a cycloid. Through a round, homogeneously dense earth, the answer is a hypocycloid. What happens if the earth spins? When the points lie in the equatorial plane, the answer remains a hypocycloid.

When the points are at, say 45 N and 45 S, the shortest time path is not a plane curve, let alone a hypocycloid. Consider an ideal rock that when dropped at earth's surface will drill its own hole without resistance through the rotating earth. Let Γ be the path of such a rock with drop point *A* at 45 N and resurface point at *B*. Let *O* be earth's center. Figure 5 displays the projection from *O* of Γ and the projection from *O* of a straight line path between *A* and *B* onto earth's surface. The projection of Γ is slightly nearer the earth's equator than is the projection of the line segment (except when they concur at *A, B*, and at the equator). However, the projection of Γ onto the equatorial plane is a hypocycloid. I have no idea about the solution path when the two given points are non-symmetrical, such as the point-pair of the north pole and a point on the equator.

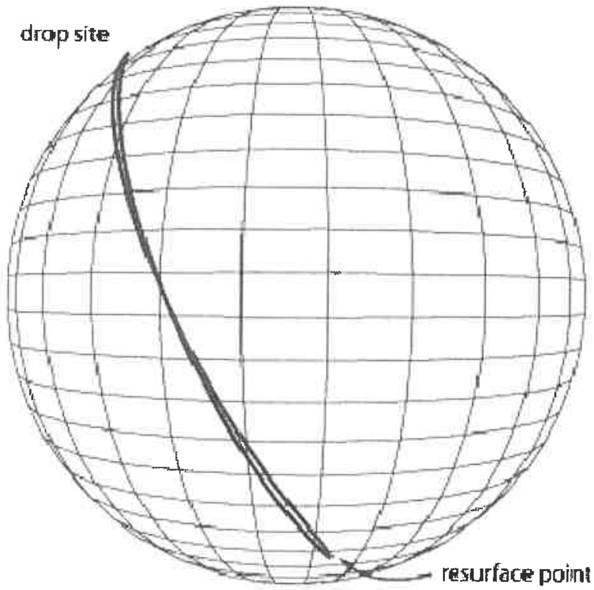


Figure 5. Projections of the least time path and straight line path onto earth's surface

The blank book of Micromegas

Voltaire's story ends with Micromegas giving the French philosophers a book in which are the answers to everything. When they return to Paris, the secretary of the French Academy opens the book and finds it empty. A strange ending! What does it mean?

Here are some possible answers to this open-ended question:

Answer 1: The absent-minded professor. The simplest answer is that Micromegas gave the scientists the wrong book. Perhaps all of his books had the same cover, and he simply picked up a blank book journal instead of the intended book. It is possible that Micromegas, like many scientists, is somewhat absent-minded. For example, Swift's island of Laputa in Gulliver's Travels is a community of scientists all of whom have this syndrome. To help them function in society, each scientist employs a flapper, a servant who carries a ball or bladder attached to a short stick.

> The flapper is employed to attend his master in his walks, and upon occasion to give him a soft flap on his eyes, because he is always so wrapped up in cogitation, that he is in manifest danger of bouncing his head against every post, and in the streets, of justling others [4, pp. 174—5].

Even Einstein needed to be walked home from his office at Princeton lest he get lost while he daydreamed.

Answer 2: A technological error. Another possibility is a technological error. Since Micromegas' nose is a mile long, and since he dissected very tiny worms that were 100 feet long, it may be that the pages of the books that he read himself were several square miles. When he reduced this to the size manageable for a human, say one square foot, perhaps the print became so thin it vanished.

Answer 3: A practical joke. Since Micromegas laughs uncontrollably in response to a philosopher saying that the universe was created solely for man, perhaps he decided that a practical joke was in order. That is, he intentionally gave Maupertuis's party a blank book.

Answer 4: Invisible ink. Man has but five senses: sight, sound, touch, smell, and taste. The Saturnian race Micromegas visited had several hundred, while Micromegas' race had a thousand. If Micromegas has a thousand senses, books in his library are therefore quite different media-wise than a book in eighteenth-century Paris. After all, if we gave the eighteenth century French academicians a CD, an LP, or a tape, they would be hard-pressed to see immediately that the medium had any content. That is, maybe the book was full of information, but man does not have the technological or the appropriate senses with which to read the book.

Answer 5: The philosopher king. Micromegas was first published in 1752, but an earlier draft was written in 1739 for Frederick the Great with the giant as a Frederick figure. In the 1740's, Voltaire thought that Frederick would become a genuine philosopher king. After much urging on Frederick's part, Voltaire became poet in residence at Frederick's court in 1750. Under close scrutiny, Voltaire's vision of Frederick's identity faded. That is, the philosopher king---in as far as Frederick being one---was an empty idea, just as empty as the book that Micromegas-Frederick gave to the French philosophers.

Answer 6: Nonsense. At one time or another, many of us have asked the question, ``Why is there anything?" as did Voltaire. But unlike most of us, Voltaire is a poet, and discourses with nature at length in print; she responds, ``I know nothing about the matter. Pray go and inquire of Him who made me" [**6**, vol. XII, *Nature*, p. 74]. In a despondent tone, Voltaire writes,

> The more I read, the more I meditate, and the more I acquire, the more am I enabled to affirm that I know nothing [**6**, vol. XII, *Occult qualities*, pp. 51—52].

What means this darkness?

Voltaire understood many things. He admired Newton, and his explanation of the laws of motion. Voltaire made a point of writing about Newton's achievements. His list of scientists and their recent accomplishments appearing in Micromegas is impressive. Voltaire was intrigued with the quest to know the nature of things. But complete understanding, as he perceived it, eluded him. Knowledge of most anything is fragmentary, and compared to what is unknown about that anything, those fragments are almost nothing. He seemed to abhor the idea that matter was all there was in the universe, reluctantly concluding [**6**, vol. XIII, *Somnambulists and Dreamers*, p. 259], ``What am I, therefore, if not a machine?" No answers seemed to exist for the origin of ideas, the mind, and that which is called spirit? He both relished and ridiculed debate. He argued metaphysics with the best of his peers. But for what value?

> When men have disputed well and long on matter and spirit, they always end in understanding neither one another nor themselves [**6**, vol. XIII, *Soul*, p. 272].

There are no easy answers to life and its significance. Voltaire was genuinely irritated with the established ways of thinking that proclaimed and demanded otherwise. Come, he says, let us agree together.

> Let each of us boldly and honestly say, `How little it is that I really know' [**6**, vol. XII, *Monsters*, p. 18].

One almost hears Voltaire saying, *How little it is that we will ever really know.*

Voltaire suspected that no absolute answers existed to the questions that he most desired to know, and as a result, he felt that the answers with which we amuse ourselves and pride ourselves in reaching are probably mostly illusions as well. In that respect, it is no wonder that Micromegas' book was blank.

Answer 7: Tabula Rasa. John Locke (1632--1704) describes man at birth as a blank sheet: as we grow and experience the world, we write in that book, creating a personal identity and an understanding of the world. In the same manner, Micromegas's book was blank. But we as a people, with our collective inquisitiveness, write in that book, filling it with discoveries, understanding, further questions, and renewed hope. The book is written as we learn. In that sense, Micromegas's book indeed contains the answers to all questions about the universe. The book is never complete at any specific time. It's somewhat like a timekeeper enumerating the integers from one to infinity. He'll never count them all. But as long as the office of timekeeper is handed down from one generation to the next, for any particular integer *N*, there will be a time when *N* is counted. For any specific question, there could be a time when a good answer to that question might appear in the book. As a result of that answer, there may be many more questions. But Micromegas's book is a big one. There will always be plenty of pages left to fill.

Concluding remarks

A copy of *Micromegas* is most likely available at your local library. A free-ware translation is available at **[5]**. Assign the story as a reading in a liberal arts mathematics class or a history of mathematics class. Ask your students to write an essay about elements of the story, such as how each of the many philosophers Voltaire mentions in the story would answer Micromegas's question, ``What is the use of existing?" or why Micromegas's book is empty. Sometimes in looking for a needle in a haystack, much more is found than the needle. *Micromegas* is a good read. I heartily commend the story.

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